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Abstracts and Excursion Guide



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28–30 September, 2009

Edited by:

D. Peryt
and **M.A. Kaminski**



Seventh Micropalaeontological Workshop

MIKRO-2009

**Św. Katarzyna, Poland
September 28–30, 2009**

ABSTRACTS and EXCURSION GUIDE

September, 2009

Seventh Micropalaeontological Workshop MIKRO-2009

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Seventh Micropalaeontological Workshop

MIKRO-2009

ABSTRACTS and EXCURSION GUIDE

Edited by:

Danuta Peryt

Institute of Paleobiology
Polish Academy of Sciences
Twarda 51/55, 00-818 Warszawa, Poland

and

Michael A. Kaminski

Department of Earth Sciences
University College London
Gower Street, London, WC1E 6BT, U.K.

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PREFACE

Since 1998, the Grzybowski Foundation in partnership with one of the Polish geological or palaeontological institutions have organised micropalaeontological workshops called “MIKRO” meetings approximately every two years. Starting from 2005 the conference language has been English, and meetings were transformed from Polish micropalaeontological workshops into international ones.

MIKRO-2009 organised by the Institute of Paleobiology of the Polish Academy of Sciences and the Grzybowski Foundation is the seventh meeting in this series and follows previous meetings held in Kraków (1998, 1999), Zakopane (2001), Kazimierz (2003), Szymbark (2005), and Gdańsk (2007).

The main idea behind this meeting and this abstract volume is to present results of current research on the taxonomy, biostratigraphy, and palaeoecology of different groups of microfossils, mainly foraminifers, calcareous nannoplankton, ostracods, conodonts and graptolites from Poland and Central Europe.

The Organising Committee of the 7th Micropalaeontological Workshop MIKRO-2009 is pleased to welcome you to Św. Katarzyna – a site in the heart of the Holy Cross Mountains, at the foot of Łysica (612 m above sea level) – the highest peak of the Holy Cross Mountains. The Holy Cross Mountains are one of the oldest mountain ranges in Europe. They occupy an area of about 2700 km² in the southwestern part of Central Poland in which the Palaeozoic formations outcrop from the Mesozoic and Cainozoic cover.

The meeting will consist of two days plenary sessions and a one-day field excursion in the Holy Cross Mts. area. The field excursion will visit four quarries to see examples of Palaeozoic, Mesozoic and Cainozoic deposits, respectively the Upper Devonian limestones on the Wietrznia Hill in a large, inactive quarry, Upper Jurassic limestones in the Gnieździska Quarry, Middle Miocene organodetrital limestones in the Pińczów Quarry, and Lower Maastrichtian siliceous limestones outcropping near Busko Zdrój.

We are certain that the MIKRO-2009, with more than 50 micropalaeontologists registered and over 60 contributions will be an excellent place for many interesting discussions and new ideas.

We also wish to thank our sponsors who contributed to the organizational costs of the meeting – the Institute of Paleobiology, Polish Academy of Sciences, the Grzybowski Foundation, the Polish Geological Institute, the Micropalaeontological Society, the Precoptic Co., and the printing office – Usługi Poligraficzne i Wydawnicze Piotr Ciesielski.

For the MIKRO-2009 Organizing Committee

Danuta Peryt and Mike Kaminski

Dynamics of appearance, flourishing, and extinction in the Devonian of radiolarians with two porous spheres and one main spine

Marina S. AFANASIEVA¹ and Edward O. AMON²

¹ A.A. Borissiak Paleontological Institute, Russian Academy of Sciences, Laboratory of Protistology, Profsoyuznaya 123, 117997 Moscow, Russia; mafan@paleo.ru

² Zavaritsky Institute of Geology and Geochemistry, Ural Branch, Russian Academy of Sciences, Pochtovyi per. 7, Yekaterinburg 620151, Russia; amon@igg.uran.ru

The origin, basic evolutionary patterns, and great biotic crises in Phanerozoic radiolarian development were intimately connected with the geological history of the Earth. Glaciations and cold climate played a special role in radiolarian evolution. Radiolarians, which were typical for warm interglacial periods (greenhouse) disappeared during interglacial to glacial transition intervals (icehouse), and vice versa. Some possible regularities that resulted in increase radiolarian interglacial biodiversity, could be circumstanced by stabilization of climate and enhanced oceanic production. Biological mechanism, explaining these events, may be caused by phenomenon of solitary population waves (Kovalev, 2007).

New species constantly appear under both favourable and severe conditions. Therefore, it is incorrect to propose that changes in global climatic conditions necessarily result in general deterioration of conditions in the habitats of all species. A crisis for some taxa is a chance for others (Kovalev *et al.*, 2007; Chernykh *et al.*, 2007). New morphological formations occurred usually under general stress. They probably invaded into global radiolarian fauna like a pandemic virus and instantaneously migrated to populations of remote water areas. Processes of expansion of species with morphological and/or physiological innovations into new ecological systems and adaptation to new niches are regarded as different phases of existence of populations. The phase of expansion is unique event of solitary population wave. In this situation, increasing number of alien taxa is accompanied by extreme increase of diversity. However, the capability of forming solitary population waves is only manifested in phylogenetically “juvenile taxa” (Kovalev, 2007).

The Devonian radiolarians with two porous spheres and one main spine are a good object, where law of solitary population waves found whole confirmation. Four solitary population waves of expansion of examined radiolarian morphotype are observed during Devonian (Afanasieva & Amon, 2009). The first population wave emerged in the Early Emsian of Japan and it was attenuated in the Famennian of southern China. The second one started in the Middle Emsian of New South Wales and was accompanied by an explosive increase of new genera and species in the Early Frasnian of Western Australia. The third one emerged in the Late Emsian of Southern Urals and followed fan-shaped pattern of dispersal of new morphotype in the Late Eifelian of Prague Basin; in the Givetian of Northern Mugodzhary; in the Middle Frasnian of the Rudny Altai, Volga-Urals and Timan-Pechora basins; in the Late Frasnian of southern China, Rudny Altai, Northern Mugodzhary and Central Poland. In the Famennian, the third population wave was attenuated. The fourth population wave emerged in the Early Famennian of the Timan-Pechora Basin and showed circumradial expansion of this morphotype.

The study was supported by the Program of the Presidium of RAS “Origin of Biosphere and Evolution of Geo-Biological Systems” and the Russian Foundation for Basic Research, project no. 07-04-00649.

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Stratigraphy of the Maikopian series of Azerbaijan

Malakhhat A. AFANDIYEVA¹, Rustam G. BABAYEV¹, Cari L. JOHNSON²

¹ Azerbaijan National Academy of Sciences Geology Institute, 29 A.H. Javid av., Baku, AZ1143, Azerbaijan; m.efendiyeva@gia.ab.az

² Geology and Geophysics, WBB 609, University of Utah, 135 South 1460 East, Salt Lake City, UT 84112 USA; cari.johnson@utah.edu

Oligocene–Lower Miocene succession of deposits corresponds to one of the basic oil-generating source rocks for the overlying South-Caspian basin of the main reservoir of the Productive Series (Early Pliocene). Lithologically, this complex of deposits is mainly expressed by monotonous series of dark-grey shaly clays in the major part of area of distribution.

These deposits of the Oligocene–Early Miocene, defined as the Maikopian series, are widely distributed from the foothills of Carpathians till the foothills of Kopetdag and include Azerbaijan territory as a part. In spite of fact that the Maikopian suite is studied by various geologists over the last 100 years, the subdivision and correlation of sections of these deposits is still one of the actual and incompletely solved issues of the present stratigraphy.

The proposed work is based on the detail study of the sections of the Oligocene and Lower Miocene deposits, having contacts with underlying and overlying deposits, and which generally covers the whole stratigraphic range, with application of integrated modern methods (biostratigraphy, geochemistry, lithology-petrography, and radiometry). This is the first integrated study carried out for the last 50 years for the Maikopian deposits series within the territory of West Azerbaijan (Ganja oil and gas bearing region). As a result 175 samples had been studied from the following sections: Zeyva, Ajidere, Gurzalar and Garachinar.

Investigations of the samples allowed us to determine the following microfaunal zones in these deposits: zones with small *Globigerina*, zones with *Caucasina schishkinskajae oligocenica*, zone with *Nonion dendriticus*, a zone with sparse fauna, zone *Bolivina* ex gr. *plicatella*, zone *Virgulinea poiliensis*, a zone with untypical fauna, zone with *Neobulimina elongata leninabadensis* and layers with *Saccamina zuramakensis*, but also to trace their concrete correspondence to the stratigraphic subdivisions from the Stratigraphic code of Azerbaijan.

Among representatives of microfaunal remnants the leading role belongs to the foraminifera. They are all well preserved. Numerous representatives of the genera: *Globigerina*, *Cibicides*, *Rhabdammina*, *Virgulinea*, *Saccamina*, *Bolivina*, and even the rocks of Kotsahurian regional stage, which are free of microfaunistic remnants over the major part of their distribution, contain significant quantities of representatives of the genera *Saccamina* and *Rhabdammina*, as well as significant amount of fish and vegetative remnants.

The performed investigations had allowed not only to trace the microfaunal zones in sections within the studied territory, but to define their correspondence to the Stratigraphic code of Azerbaijan, which, in its turn, allows us to correlate the Maikopian series deposits of the Ganja oil and gas bearing region with analogous deposits as in Azerbaijan and beyond.

General stratigraphic scale			Regional stratigraphic subdivisions		
Period	Epoch	Stage	Regional stage	Series	Microfaunal zones and layers
Neogene	Miocene	Burdigalian	Kotsahurian	Maikopian	Layers with <i>Saccamina zuramakensis</i>
			Sakaraulian		Zone <i>Neobulimina elongata leninabadensis</i>
		Aquitanian	Caucasian		Zone with uncharacteristic fauna
					Zone <i>Bolivina</i> ex gr. <i>plicatella</i>
		Palaeogene	Oligocene		Chattian
Rupelian	Rupelian				Zone with <i>Nonion dendriticus</i>
					Zone with <i>Caucasina schishkynskae oligocenica</i>
					Zone of small <i>Globigerina</i>

The present investigation had been performed under the support of CRDF fund (AZG2-2881-BA-07).

Upper Cretaceous assemblages with taxa of the genus *Neoflabellina* (benthic foraminifera) in the Middle Coniacian–Maastrichtian of the East European Platform and Mangyshlak

Sergei I. AKIMOV¹ and Vladimir N. BENYAMOVSKIY²

¹ Department of Paleontology, Geological Faculty, Moscow State University, Vorob'evy Gory, Moscow 119899, Russia; themoronbrothers@inbox.ru

² Geological Institute, Russian Academy of Sciences, Pyzhnevskiy line 7, Moscow 1190117, Russia; ben36@mail.ru

Species of the genus *Neoflabellina* are found constantly in the deposits of the Middle Coniacian–Maastrichtian interval in many reference sections in the south of the Russian plate and Mangyshlak. In recent years they have been studied intensively in numerous reference sections of these structures (Akimov & Benyamovskiy, 2008). The following is a brief description of ten Upper Cretaceous assemblages with representatives of the genus *Neoflabellina* of southern East European Platform and Mangyshlak:

1. The Middle Coniacian assemblages with *Neoflabellina suturalis praerugosa* is characterised by FO's of species *N. suturalis suturalis* (Cushman) and *N. suturalis praerugosa* Hiltermann.

2. The Upper Coniacian–Lower Santonian assemblage with *Neoflabellina ovalis* is different from the underlying new additions to the assemblage of species-index such as *N. ovalis* (Wedekind) (= *N. santonica* Koch), as well as *N. suturalis praecursor* (Wedekind). The latter two species characterise the terminal Coniacian and lower Santonian.

3. The middle–upper Santonian assemblage with *Neoflabellina gibbera* differs from the lower by a set of changes in the composition of neoflabellinids assemblage: the beginning of the development of *N. deltoidea* (Wedekind), which is continuing in the Campanian. Secondly, it is characterised by the appearance of *N. gibbera* (Wedekind) and the disappearance of older *N. suturalis praerugosa*.

4. The assemblage with *Neoflabellina deltoidea* (lower Campanian) is characterised by the disappearance of species of the group *N. suturalis*, the FO of *N. cf. wedekindi* Koch and the continued presence of a constant *N. deltoidea*.

5. The assemblage with *Neoflabellina rugosa sphenoidalis* of the lower part of the upper Campanian is characterised by the appearance of species of the group *N. rugosa*: *N. rugosa sphenoidalis* (Wedekind), *N. rugosa caesata* (Wedekind), as well as by the beginning of the spread of *N. praereticulata* Hiltermann, and the disappearance of *N. deltoidea*.

6. The assemblage with *Neoflabellina rugosa leptodisca* of the middle part of the upper Campanian. The lower boundary of this complex is set on the appearance of *N. rugosa leptodisca* (Wedekind), the continuing distribution of *N. rugosa sphenoidalis*, and the disappearance of species of the lower complex: *N. rugosa caesata* and *N. deltoidea*.

7. The assemblage with *Neoflabellina buticula* of the uppermost Campanian allocated to the FO of *N. buticula* Hiltermann and *N. permutata* Koch.

8. The assemblage with *Neoflabellina praereticulata*–*N. reticulata* represents a transition interval from Campanian to Maastrichtian. The lower limit of this complex was determined by the acme of *N. praereticulata*, a single occurrence of *N. reticulata* (Reuss), combined with the disappearance of *N. buticula* and *N. rugosa leptodisca*.

9. The assemblage with *Neoflabellina reticulata* (lower Maastrichtian) is characterised by a constant and widespread occurrence in many reference sections of the typical *N. reticulata*. In some sections is marked by the FO of another form of the group *N. reticulata*: *N. neoreticulata* Titova, and the beginning of the spread of *N. postreticulata* Hofker.

10. The assemblage with *Neoflabellina permutata* (upper Maastrichtian) is represented by the relatively frequent occurrence of *N. permutata*, rare *N. reticulata* and *N. postreticulata*.

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Akimov, I.S. & Benyamovskiy, V.N. 2008. Stages of development of the genus *Neoflabellina* (benthic foraminifera) in the Late Campanian–Maastrichtian of the south of Russian Plate. Cretaceous System of Russia and adjacent countries: problems of stratigraphy and paleogeography. *Proceeding of the Fourth All-Russian meeting. Novosibirsk*. Publishing House SB RAS, 12–14. (In Russian)

Ostracods of the Rybinsk horizon (Lower Triassic) of the Moscow Syncline (Russia) and their connection with Early Olenekian marine transgression

Mikhail AREF'EV¹, Dmitry KUHTINOV², Ekaterina TESAKOVA³,
and Anton SHIRYAEV¹

¹ Museum of Natural History of St. Alexius Orthodox Brotherhood of Mercy, Novoalekseevka 152149, Yaroslavl' Region, Russia; mihail-3000@inbox.ru

² Lower Volga Research Institute of Geology and Geophysics, Moskovskaya St., 70, Saratov 410600, Russia

³ Department of Paleontology, Geological Faculty, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia; ostrakon@rambler.ru

The research group of St. Alexius Orthodox Brotherhood of Mercy conducted a multidisciplinary study of the Rybinsk horizon (lower Olenekian, Scythian) of the Moscow Syncline (Eastern Europe). The extremely fossil-rich lower Triassic locality Tikhvinskoe (Volga River) was studied in the western part of the Moscow Syncline. The section of the site exposes grey-coloured Parshino beds, and variegated and red coloured Cheremukha beds of the Rybinsk Formation. Parshino beds are believed to have been accumulated below the normal wave base, and the deposition of the Cheremukha beds occurred above the normal wave base.

The lower part of the Parshino member contains the richest ostracod assemblage, including 15 species of the genera *Clinocypris*, *Darwinula*, *Nerechtina* and *Gerdalia*. The overlying Cheremukha beds yielded three assemblages. The lower one includes three species of *Clinocypris* and two species of *Darwinula*. The middle assemblage includes eight species of *Clinocypris* with sporadic forms of *Wetluginella*. The uppermost assemblage contains five species of *Clinocypris*. The ostracod distribution in the section indicates decreasing diversity of ostracod fauna upsection. In parallel, the Cheremukha beds show the appearance of bivalves *Bakevella*, diverse bryozoans, and possibly foraminifera.

The Tikhvinskoe locality is correlated with the lower Triassic deposits outcropping along the Volga River between Puchezh and Yur'evets (the central part of the Moscow Syncline) which are represented by red-coloured sediments with numerous signs of wave activity in shallow water conditions, pedogenic phenomena, and storm deposits. Most of these deposits were seemingly deposited above the basis of normal wave activity in the zone of coastal marshes.

The section between villages Palashino and Belovskaya yielded a relatively diverse ostracod assemblage with 25 species of the genera *Darwinula*, *Nerechtina* and *Gerdalia*, with rare *Clinocypris*, *Marginella* and *Suchonella*. The section also produced bivalves (cf. *Bakevella*) and bryozoans.

In the eastern part of the Moscow Syncline, the deposits of the Rybinsk regional stage are represented by the Shiliha Formation. The deposits of this formation were associated with seasonally flooded and mostly aerated ecotopes of the fluvial plain. The found ostracod associations are very poor and include few species of *Darwinula* and *Gerdalia*.

The studied Rybinsk's ostracod assemblages indicate facies change from mostly marine (the western areas of the Moscow Syncline) to strongly terrestrial (in its eastern part). The occurrence of *Clinocypris* provides evidence for the accumulation of the Rybinsk Formation under conditions of marine basin that reached western and central parts of the Moscow Syncline. The extinction of fresh-water ostracods in the upper part of the Tikhvinskoe section may indicate an increase in salinity in the Cheremukha time during the regressive phase of the early Olenekian transgression.

The biostratigraphic value of Moscovian (Middle Pennsylvanian) fusulinoids

Daria V. BARANOVA¹ and Pavel B. KABANOV²

¹ A.A. Borissiak Paleontological Institute, Russian Academy of Sciences, Laboratory of Protistology, Profsoyuznaya 123, 117997 Moscow, Russia; baranova.daria@gmail.ru

² TNK-BP, Gor'kogo 42, 625000 Tyumen, Russia; pbkabanov@tnk-bp.com

Fusulinoidea is conventionally regarded as a foraminiferal group having high biostratigraphic potential due to their abundance and rapid evolution rate. This role has been tested in the late Moscovian (Carboniferous) epeiric carbonate succession of the southern Moscow Basin. The succession consists of icehouse-style cyclothems/sequences with prominent lowstand systems tracts. These sequences are bound by regionally traced parallel unconformities marked by thin calcrete palaeosols. Subphotic depth were probably attained at highstands as suggested by marly *Zoophycos* bioturbated wackestones and tempestites with characteristic lack of syphonean algae. Cyclothem-based correlation of local sections improves the “official” biostratigraphy-biased schemes (Kabanov, 2003; Kabanov & Baranova, 2007) and creates measure against which microfossil distribution can be evaluated. The material presented here was obtained by counting fusulinoid genera in hundreds of thin sections from nine quarry sections with subsequent statistical evaluation.

It appears that the biostratigraphic potential of fusulinoid species in the tested stratal succession is overestimated. Some index-species extend outside their zones. The majority of fusulinoids excluding staffellid genera *Reitlingerina* and *Parastaffelloides* show moderate to no facies preference within the tested facies range. Only staffellids can be applied as markers of normal-marine shallow-water [first ten(s) of meters] euphotic conditions. Small schubertellid fusulinoids (genera *Schubertella* and *Fusiella*) were the most tolerant (facies independent) group. Mass accumulations of *Hemifusulina* sometimes form a distinct fusulinoid taphofacies in mud-dominated storm-bedded units of lower regressive cyclothem parts.

A new biostratigraphic criterion that can add in index-species uncertainty is the abundance ratio of common genera *Neostaffella* (= *Pseudostaffella*), *Fusulinella*, and *Fusulina*. This ratio changes consistently though the late Moscovian interval: the abundance of *Neostaffella* decreases, and *Fusulina* gradually becomes more numerous. This approach has an advantage in requiring no species identification whereas genera can mostly be distinguished in random sections. The genus *Fusulina* changes its facies preference through time moving from normal-marine subtidal to open shoal to shallowest subtidal facies. The eight formations recognised on the studied interval can be characterised by this ratio (from base to top): Vaskino Fm.: *Neostaffella* 100%; Gory Fm.: *Neostaffella* up to 82%, *Fusulinella* up to 10%, *Fusulina* up to 8%; Markovo Fm.: *Neostaffella* 35–100%, *Fusulinella* 0–70%, *Fusulina* 0–5%; Akat'ev Fm.: *Neostaffella* 40–90%, *Fusulinella* 10–45%, *Fusulina* 0–15%; Schurovo Fm.: *Neostaffella* 0–60%, *Fusulinella* 30–100%, *Fusulina* 0–31%; Korobcheevo Fm.: *Neostaffella* 5–20%, *Fusulinella* 40–93%, *Fusulina* 2–38%; Domodedovo Fm.: *Neostaffella* 0–12%, *Fusulinella* 56–84%, *Fusulina* 11–50%; Peski Fm.: *Neostaffella* 0–3%, *Fusulinella* 30%–77%, *Fusulina* 30–54%.

Our results suggest that conventional species biostratigraphy alone can give resolution of only 2–3 My, that is the duration of the upper Moscovian time interval. However, involvement of abundance information at genus level allows precision to 0.4–1.0 My which is one or two formations/cyclothems within the tested interval.

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The granularity of the Palaeocene–Middle Eocene official action planktonic foraminiferal biostratigraphical scale of the Crimea-Caucasus Realm

Vladimir N. BENYAMOVSKIY

Geological Institute, Russian Academy of Sciences, Pyzhnevsky line 7, Moscow 1190117, Russia; ben36@mail.ru

The considered infrazonal scale details the planktonic foraminiferal zones used in the official action scheme for the Palaeocene–Eocene of the Crimea-Caucasus Realm (Zonal'naja sistema Rossii, 2006). Boundaries of proposed biostratigraphic units (subzones and layers) are defined by first and last occurrences of stratigraphically important species (Benyamovskiy, 2001, 2006).

The Lower Danian *Eoglobigerina taurica* Zone is subdivided into two subzones: *Eoglobigerina eobulloides* and *Globanomalina planocompressa* and the *Globoconusa daubergensis* Zone into two subzones: *Parasubbotina pseudobulloides* and *Globanomalina compressa*. The Upper Danian *Praemurica incostans* Zone consists of the lower *Praemurica inconstans* (s.s.) Subzone and the upper *Praemurica uncinata* Subzone. The Upper Thanetian *Acarinina acarinata* Zone comprises two subzones: the lower *A. soldadoensis* Subzone and the upper *Morozovella aequa* Subzone (Ypresian). The latter subzone is divided into the layers with *M. aequa*–*M. acuta* (the lower part) and the layers with *Subbotina patagonica* (the upper part). The Ypresian *Morozovella subbotinae* (s.l.) Zone of the lower Ypresian corresponds to three subzones of *M. subbotinae* (s.s.), *M. marginodentata*, and *M. lensiformis*. The *Morozovella aragonensis* Zone of the Upper Ypresian contains two subzones of *M. aragonensis* (s.s.) and *M. caucasica*. The upper part of the *M. caucasica* Subzone includes the layers with *Globigerinatheka micra*. The *Acarinina rotundimarginata* Zone of the Lower Lutetian includes in its lower part the layers with *Turborotalia frontosa*. The *Hantkenina alabamensis* Zone of the Upper Lutetian is subdivided into three subzones: *Globigerinatheka subconglobata*, *G. index*, and *H. australis*. The Uppermost Lutetian–Bartonian *Subbotina turcmenica* Zone is subdivided into the *S. aserbaidjanica* and *S. instabilis* Subzones.

The first and last occurrences of the index and zonal taxa and the succession of the planktonic foraminifer assemblages are evidence of the evolution of foraminifers in time (the genera *Acarinina*, *Morozovella*, *Globigerinatheka*, *Hantkenina*, etc.) and their responses to palaeogeographic changes. The similarity of the Palaeocene–early Ypresian assemblages and successive changes of the index and zonal species between the Crimea-Caucasus Realm and the low-latitude belt of the Earth suggests that this Realm was closely to the Mediterranean Province of the Tethyan belt at that time. The palaeogeographic situation has changed since the late Ypresian, as evidenced by the absence in the Crimea-Caucasus Realm of the index-species of the low-latitude zonation: *Planorotalites palmerae*, *Hantkenina nuttalli*, *Globigerinatheka kugleri*, *Morozovella lehneri*, *Orbulinoides beckmanni*. The genera *Acarinina*, *Turborotalia*, *Subbotina*, *Hantkenina* and *Globigerinatheka* are typical for the middle Eocene of Crimea-Caucasian Realm. *Globigerinatheka index* being a relatively cold-water species (Premoli Silva & Boersma, 1988) occurs probably earlier here than in the tropics. The Crimean Bakhchisaray section shows the typical succession of *Hantkenina* species, from the more “primitive” *H. mexicana*, *H. liebusi* and *H. dumblei* to the more “progressive” *H. alabamensis compressa* and *H. australis*. Their ranges, however, are very short relative to their ranges in oceanic regions (Pearson *et al.*, 2006).

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Foraminifera, biostratigraphy and palaeoecology of the Treskelodden Formation (Carboniferous–Permian) of Spitsbergen (Svalbard)

Błażej BŁAŻEJOWSKI

Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; bblazej@twarda.pan.pl

The upper Palaeozoic rocks including the Treskelodden Formation are exposed between Hornsund and Bellsund fiords (south Spitsbergen). The formation consists of a sequence of fresh water and shallow marine clastic rocks sometimes with large scale cross-bedding, and with subordinate shales and organodetritic, sandy limestone intercalations with well preserved fossils.

The strata of the Treskelodden Fm (late Gzhelian to early Artinskian) contain rich foraminiferal assemblages (Błażejowski, 2009). Fifty eight foraminiferal species of twenty three genera, including two new species (*Hemigordius hyrneffjelleti* sp. nov. and *Midiella arctica* sp. nov.) have been identified. Three foraminiferal zones have been defined, with ages of late Asselian (*Pseudofusulinella occidentalis*), Sakmarian (*Midiella ovata*–*Calcitornella heathi*) and early Artinskian (*Hemigordius hyrneffjelleti*–*Midiella arctica*).

An interesting phenomenon is the presence of up to five coral horizons within the formation (Birkenmajer, 1979). Both colonial and solitary rugose and tabulate corals occur, as well as sponges, brachiopods, crinoids, bivalves, trilobite, gastropods, calcareous algae and bryozoans (Nakrem *et al.*, in press) have been described.

The biotic succession of the Treskelodden Formation records a significant Carboniferous–Permian climatic cooling trend. Highly diversified, tropical-like associations dominated by dasycladacean algae, large fusulinaceans and small benthic and epibiotic foraminifers (Chlorofoam Association) (Beauchamp, 1994) prevailed during the Gzhelian to Sakmarian time (Błażejowski, 2009). Poorly diversified, temperate-like associations, dominated by bryozoans, echinoderms, brachiopods and only small foraminifera (Błażejowski, 2009), characterizing cooler climatic settings, developed during the Artinskian (Bryonoderm-extended Association – regarded as the equivalent of modern bryomol association) (Beauchamp, 1994).

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The Lower Campanian event reflected by benthic foraminifera assemblages in the Dambovita Valley (Eastern Carpathians, Romania)

Claudia G. CETEAN¹ and Ramona BALC²

¹ Institute of Geological Sciences, Polish Academy of Sciences, ul. Senacka 1, 31-002 Kraków, Poland; ceteanc@yahoo.com

² Babeş-Bolyai University, Faculty of Environmental Sciences, Str. Fantanele, 3, 400294, Cluj Napoca, Romania

The early Campanian dissolution facies and predominantly biosiliceous sedimentation has been observed at deeper sites everywhere in the North Atlantic (e.g. Gradstein *et al.*, 1999), South Atlantic (e.g. Basov & Krasheninnikov, 1983) and the Carpathians (e.g. Båk, 2000). Initially considered an oceanic anoxic event (OAE 3, Arthur *et al.*, 1990), the early Campanian sea-level maximum had lead to the deposition of organic-rich sediments only in marginal basins of the Atlantic Ocean (e.g. Holbourn *et al.*, 1999).

We have investigated an upper Santonian–upper Campanian succession of slope silstones and mudstones of the Plaiu Formation (Dambovita Valley, Eastern Carpathians) in the Izlaz Valley outcrop and we have constructed an integrated biostratigraphy based on planktonic foraminifera and calcareous nannofossils.

In the Izlaz Valley section, the early Campanian sea-level maximum can be inferred from increased radiolaria numbers, dissolution of some of planktonic species and from the low abundance and diversity of benthic foraminifera. During this period, decreases in the proportion of agglutinated foraminifera within foraminiferal assemblages were observed in the Carpathians and even in the chalk deposits from Poland (Olszewska, 1997; Peryt, 1988), the same decrease was observed also in the Izlaz Valley section.

Another characteristic feature of this interval in the studied outcrop appears to be an invasion of shallow water taxa into this middle depositional setting. Both agglutinated and calcareous benthic foraminifera species (e.g. *Spiroplectammina baudouiniana*, *S. elongata*) known from the chalk deposits in Dobrogea (Romania), France and England seem to invade the deeper part of the basin and disappear as soon as the early–middle Campanian regression takes place. Some genera of calcareous benthic foraminifera such as: *Stensioeina*, *Globorotalites* and *Osangularia* seem particularly to flourish during the late Santonian, early Campanian and mid Campanian sea-level maxima and show increases in percentages within foraminiferal assemblages. Faunal changes caused by the three sea-level maxima are reflected by both agglutinated and calcareous benthic foraminifera morphogroups with increases in the deep infaunal morphogroup.

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Benthic foraminiferal palaeoecology of the mid-Miocene to early Pliocene Manzanilla Formation (Trinidad)

Ashleigh COSTELLOE¹, Michael A. KAMINSKI¹ and Barry CARR-BROWN²

¹ *Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, UK*

² *BioSTRATIGRAPHIC ASSOCIATES (Trinidad) Ltd. P.O. Box 5783, Laventille, Trinidad*

Benthic foraminiferal assemblages of the Manzanilla Formation are documented from the east coast and Central Range areas of Trinidad. The San José calcareous silt Member, Montserrat glauconitic sandstone Member, and Telemaque sandstone Member were deposited during the mid-Miocene to early Pliocene when the Northern Basin formed a shallow shelf marine environment. Changes in the marine environment are documented by the foraminiferal species preserved in the Manzanilla Formation, which are used to interpret the subsidence history of the Northern Basin, Trinidad. Major ecological controls on the Miocene benthic foraminiferal assemblages include decreasing accommodation space in the basin as the Central Range was uplifted by the Naparima-Nariva Thrust Fault, the influence of the Oronoco River, and the development of dysaerobic benthic foraminiferal assemblages in silled basinal facies. This study presents:

- A survey of the benthic foraminiferal species found from transitional/swamp to open marine shelf-basin environments in the Northern Basin of Trinidad.
- A critical evaluation of the palaeoecology of the mid-Miocene to Pliocene benthic foraminifera using morphogroup analysis.
- An improved chronobiostratigraphy for the mid-Miocene to Pliocene Manzanilla Formation of the Northern Basin/Gulf of Paria, Trinidad and interpretations of palaeoenvironments and depositional history.



Foraminifers and biostratigraphy of the Albian–Cenomanian deposits from the Luka section (Dnister River Valley, West Ukraine): preliminary results

Zofia DUBICKA

Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; zdubicka@twarda.pan.pl

The Albian and Cenomanian transgressions in the West Ukraine gradually covered areas of differentiated relief after a long period of continental conditions (Świdrowska *et al.*, 2008), and the marine deposition continued till the end of the Maastrichtian. In the Middle Dnister River Valley the Albian deposits are underlain by Riphean (Mohyliv Podilskyy) to Silurian strata (south of Kamyanets Podilskyy). Still younger Palaeozoic deposits (Devonian) and locally uppermost Jurassic deposits occur up the Dnister River Valley.

The 11 meter thick middle Cretaceous succession is exposed in the Luka village, located 30 km east of Ivanofrankivsk (Western Ukraine). The studied profile represents a typical transgressive succession overlying Upper Jurassic limestones. The sequence starts with coarse-grained quartz sands with large amount of glauconite and pebbles. Higher up, marly conglomerates containing glauconite and phosphatic nodules up to a few centimeters across appear. An erosion surface is located on the top of these sediments. The conglomerates are overlain by marly sandstones passing into sandy limestones and then into hard silicified limestones. A strong condensation took place in the entire succession (especially in its lower part) which is shown by its small thickness and the occurrence of phosphatic grains and glauconite.

45 species of poorly preserved benthic and planktonic foraminifers have been recorded in these sediments. The assemblages are characterised by a considerable number of representatives of *Berthelina*, *Lingulogavelinella*, *Arenobulimina*, and the occurrence of *Rotalipora*, *Heterohelix*, *Guembelitria*, *Globigerinelloides*, *Hedbergella* and *Praeglobotruncana* which jointly indicate the stratigraphic interval from the *R. appenninica* Zone of the uppermost Albian to the uppermost Cenomanian.

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Biostratigraphy and palaeoecology of Maastrichtian sediments from the Lublin Upland (Eastern Poland) based on foraminiferal assemblages

Katarzyna DYBKOWSKA

Jagiellonian University, Institute of Geological Science, Oleandry 2a, 30-063 Kraków, Poland; katarzyna.pioro@uj.edu.pl; piorokat@yahoo.co.uk

The Lublin Uplands Cretaceous deposits has been formed in the eastern part of the Mid-Polish Trough after the major transgression of the Cretaceous sea on Central Polish Area during the middle Albian. In the Lublin area, in exception of a narrow zone in the South-West part of the region, only Upper Cretaceous sediments are observed. On the denudation surface mainly the Late Maastrichtian deposits are cropped out.

The studied sections represent a different facies developments: Podgórz Quarry Section represents a south-west part of the basin, disturbed by supply of clayey material, Chełm Quarry Sections – north-east part of the basin where quiet sedimentation of chalk took place. A passage between them are represent by materials from 16 cores from Łęczna area and marls and opokas exposed in Rejowiec Quarry Section. A south-east part of the same facies has been studied in scarps in Dańczypol and Pielaki villages.

Based on foraminiferal assemblages a biostratigraphy, palaeoenvironmental conditions (like palaeodepth, palaeotemperature, oxygenation and organic matter flux) and palaeobiogeography have been estimated. Samples from all sections contain abundant and very well preserved microfauna, however compositions of foraminiferal assemblages are not highly differentiated. Qualitative and quantitative analyses indicated high planktonic/benthic (P/B) variation: 15–75% in Chełm section, 30–50% in Rejowiec section, 60–65% in Podgórz, Pielaki and Dańczypol sections. Based on P/B ratio, benthic foraminifera morphogroups (*sensu* Koutsoukos & Hart, 1990), ecomarker species (like *Bolivinoidea*, *Pullenia jarvisi*, *P. cretacea*, *Praebulimina*, *Gavelinella pertusa* and othes) and presence of a bathypelagic genus *Globotruncana* a palaeodepth correlation of these sections has been undertaken. In all of the studied sections high variation in abundance of the ecomarker species *Guembelitra cretacea* has been observed, additionally, high participation of abnormal specimens has been noted in the upper part of the Upper Maastrichtian deposits.

Foraminiferal association from Podgórz and Chełm section suggest early Late Maastrichtian (*Gavelinella gankinoensis* Interval Subzone *sensu* Gawor-Biedowa, 1984; lowermost part of *Guembelitra cretacea* Range-Zone *sensu* Peryt, 1980) and indicate a comparable palaeodepth (except of deeper, lowermost part of Chełm section). Additionally, Machalski (2005) nominated both of sections to the *Spyridoceras tegulatus* – *Belemnella junior* Zone (*sensu* Hemmoor). Foraminiferal assemblages from Rejowiec Quarry section, Dańczypol section and Pielaki section suggest the latest Maastrichtian (*Bolivinoidea giganteus* Range Subzone *sensu* Gawor-Biedowa, 1984; upper part of *Guembelitra cretacea* Range-Zone *sensu* Peryt, 1980) and indicate a higher palaeodepth in the south-east part of the studied area. Based on macrofauna Machalski (2005) suggested a correlation of Rejowiec section with uppermost Maastrichtian *Belemnella kazimiroviensis* Zone. However all of the above zones proposed for area studied correspond to *Abathomphalus mayaroensis* Zone in the standard planktonic zonation and *Bolivinoidea draco draco* Zone in the standard benthic zonation.

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Microfauna changes around the Sarmatian/Pannonian boundary in the Transylvanian Basin

Sorin FILIPESCU¹, Angela MICLEA¹, and Arjan DE LEEUW²

¹ Babes-Bolyai University, Department of geology, Kogălniceanu 1, 400084, Cluj-Napoca, Romania; sorin@bioge.ubbcluj.ro

² Palaeomagnetic Laboratory "Fort Hoofddijk", Utrecht University, Budapestlaan 17, NL-3584 CD Utrecht, The Netherlands

Miocene deposits have been investigated at Oarba de Mures (Transylvanian Basin) in order to recognise of the Sarmatian–Pannonian boundary based on microfauna.

Previous studies dealt with sedimentology (Sztanó *et al.*, 2005), radiometric dating (Vasiliev *et al.*, 2006), and dinoflagellate biostratigraphy (Sütő & Szegő, 2008).

Detailed sampling allowed a good resolution on microfaunal changes across the uppermost Sarmatian and lowermost Pannonian. Most of the microfauna experienced contemporary transport and resedimentation in deep-sea fine turbidites. Even so, cyclicity in energy of the environment, levels of oxygenation and eutrophication have been observed.

Foraminiferal assemblages contain rotaliids (species of *Ammonia*, *Elphidium*, *Nonion*, *Porosonion*), miliolids (*Quinqueloculina*, *Varidentella*, *Articulina*, *Sarmatiella* etc.), occasionally *Bolivina* and rare planktonics. These occur together with facies- and age-diagnostic ostracods (*Aurila*, *Loxoconcha*, *Gomphocythere*, *Cyprideis* etc.), mysids (*Sarmysis* spp.), diatoms (*Coscinodiscus* spp.), dasyclads (*Halicoryne moreletti*), and fish (bones and teeth).

Foraminifera were useful to restore the genetic units resulting from relative sea-level fluctuations in the turbiditic system, based on the abundances of characteristic groups.

A very clear Sarmatian/Pannonian boundary has been observed based on microfauna. The foraminifera belonging to the uppermost Sarmatian *Porosonion aragviensis* Biozone were replaced at the boundary by typical Pannonian ostracod assemblages (species of *Typhlocypris*, *Lineocypris*, *Amplocypris*). A very particular assemblage with abundant miliolids suggest a possible correlation of the uppermost Sarmatian assemblage with their Eastern Paratethys Chersonian equivalents.

Even more, the preliminary data on magnetostratigraphy and volcanic ashes suggest a possibly younger age for the Sarmatian / Pannonian boundary than previously considered (around 11.2 Ma).

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**Characterisation of paralic palaeoenvironments using benthic foraminifera
and thecamoebians from early Cretaceous sediments
(Scotian Shelf, Atlantic Canada)**

Flavia FIORINI

The Petroleum Institute – Abu Dhabi – UAE; ffiorini@pi.ac.ae

The benthic foraminifera and thecamoebians from an early Cretaceous cored interval of Cohasset A-52 Well (located on the Scotian Shelf-North Atlantic) were used to interpret the depositional environments of these sediments.

Palaeoenvironmental interpretation was based on the analysis of samples from four cored intervals of the Well corresponding to 25 m of interbedded gray-black shale, mudstone and sandstone belonging to the Cree Member of the Logan Canyon Formation (Aptian–Albian).

The foraminiferal association recorded in the samples is comprised mainly of agglutinated specimens of *Trochammina*, *Haplophragmoides*, *Ammobaculites* and *Verneulinoides* and is comparable at the generic level with the microfauna that live in present marshes. A scattered occurrence of calcareous benthic foraminifera (typical of marginal marine environment) and thecamoebians specimens belonging to the genera *Cucurbitella*, *Diffugia* and *Heleopera* is also recorded.

The comparison of this microfauna with modern and fossil foraminiferal associations from paralic environment suggests that the studied sediments were deposited in a marsh-estuarine environment.



Agglutinated foraminifera as a tracer of water masses along an inner neritic to upper bathyal transect in the Marmara Sea

Fabrizio FRONTALINI¹, Michael A. KAMINSKI², Rodolfo COCCIONI¹, Carla BUCCI¹, and Ali AKSU³

¹ Dipartimento di Scienze dell'Uomo, della Natura e del Territorio, Sezione di Geobiologia, Laboratorio di Micropaleontologia Ambientale, Facoltà di Scienze e Tecnologie, Università degli Studi "Carlo Bo", Campus Scientifico Località 'Crocicchia' 61029, Urbino, Italy; fabrizio.frontalini@uniurb.it

² Department of Earth Sciences, University College London, Gower Street, London WC1E 6BT, UK

³ Department of Earth Sciences, Memorial University of Newfoundland, St. John's, NF, Canada A1B 3X5

The Marmara Sea is an intercontinental basin with two narrow and relatively shallow straits connecting the Mediterranean Sea with the Black Sea. The Marmara Sea is characterised by the outflow of brackish surface water from the Black Sea and saline bottom water inflow from the Mediterranean Sea. These oceanographic features determine the establishment of a sharp halocline which leads to a permanent stratification generating low-oxygen and stratified conditions below a thin, well-mixed and highly oxygenated surface layer. Previous studies have tried to recognize these water masses on the basis of calcareous benthic foraminifera. This study aims at documenting, for the first time, the agglutinated foraminifera along an inner neritic to upper bathyal transect in this basin. A total of fifty agglutinated species was identified belonging to thirty-five genera. Statistical analysis defines three main assemblages which can be related to the bathymetric depth and in turn to the hydrological features of the water masses. Accordingly, few species including *Discammina compressa*, *Lepthohalysis scottii*, *Miliammina fusca* and *Trochammina inflata* occur only in one sample at 15m water depth, whereas they became rare or absent in all other samples. On the other hands, many agglutinated species show an intermediate water-depth distribution, among them the most abundant are *Ammoscalaria pseudospiralis*, *Cribr stomoides jeffreysii*, *Eggerelloides scaber*, *Lagenammina fusiformis* and *Reophax scorpiurus*. Other species such as *Bigenerina nodosaria*, *Pseudoclavulina crustata*, *Siphonotextularia concava*, *Spirorutilus* sp., *S. sagittula*, *Textularia agglutinans*, *T. bocki*, *T. cushmani* and *T. pala* show a deeper bathymetric distribution. The shallowest assemblage is characterised by both the lowest diversity and highest dominance values. These faunal parameters can be a result of the strong influence exerted by the Black Sea outflow with its homogeneous, low salinity, and lower density waters which can be tolerated by only a limited number of species. High values of diversity have been identified at water depths shallower than 150 m. This increase has been associated with the inflow of Mediterranean counter-current bringing more oxygenated and saline waters. The diversity values of the deep assemblages show a complex pattern exhibiting a rapid increase and peaking at 225 m water depth. On the other hand, the lowest value, which also corresponds to the lowest value of dissolved oxygen, was found at 300 m water depth. A significant increase in diversity has been recognised from 300 m to 350 m water depth linked to a rise in dissolved oxygen probably due to a seasonal Mediterranean bottom water undercurrent.

This study confirms that the complex interplay of water masses in the Marmara Sea affects the assemblage structure of agglutinated foraminifera, thereby raising the possibility that they may serve as tracers of water masses.



Calcareous nannoplankton from the Podhale Flysch (Inner Carpathians, Poland)

Małgorzata GARECKA

Polish Geological Institute, Carpathian Branch, Skrzatów 1, 31-560 Kraków, Poland; malgorzata.garecka@pgi.gov.pl

Although many micropalaeontological studies were carried out in the Podhale flysch the age of these sediments is not precisely defined. The individual groups of microfossils gave often unequivocal results, especially in the case of calcareous nannoplankton. The aim of this paper is to explain the differences between the ages of the Podhale flysch sediments based on calcareous nannoplankton, correlate with other groups of microfossils (dinocysts and small foraminifera) and to devise a biostratigraphic scheme of the Podhale flysch deposits based on the coccolithes. Szaflary beds, Zakopane beds, Chochółów beds and Ostrysz beds were sampled. The samples were taken from the outcrops and drillings during field studies. In the Podhale flysch deposits three calcareous nannoplankton zones were distinguished (based on the scheme by Martini, 1971): NP24, NP25, NN1 (Upper Rupelian–Lower Aquitanian). The upper part of the Szaflary beds, Zakopane beds and the lower part of Chochółów beds belong to the NP24 Zone based on the occurrence of *Helicosphaera recta* Haq, *Cyclicargolithus abisectus* (Müller) Wise, *Sphenolithus distentus* (Martini) Bramlette & Wilcoxon, *Reticulofenestra ornata* Müller, *Reticulofenestra lockeri* Müller in the assemblage. The upper part of the Chochółów beds (and Brzegi beds) belong to the NP25 Zone based on the presence of *Sphenolithus conicus* Bukry and other NP24 Zone taxa. The assemblage from Ostrysz beds is characteristic of the NN1 Zone. This is based on the presence of *Helicosphaera scissura* Miller and *Sphenolithus delphix* Bukry. Up to the present the age of the Ostrysz beds was determined as late Oligocene (but not the latest) based on dinocysts assemblages. The Biely Potok Formation in the Slovakian Inner West Carpathians (= Ostrysz beds) belongs to the Lower Miocene (NN1) too. The state of preservation of the calcareous nannoplankton from the Podhale flysch is generally poor. In the studied samples the long-ranging, recycling and damaged (mechanical deformation, calcitization, corrosion) specimens are observed. The autochthonous taxa occurred sporadically. In the studied samples Prinsiaaceae, Coccolithaceae, Pontosphaeraceae, Braarudosphaeraceae families are dominated. Olszewska paid attention to similarity between small foraminifera assemblages from the Podhale flysch Basin and Menilitic-Krosno beds (Polish Outer Carpathians) and Central Carpathian Palaeogene Basin in Slovakia. Dinocyst studies confirmed partly these suggestions. Calcareous nannoplankton assemblages from the Podhale flysch Basin refer to assemblages from Menilitic-Krosno beds but the latter are more impoverished.



Biostratigraphy of the Upper Cretaceous sediments of the Ksani River gorges (Georgia) by microforaminifers and calcareous nannoplankton

Tamara GAVTADZE¹, Khatuna MIKADZE² and Zviadi CHKHAIDZE¹

¹ LEPL Alexandre Janelidze Institute of Geology, M. Alexidze 1/9, Tbilisi 0171, Georgia; tamaragavtadze@yahoo.com

² Georgian National Museum, Institute of Paleobiology, Niagvris 4, Tbilisi 0108, Georgia; xatmi@mail.ru

Outcrops of Meso-Cainozoic sediments of the Ksani River are confined to the Zhinvali-Gombori allochthonous zone. According to the unified scheme accepted for this region (Gambashidze, 1979), within this facies type the following suites are distinguished: Ukughmarti (K_{1al}-K_{2cm1}), Ananuri (K_{2cm2}-t₁), Margalitisklde (K_{2t1}-cn), Eshmakiskhevi (K_{2st}), Jorchi (K_{2cp}) and Sabue (K_{2m}) suites. The study of the calcareous nannoplankton and microfauna from the sections enabled accurate dating and their detailed subdivision. Such studies are carried out for the first time.

In the Ukughmarti suite is established the zone *Eiffellithus turriseiffelli* (CC9) dated as Early Cenomanian and Early Turonian. The Ananuri suite corresponds to the upper part of the zone CC9 and to the zones *Microrhabdulus decoratus* (CC10), *Quadrum gartneri* (CC11) and is dated as the Late Cenomanian and Early Turonian. The planktonic foraminifers have been found only in the upper sediments of the Ananuri suite and they indicate the *Whiteinella archaeocretacea* Zone. Besides the index-species *Whiteinella brittonensis* (Loeblich & Tappan), *Dicarinella imbricata* (Mornod) are also found.

The Margalitisklde suite by its nannoplankton corresponds to the zones *Lucianorhabdus maleformis* (CC12) and *Marthasterites furcatus* (CC13). In the sediments of the *Lucianorhabdus maleformis* (CC12) zone by foraminifers was established an assemblage with *Marginotruncana pseudo-linneiana*-*M. lapparenti*. Within the limits of the zone *Marthasterites furcatus* (CC13) by foraminifers is identified the *Dicarinella concavata* zone. Both groups of organisms date the Margalitisklde suite as the Late Turonian–Early Coniacian. The Eshmakiskhevi suite is represented by the following zones: *Micula decussata* (CC14), *Reinhardtites anthophorus* (CC15), *Lucianorhabdus cayeuxii* (CC16), *Calculites obscurus* (CC17) and *Broinsonia parca parca* (CC18); they cover the Late Coniacian–Early Campanian time interval. In the same sediments the Santonian–Early Campanian foraminiferal zones are distinguished; they are: *Archaeoglobigerina bosquensis*, *Contusotruncana fornicata* and *Globotruncana arca*. In the Ksani River valley, the Jorchi suite starts with the zone *Uniplanarius trifidus* (CC22), by foraminifers corresponding to the zones *Globotruncana ventricosa* and *Rugoglobigerina rugosa* and is dated as Late Campanian. In the Ksani River valley the Sabue suite according to nannoplankton is represented by the Late Maastrichtian zone *Micula murus* (CC25c–CC26a), and by the foraminifer species – *Gansserina gansseri*.



Foraminifera from the Eocene La Meseta Formation of Seymour Island (Antarctica)

Andrzej GAŹDZICKI and Wojciech MAJEWSKI

*Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; gazdzick@twarda.pan.pl;
wmaj@twarda.pan.pl*

The La Meseta Formation exposed in the northeastern part of Seymour Island (Antarctic Peninsula) is a sequence of richly fossiliferous, shallow-marine, deltaic and/or estuarine, poorly consolidated sandstones and siltstones. It is approximately 700 m thick, and preserves an exceptional record of Eocene life (Feldmann & Woodburne, 1988). Throughout the formation, rich and diverse microfossils, invertebrates, vertebrates, and plants occur in a number of fossiliferous horizons (Gaździcki, 1996, 2001; Francis *et al.*, 2006). The results of geochemical analyses of fossil shell material from the La Meseta Fm suggest a climatic cooling event during the time of deposition of the uppermost part of the formation (Gaździcki *et al.* 1992; Ivany *et al.*, 2008). This cooling event may be correlated with the late Eocene continental glaciation in West Antarctica (see Birkenmajer *et al.*, 2005).

Among microfossils, foraminifera are very rare in the La Meseta Formation. So far, only a few specimens of *Cibicides* encrusting brachiopod shells have been found (Bitner, 1996) in Telm2 (= Acantilados Allomember *sensu* Marenssi, 2006). Recently, we have found two distinctive foraminiferal assemblages at two locations (ZPAL 2 and ZPAL 5 of Gaździcki, 2001) in the lowermost part of the Acantilados Allomember. The basal facies of this unit exposed southwest of Cross Valley along López de Bertodano Bay, which contains studied benthic foraminifera is characterised by 2 m of gray to red-brown limonitic, glauconitic, sandy siltstones and pebble conglomerates, which developed as a result of accumulation on an erosional surface that was flooded during an early Eocene transgressive cycle.

The benthic foraminifera are represented by *Nonionella*, *Globocassidulina*, *Epistominella*, *Gyroldina*, *Bulimina*, *Cibicides*, *Portatrochammina* in assemblage ZPAL 2, and *Elphidium*, *Guttulina*, *Cibicides*, *Globocassidulina*, *Epistominella*, *Nonion*, *Astrononion*, *Planularia* in assemblage ZPAL 5. Both recognised foraminiferal assemblages include almost exclusively hyaline taxa that are characteristic for inner shelf, marine lagoons, and estuarine temperate environments. Numerous *Elphidium* and *Cibicides* found in the ZPAL 5 assemblage suggest shallower and more turbid water conditions than for the ZPAL 2.

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Miocene deposits of Kamienica Nawojowska (Outer Carpathians, Nowy Sącz Basin, Poland) in the light of ecostratigraphy

Małgorzata GONERA

*Institute of Nature Conservation, Polish Academy of Sciences, Mickiewicza 33, 31-120 Krakow, Poland;
gonera@iop.krakow.pl*

The Nowy Sącz Basin is the molasse of the Outer Carpathians, discovered by Uhlig (1888). Only in the vicinity of Niskowa these Neogene deposits had been cropping out – and studied exhaustively in the 20th century. A new outcrop of marine deposits of the Nowy Sącz Basin became exposed due to flood erosion in the Kamienica Nawojowska River (Gonera & Styczyński, 2002).

Foraminifera from these fossil-bearing mudstones were examined using standard micropalaeontological techniques. Planktonic specimens are extremely rare, scarce and very poorly preserved, so have not been used as biostratigraphic indices. Quantitative analysis was therefore performed on benthic specimens (Gonera, in prep.). The data were used for palaeoenvironmental reconstruction and age determination via the climate-related ecostratigraphy of the Paratethys.

The foraminifera of the Kamienica Nawojowska indicate an environment of normal saline waters of the inner shelf and a temperature not lower than 18°C. The area was ideal for the proliferation of epifauna: 89.7% of the foraminiferal assemblage is composed of *Miliolina* spp., *Elphidium crispum*, *Ammonia beccarii*, and *Pararotalia aculeata*. The habitat below the sediment surface had not been colonised by foraminifera, presumably because there was not an adequate food/oxygen balance. The equitability index of the assemblage reflects a compromise between an r- and a K-mode strategy, a pattern of life typical of environments with poor and unstable resources.

The age of the Nowy Sącz Basin deposits have been considered many times since Uhlig's (1888) work. The estimations had been performed on various fossils (molluscs, pollen, macroscopic plant remains, foraminifera, otoliths). The stratigraphy and age of the deposits is still being debated, and individual authors have not reached consistent conclusions.

As already mentioned, standard biostratigraphy cannot be applied to the studied Kamienica Nawojowska deposits, so climate changes of the Paratethys have been used.

Palaeotemperature – a key indicator of climate – can be estimated by the study of assemblages of foraminifera. *Borelis melo* – one of the warm-water benthic foraminiferal taxa is common in the studied deposits.

It is worth to note that in the Badenian stratotype (Baden-Sooss, Austria) none of the warm-water taxa of foraminifera are present later than the N9 Zone. It is one line of evidence for the climate deterioration represented in the upper part of the Badenian. On the basis of this climate-related feature of the assemblage, the age of the Kamienica Nawojowska assemblage can be classified as Early Badenian (equivalent to the *Orbulina suturalis* Zone).

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Kimmeridgian protoglobigerinids (Foraminifera) from Crussol (SE France)

Ágnes GÖRÖG¹ and Roland WERNLI²

¹ Department of Palaeontology, Eötvös University, Pázmány Péter sétány 1/C, Budapest, Hungary, H-1117;
gorog@ludens.elte.hu

² Université de Genève, Département de Géologie et Paléontologie, 13 rue des Maraîchers, CH-1211, Genève 4, Suisse;
Roland.Wernli@unige.ch

A detailed investigation of the protoglobigerinids from the Kimmeridgian section of Montagne de Crussol, near Valence, Rhone valley, in SE France was carried out. This monotonous succession of predominantly hemipelagic, micritic limestones well dated by ammonites has been analysed in detail by means of numerous rock thin sections, acetolysis extractions and standard washings. The relatively well preserved associations of the isolated protoglobigerinids comprise three species: *Globuligerina bathoniana*, *Favusella hoterivica* and *F. parva*. The smallest form *F. parva* (based on surface ornamentation it was referred to genus *Favusella*) is the most common species distributed in almost all the section from the *Orthosphinctes* to the *Beckeri* Zones. *Globuligerina hoterivica* has been retrieved less frequently from *Platynota* to *Beckeri* Zones, while the rarer *Globuligerina bathoniana* occurs only in the Late Kimmeridgian. Similar faunas have been recognised in the rock thin sections.

The exhaustive compilation of the literature reveals that the records of the Kimmeridgian protoglobigerinids are rare and generally of bad quality.

The associations from Crussol essentially differ from that of the other faunas by the absence of *Globuligerina oxfordiana* and the presence of *Favusella hoterivica* this last species showing its oldest occurrence at Crussol. Additionally we can emend the previous knowledge about the Kimmeridgian protoglobigerinids:

- in the early Kimmeridgian, besides *F. parva* and *G. bathoniana*, *F. hoterivica*, *G. oxfordiana* and *C. stellapolaris* also exist,
- we could point out *F. parva* and *F. hoterivica* from the late Kimmeridgian.

Based on our study and the compilation of the literature a palaeogeographical map was plotted, which shows that the majority of the occurrences come from the northern margin and central part of the Tethys besides some from the North Atlantic.

Accordingly, the Crussol's collectings add a very important contribution to the knowledge of the Kimmeridgian protoglobigerinids and fill an important gap in the stratigraphic distribution and the evolution of these foraminifers in the Late Jurassic.



**Recovery of benthic foraminifera after the eruption
of the Soufrière Hills Volcano (Montserrat, Lesser Antilles),
May 20th 2006 and other recent volcanic activity**

Malcolm B. HART, Jodie K. FISHER, Christopher W. SMART, Debbie WALL-PALMER,
Nathan WEEKES and Hayley ALLEN

*School of Earth, Ocean & Environmental Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK;
m.hart@plymouth.ac.uk*

Since the beginning of 2004, the University of Plymouth has been working in collaboration with the University of Bristol, University of Paris and the National Oceanographic Centre (University of Southampton) on a major project in the Caribbean Sea. In 1995 the Soufrière Hills volcano (part of the Lesser Antilles Volcanic Arc) began erupting and this activity has continued to the present day. Our involvement was specifically:

- to document the microfossils in a number of marine borehole collected in the area;
- to establish a stable isotope stratigraphy for the cores;
- to provide AMS radiocarbon dates for selected horizons; and
- to date the volcanic deposits present in the cores with a view to generating a tephrochronology of the volcanic activity.

Using cores collected during the cruise of the RV. *L'Atalante* in 2002 the tephrochronology back to 260,000 years b.p. has been established (Le Friant *et al.*, 2008). The cores collected by the RRS *James Clark Ross* (May, 2005) have been used to document the fate of pyroclastic flows entering the ocean and the presence of major carbonate turbidite flows in the marine areas adjacent to carbonate platforms. Throughout these investigations the benthic foraminifera have been documented and compared to the faunal changes in the South China Sea near Mt Pinatubo.

In December 2007 another cruise to the Montserrat area, on the RRS *James Cook* provided the opportunity to collect further samples from the Caribbean Sea that had been affected by the major eruption of the Soufrière Hills volcano on the 20th May 2006. Samples were collected, fixed in buffered formalin, washed and stained in Rose Bengal on board the RRS *James Cook* with a view to investigating both the impact of this major eruption on the planktic and benthic foraminifera and the level of recovery by the benthic foraminifera only 18 months after the eruption.

Work is still in progress but we have a number of interesting findings to date:

- To the west of Montserrat, where the 20th May eruption produced a major ash-fall (9–10 cm thick), there appears to be a significant “kill layer” of foraminifera and pteropods below the ash layer; the aragonite shells of the pteropods in this “kill layer” are badly etched, perhaps reflecting the acidification of the ocean as the ash fell through the water column; and
- There are living specimens of *Reophax* within the upper layers of the ash from the eruption of the 20th May 2006, and this would suggest recolonisation within 18 months. The mechanisms for this recolonisation are not known. These individuals are accompanied by living specimens of *Bulimina* spp., some of which are “at depth” within the sediment.

To the south-east of Montserrat, there are two extinct submarine volcanic centres that are now cloaked with hemipelagic sediment. Core JR123-11V, collected in 2005, recorded the presence of benthic foraminifera within the ash-rich sediments in the very crater of one of the volcanic centres. As the water depth in the crater is ~750 m (though it may have been less in the Last Glacial Maximum) and the surrounding water depths are in excess of 1–2 km, the mechanism by which these foraminifera migrated into the crater is unknown.

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The early evolution of the planktic foraminifera and the significance of the evidence from Poland

Malcolm B. HART, Wendy HUDSON and Christopher W. SMART

*School of Earth, Ocean & Environmental Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK;
m.hart@plymouth.ac.uk*

In the 1960s and 1970s Oberhauser and Fuchs (both of the Austrian Geological Survey) described a number of new species and genera of Triassic age that were thought to be the earliest planktic foraminifera. Between 2006 and 2008 the authors have systematically re-evaluated the holotypes, paratypes and other samples in the Geologische Bundesanstalt in Vienna, including photography using an environmental SEM.

The Triassic material of Oberhauser and Fuchs is now regarded as being representative of benthic taxa, although we now record the lineage through *Oberhauserella* and *Praegubkinella* as the pathway to the first planktic genus, *Conoglobigerina*. The *Praegubkinella*–*Conoglobigerina* transition appears to be associated with the Early Toarcian “anoxic event” and the extinctions at that time. This has been described from a succession in Switzerland by Wernli (1995). By Bajocian times the *Conoglobigerina* fauna had diversified and migrated over much of Alpine Europe, with some assemblages forming foraminiferal packstones reminiscent of modern “Foraminiferal Ooze”.

Many taxonomic problems remain, especially the relationship between *Conoglobigerina* and *Globuligerina*. The other key issue is the relationship between “*oxfordiana*” (Grigelis, 1958) and “*bathoniana*” (Pazdrowa, 1969). Understanding the Jurassic faunas from Southern Poland is key to the present taxonomic problems and the early evolution of the planktic foraminifera. The fact that these faunas also evolved in an aragonitic ocean is also significant to our understanding of the development of the Jurassic ocean system.

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The Foraminifera.eu Internet Project

Michael HESEMANN

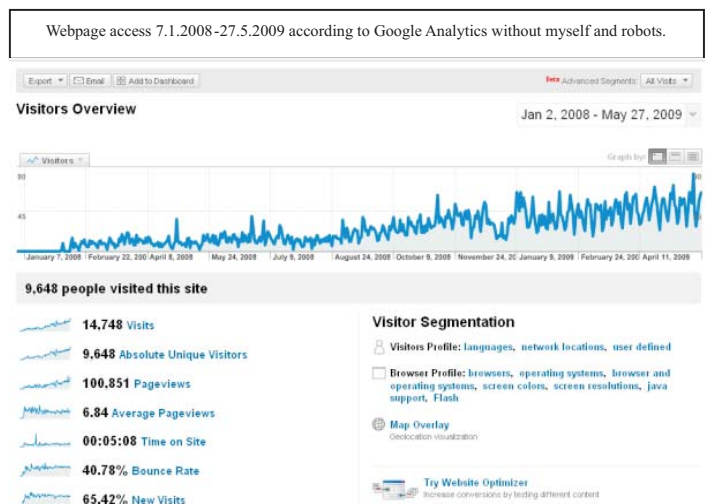
Waterloostr. 24, D-22763 Hamburg, Germany

Foraminifera are little-known to a broader public though forming a considerable part of Earth's biomass and being of substantial economical use as an indicator in the oil industry and for environmental politics. The project www.foraminifera.eu wishes to foster interest in foraminifera by linking scientists with hobby-naturalists through a free accessible online-database of images. Its history, mission and an outlook will be presented.

History and background. The project started with the idea to show my collection of foraminifera to friends and family with the first release of 7 images on the 22nd of December 2007. My small collection has been built up at an evening course on micropalaeontology. As a hobby-photographer, I favoured to take images rather than producing slides. In 2008, I joined the local "Mikropaläontologische Arbeitsgruppe" of the "Mikrobiologische Vereinigung Hamburg" (www.mikrohamburg.de/HomePalaeo.html), a group of enthusiastic pensioners dealing with foraminifera since 30+ years and with an outstanding technical experience (e.g. having repaired and running a SEM, production of plummer-cells with up to 3000 specimen neatly lined up). This group inspired and helped me to enlarge the collection, and within half a year 150 images went online. I added a database to better access and handle the images and improved my own work-flow by e.g. automatising photoshop procedures. I joined the German online community of fossil-hunters www.steinkern.de and offered to take images in return for sent-in samples. The reaction was overwhelming, several samples and images arrived. With rising popularity the web-page began to generate own contributors, such as Dr. Frontalini, the first scientist providing SEM images. At the end of 2008 more than 700 images were online and a group of 50+ contributors had been established and it was time to rethink the whole project.

New Mission. The progress of the webpage with more than 100.000 page-views motivates me and the contributors. Instead of working for the own cupboard, local clubs or hobby-magazines the project opened the opportunity to help others worldwide by providing images for a thesis, book, article, exchanging samples, organizing a field-trip or simply discuss an issue. So the idea arose to focus more on aspects of community and motivation. At the 2nd International Course on Benthic Foraminifera in Urbino April 2009 I was able to discuss the new mission with students and professional foraminiferologists. The new mission is to foster the interest in foraminifera by linking scientists with hobby-naturalists through a free accessible online-database of images and additional features. Operational single steps will be:

- to attract scientists by improving the quality of taxonomy, by enlarging the database-features, and simply by adding more images and show that other scientists contribute.
- to attract non-scientists by adding specific content/offers for each key-group: dedicated forum-collectors with outstanding collections and experience by personalised pages, non-commercial fossil hunters, teachers and undergraduate students, hobby-microbiologists by processing their samples and providing additional help, single editors and small publishing



houses, graduate students and scientists of other areas by providing images, and people interested in Bio-Art. Presence in and contributions to different online-communities is essential. I started with mini-lectures and will add a taxonomical, morphological guide run through a database-query. The processing of sent in samples in exchange for images will be still the backbone, as only interested people have samples.

Outlook. As hundreds of images, tens of samples and several projects are waiting to be dealt with, a major challenge will be the organization without losing control and wasting time with coordination. I plan to go on with my way of project-orientated delegation within the overall frame set and webpage programming done solely by me.

The project has not attracted a big mass of people as the internet-statistics might indicate. Only 1.2% of the 10 000 visitors have contacted me. From whole of Asia it has been just one person from Iran, in contrast to 2000+ visitors. Nonetheless about 55 people are continuously contributing now, which indicates they are seriously studying foraminifera and want to share their enthusiasm. They may be seen as “lighthouses in a world of ignorance” and the emphasis will be to help these dedicated people with their projects.



Palaeoenvironment of the Early Badenian (Middle Miocene) in the southern Vienna Basin (Austria)

Johann HOHENEGGER¹, Nils ANDERSEN², Katalin BÁLDI¹, Stjepan ĆORIĆ³,
Peter PERVESLER¹, Christian RUPP³ and Michael WAGREICH⁴

¹ Department of Palaeontology, University of Vienna, A-1090 Wien, Austria; johann.hohenegger@univie.ac.at

² Leibniz Laboratory for Radiometric Dating and Stable Isotope Research, Christian-Albrechts-University, D-24118 Kiel, Germany

³ Geological Survey of Austria, A-1030 Wien, Austria

⁴ Department of Geodynamics and Sedimentology, University of Vienna, A-1090 Wien, Austria

Multivariate latent structure methods were used to determine environmental factors that influenced the distribution of magnetic susceptibility, calcium carbonate, organic carbon, stable oxygen and carbon isotopes, ichnofossils, calcareous nannoplankton and benthic as well as planktonic foraminifera in the 102 m long section of late Early Badenian age (Middle Miocene, Upper Lagenid Zone) cored at Baden-Sooss for scientific investigations. Five factors “temperature”, “eutrophication”, “water stratification”, “oxygen-rich particulate organic material” and “surface productivity” controlled the variables to different degrees. The tectonically unaffected deeper part of the section started with a short warm period possibly characterising environmental conditions of the preceding Lower Lagenid Zone. A long “warm” period followed the first temperature decline. Increased terrestrial input caused by intensified weathering through seasonal changes characterised warm periods. The subsequent long “colder” period is distinguished by increased oxygen depletion, mixed water masses and dysoxic bottom conditions that favour carbonate and organic carbon production as well as infaunal foraminifera. The following “warm” period with decreasing oxygen depletion appears abruptly in the sedimentary record through tectonic deformation. In the following period, “colder” water conditions dominated interrupted by short warmer intervals, finally tending to warmer water at the top of the cored interval. Although intermediate temperatures prevailed in the youngest period, oxygen depletion remained relatively high after reaching a maximum in the previous period. This increase in oxygen depletion toward the top of the section is reflected in rising $\delta^{13}\text{C}$ isotope values together with decreasing temperatures, thus following – just after the Miocene “Monterey” excursion – the slight global cooling trend between -14.7 and -13.9 myr preceding the main Middle Miocene cooling period.



Nomenclature to describe the transition from biserial to uniserial chamber arrangement in agglutinated foraminifera

Michael A. KAMINSKI¹, Claudia G. CETEAN² and Jaroslaw TYSZKA²

¹ Department of Earth Sciences, University College London, WC1E 6BT London, UK; m.kaminski@ucl.ac.uk

² Polish Academy of Sciences, Institute of Geological Sciences, Cracow Research Centre, Senacka 1, 31-002, Kraków, Poland

We define terms used to describe the transition from biserial coiling to uniserial in benthic foraminifera. The morphological transition from biserial to uniserial chamber arrangement may be abrupt, or form a morphological progression from biserial through transitional stages defined as “loosely biserial”, “lax-uniserial”, and finally “loosely uniserial”. The precise meanings of the intermediate stages are here defined by means of examples.

The transition from biserial to uniserial coiling is seldom abrupt or straightforward among agglutinated foraminifera, but is often characterised by intermediate stages. In the literature a number of loosely-defined terms can be found to describe the transition, such as “loosely biserial”, “a tendency to become uniserial”, or “irregularly uniserial”. However, these terms themselves are not used consistently, and are not found defined in the Hottinger’s popular glossary of terms used in foraminiferal research.

As part of an effort to revise and update the descriptions the agglutinated foraminiferal genera, we believe it is useful to precisely define the terms used to describe the transitional or intermediate stages between biserial and uniserial coiling, as so many of the agglutinated genera exhibit such behaviour. As Hottinger (2006) states in the introduction to his glossary: “The alternating arrangement of the shell cavities is a very fundamental and widespread pattern of the foraminiferal architecture”. Therefore, the purpose of this paper is to properly define these morphological terms to ensure that their use is consistent and well-understood by foraminiferal researchers.

Terms used to denote the transition from biserial to uniserial coiling

Biserial – trochospiral chamber arrangement with about 180° between consecutive chambers, thus producing two rows of chambers (Hottinger, 2006). In true biserial forms the chambers comprising the each row share a common suture between them.

Loosely biserial – chambers are arranged in two alternating rows, but the chambers within a row barely make contact with one other. In lateral view, the sutures separating the terminal chambers extend obliquely from one side of the test to the other.

Lax-uniserial – chamber arrangement is truly intermediate between biserial and uniserial, such that the ultimate chamber is only in contact with the penultimate chamber. The chambers are cuneate and alternate in position, and the sutures between chambers are oblique. The centre points of the chambers still preserve a biserial arrangement. The term was introduced by Neagu & Neagu (1995) to describe the genera *Hagimashella* and *Bicazammia*. Loeblich & Tappan (1987) described this type of coiling as “alternating in a loose biserial” in the case of *Haeuslerella*.

Alternating uniserial – the axis of growth has a zigzag form, but each segment (or rectilinear portion) of the zigzag consists of more than two chambers. Where the growth axis shifts direction, chambers are cuneate and sutures are oblique. In the rectilinear segments, sutures are orthogonal to the growth axis. This term was introduced by Labaj *et al.* (2003) to describe this shape based on models of foraminiferal architecture. This alternating uniserial architecture is observed in the species *Ammobaculites pauperculus* Zheng, 2001, which was described as “curved and twisted” in the rectilinear portion (Zheng & Fu, 2001). In this species each segment of the zigzag consists of 3–4 chambers.

Loosely uniserial – chambers are arranged in a single row along a straight or slightly meandering axis, but sutures between chambers are not necessarily orthogonal to the growth axis. In loosely uniserial forms, chambers are more chaotic and irregular, as in the genus *Subreophax*.

Uniserial – chambers arranged in a single row (Hottinger, 2006). The axis of growth is rectilinear and sutures between chambers are horizontal or orthogonal to the growth axis.

Pseudouniserial – chambers are externally arranged in a single row and sutures between chambers are horizontal or subhorizontal. Loeblich & Tappan (1985) used the term to describe their genus

Gyrovalvulina, which has chambers terminally arranged in a loose spiral. Chambers gradually become broader and fewer per whorl, until each chamber extends more than half the distance around the test but is not completely uniserial. The spiralling nature of the terminal chamber is illustrated by alternating position of the apertural tooth, which projects obliquely within the chamber cavity. Pseudo-uniserial coiling may be further characterised as cryptobiserial, cryptotriserial, etc. depending upon the angle successive chambers make with respect to previous chambers.

Cryptobiserial (new term) – chambers are externally arranged in a single row and sutures between chambers are horizontal, but the internal structure of the test reveals that coiling still exists, for example the position of aperture or internal connections alternates between chambers. Chambers within the uniserial part typically rotate with respect to one another. This feature was first pointed out by Geroch (1961) with respect to his genus *Pseudoreophax*. Loeblich & Tappan (1987) used the term “pseudobiserial” to describe this mode of coiling, though we prefer the term “cryptobiserial”, noting that the spiraling nature can only be determined by observing the internal structure of the test.

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Holocene ostracods of the Caucasian Black Sea shelf

Maria KARPUK¹ and Ekaterina TESAKOVA²

Department of Paleontology, Geological Faculty, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia;

¹maria.k.mix@gmail.com; ²ostracon@rambler.ru

Sixty eight samples from the boreholes cores Ak-497 and Ak-2571 drilled off the Caucasian shore of the Black Sea shelf during 25th and 28th cruises of the research vessel «Akvanavt» (Institute of Oceanology) were studied. Twenty three species (16 genera) of ostracods were identified and assigned to three groups in relation to salinity: holeuryhaline (1–26‰), stricteuryhaline (11–26‰), and polyhaline (18–26‰). The distribution of the defined ostracod groups in the section indicated changes in salinity and transgressive-regressive cycles. These data are in good agreement with data on mollusks. In some cases, it was possible to specify the eustatic curve inferred from molluscan data. For example, ostracod data suggested a more extensive Pontian regression than the Kolkhidian and Khadjibeian ones. At the same time, the Khadjibeian regression appears to be the largest in the entire Holocene as indicated by mollusks. Furthermore, ostracod data point to a small scale transgression during middle–upper Djemetian regression and a small regression during the upper Djemetian transgression detected by ostracods. Moreover, the Phanagorean regression in the core Ak-497 is detected by ostracods stratigraphically lower in the section as compared to mollusks.

Twenty seven assemblages (with subdivisions) have been defined based on the distribution of ostracods in the studied cores. Assemblages in the core Ak-497 were recognised based on changes of dominant species. The combination of dominance changes and features of taxonomic composition were used for definition of assemblages in the core Ak-2571. The found assemblages are controlled by salinity.

The ostracod sequences of the two studied cores show similarity in appearance-disappearance patterns. In addition, data from the core Ak-522 was used for comparison.

The following strata have been defined in the core Ak-2571 (from top to bottom): 1) layers with *Bythoceratina* with upper (*Bythoceratina*-1) and lower (*Bythoceratina*-2) sublayers. The sublayer with *Bythoceratina*-1 is recognised by the presence of *Xestoleberis*; the sublayer with *Bythoceratina*-2, by its absence. Layers with *Xestoleberis* are identified by the re-occurrence of *Xestoleberis*. The boundary between these and the overlaying layers is drawn based on the disappearance of *Bythoceratina* and re-occurrence of *Xestoleberis*. 2) layers with *Palmoconcha*. The upper boundary is defined by the disappearance of *Xestoleberis* and the appearance of *Palmoconcha*. The lower boundary of the layers with *Palmoconcha* is unknown.

The core Ak-522 shows an identical sequence. Layers with *Bythoceratina* with *Bythoceratina*-1 and *Bythoceratina*-2 sublayers are recognised here by the same indicators as in the core Ak-2571. Layers with *Xestoleberis* are defined in the lower part of the section. This core is subdivided in ostracod layers for the first time.

The core Ak-497 has the following sequence of ostracod layers (from top to bottom): 1) layers with *Cytheridea* with sublayers with *Cytheridea*-1 by the presence of *Xestoleberis*, and sublayers with *Cytheridea*-2 by the disappearance of *Xestoleberis*. 2) layers with *Leptocythere ramosa* are recognised based on the presence of *L. ramosa*. 3) layers with *Xestoleberis* are identified by re-occurrence of *Xestoleberis* and disappearance of *L. ramosa*.

Middle Miocene oxygen minimum zone expansion offshore West Africa: evidence for global cooling precursor events

Severyn KENDER¹, Michael A. KAMINSKI², Victoria L. PECK³ and Robert W. JONES⁴

¹ British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK; sesev@bgs.ac.uk

² University College London, Gower Street, London, WC1E 6BT, UK

³ British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, UK

⁴ BP, Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UK

Three dissolution events ca. 16 Ma, 15.5 Ma, and 14.3 Ma ago have been identified in sediments from the Congo Fan. Multiproxy benthic foraminiferal and sedimentary records suggest an expanded oxygen minimum zone consistent with enhanced upwelling at these times. Low oxygen species *Bulimina elongata*, *Brizalina alazanensis*, *Bulimina marginata* and *Valvulineria pseudotumeyensis* begin to dominate from ca. 16 Ma, replacing more oxic indicators such as *Oridorsalis umbonatus* and *Cibicidoides crebbsi*. The low oxygen faunas show reduced diversity and exhibit erratic abundance values from 100 to 2000 specimens per g. of sediment. Agglutinated foraminifera *Glomospira* spp. are also associated with these low oxygen faunas. Benthic isotope records from *Cibicidoides* spp. show shifts similar to those of the global composite, with marked bottom water cooling from ca. 16 Ma. Total organic carbon values show a general increase over the low oxygen intervals. Marine carbonate records from adjacent North Africa indicate coincident episodes of increased continental weathering (John *et al.*, 2003), suggesting that an intermittently stronger polar front strengthened west African offshore winds, increasing surface water productivity, and enhanced North African weathering during these events. We propose that Columbia River Flood Basalt volcanism, estimated to have released 10⁶ Tg CO₂ and 10⁶ Tg SO₂ between 16 and 15.6 Ma ago, may have influenced these climatic changes.

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Cretaceous–Tertiary boundary transect from shallow shelf to continental slope in the Eastern Black Sea region: foraminiferal assemblages and lithofacies

Ludmila F. KOPAEVICH¹, Vladimir N. BENYAMOVSKIY², Aleksandr S. ALEKSEEV³ and Elena V. YAKOVISHINA¹

¹ Department of Historical and Regional Geology, Geological Faculty, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia

² Geological Institute, Russian Academy of Sciences, Moscow, Russia; ben36@mail.ru

³ Department of Palaeontology, Geological Faculty, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia

We present information on the foraminiferal assemblages and lithofacies in two studied sections in the Crimea.

Belbek section. Southwestern Crimea, 44°39' N, 33°49' E. Kacha tectonic uplift. The terminal Maastrichtian sandy marls (hard and soft) and sandstones contain abundant belemnite rostra of *Neo-belemnella kazimiroviensis* and a poor planktonic foraminiferal assemblage of *Heterohelix globulosa*, *Rugoglobigerina* aff. *rugosa* and *Globotruncana* sp. The benthic foraminiferal assemblage of *Falsoplanulina mariae* (= *F. ekblovi*) Zone LC23 of the Upper Maastrichtian of the epicontinental East European Province of the North European Realm (Benyamovskiy, 2008) includes Late Maastrichtian comparatively shallow-water widespread European carbonate platform taxa: *Gaudryina pyramidata*, *Cibicidoides spiropunctatus*, *C. bembix*, *Gavelinella midwayensis*, *Brotzenella praeacuta*, *Falsoplanulina mariae*, large lenticulinids and nodosariids. The carbonate with glauconite sandstone and bryozoic limestone above the last belemnite do not contain planktonic foraminifera. In its benthic assemblage shallow-water taxa *Gavelinella danica*, *Cibicidoides succedens*, *Gyroidinoides octocamerata*, *Osangularia lens*, *Brotzenella* aff. *acuta*, *Anomalinoidea danicus*, *A. burlingtonensis*, *A. nobilis*, *Ataxophragmium frankei* allow us to date this unit as Danian (Maslakova & Nguyen Van Ngoc, 1975).

Klementiva Mountain section. Eastern Crimea, 44°58' N, 35°15' E. Indol-Kuban tectonic deep flexure. Here, a thick (50 m) sequence of dark gray siltic marls overlies Middle Albian clays with an unconformity in the south slope of this mountain. The second unit (15 m) is alternation of siltic marls and fine-grained calcareous glauconitic sandstones. A thick sandstone bed (2–5 m) is in the top of section. The first unit has a typical oceanic Tethyan Upper Maastrichtian planktonic foraminiferal assemblage consisting of *Abathomphalus mayaroensis* Zone with a dominance of different heterohelids: *Heterolepa globosa*, *H. navarroensis*, *H. pseudotessera*, *H. pulchra*, *H. striata*, *Pseudoguembelina punctulata*, *Pseudotextularia deformis*, *P. elegans*, *Recemiguembelina intermedia*, *R. fructicosa*, *Planoglobulina brazoenensis*, *P. arervulinoides* and in globotruncanids *Globotruncana arca*, *Globotruncanella stuarti*, *Abathomalus mayaroensis*, *Contusotruncana contusa*, *Globotruncanella havanensis*, *G. petaloides*, *Rugoglobigerina rugosa*, *Archeoglobigerina bosquensis*, *A. blowi*, and rare planomaliniids *Globigerinelloides volutus*, *G. messina*, *G. biforaminata*. The second unit contains lowest Danian planktonic foraminiferal assemblages with very small and smooth taxa of the genera *Parvulaglobigerina*, *Eoglobigerina*, *Subbotina*, *Globanomalina* and *Guembelitria cretacea*, *Chiloguembelina midwayensis*, *Globoconusa daubjergensis* (very small). Both units contain abundant taxa of cosmopolitan deep-water agglutinated foraminifera of the genera: *Bathysiphon*, *Dendrophrya*, *Lagenammmina*, *Psammosphaera*, *Saccammmina*, *Rhabdammina*, *Silicobathysiphon*, *Hyperammmina*, *Ammodiscus*, *Glomospira*, *Glomospirella*, *Aschemonella*, *Kalamopsis*, *Reophax*, *Subreophax*, *Ammobaculites*, *Haplophragmoides*, *Ammosphaeroidina*, *Trochamminoides*, *Gaudryina*, *Clavulinoides*, *Tritaxia*, *Dorothyia*, *Remesella*, *Marssonella* and *Spiroplectammmina* which occur in deep marine strata of Maastrichtian–Palaeocene age throughout the world.

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Taxonomy, biostratigraphy and palaeoenvironmental implications of Late Cretaceous dinoflagellate cysts from the southwestern Barents Sea – preliminary observations

Wiesława KRÓL and Jarosław TYSZKA

Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1, 31-002 Kraków, Poland; ndkrol@cyf-kr.edu.pl

There is a lack of published information about the dinoflagellate cysts from the Upper Cretaceous sediment of the Barents Sea area. The articles related to the West Greenland deposits may be helpful for an interpretation of the geology in the region, but particular descriptive taxonomic and biostratigraphical work regarding Barents Sea Cretaceous dinoflagellate cyst assemblages is required.

The Barents Sea is an area surrounded by the Norwegian and Russian northern coasts, Novaya Zemlya, Franz Josef Land, Svalbard Archipelago and the eastern margin of the Atlantic Ocean. It is the largest continental shelf on the globe, and it consists of platforms and basins formed by two major continental collisions and subsequently sundered by continental separation.

The palynological slides, which we will investigate thanks to the kindness of Norwegian Petroleum Directorate, represent the Cretaceous and Palaeogene deposits of the southwestern part of the Barents Sea. They were prepared with cuttings from four boreholes, two of which (7119/5-1 and 7119/12-1) were drilled in the Tromsø Basin area and two others (7120/5-1 and 7121/5-1) in the Hammerfest Basin.

Initial observations of the slides reveal that dinocysts assemblages are well preserved and diversified allowing detailed quantitative and qualitative analysis.

Preliminary studies of the Upper Cretaceous of the borehole 7119/12-1 show a high abundance of typical representatives of Late Cretaceous gonyaulacoid and peridinioid forms, e.g., *Odontochitina*, *Florentinia*, *Pseudoceratium*, *Spiniferites*, *Hystrichosphaeridium*, *Oligosphaeridium*, *Cribroperidinium*, *Circulodinium*, *Surculosphaeridium*, *Cerodinium*, *Spinidinium* and *Chatangiella*.

The main aim of our research is the taxonomical description of the dinoflagellate cysts, construction of biostratigraphical profiles, and interpretation of the palaeoenvironment based on the assemblages. Additionally, there is planned a comparison to other regions such as the West Greenland and the North Sea.

There is also an ongoing study on the Cretaceous foraminifera from the same boreholes carried out by PhD student Eiichi Setoyama. The comparison of the results received from the examination of palynological and foraminiferal assemblages from the same borehole sections will provide a firm basis for understanding the composition, systematic affinities and distribution patterns of the Boreal microfossils. The information gained from quantitative analyses of these materials can provide much-needed constraints on the biostratigraphy and facies assessments of the sedimentary successions, as well as on the subsidence history of the depositional areas.



Ostracoda from fossil lakes of late Glacial and early Holocene age in the region of Mrzeżyno (the Southern Baltic)

Jarmila KRZYMIŃSKA and Piotr PRZEZDZIECKI

Polish Geological Institute, Marine Geology Branch, ul. Kościarska 5, 80-328 Gdańsk, Poland;
jarmila.krzyminska@pgi.gov.pl; pprzezdziecki@pgi.gda.pl

The research was carried out to supply evidence for deposits of sand for artificial reinforce of the sea-shore. The research region (70 km²) is situated within shallow-sea zone (from 8 to 16 m). Geological structure of the region was recognised by seismoacoustical profiling (ORETECH 3010, range 3.5 kHz) and vibro-sounders. The greater part of the bottom is covered by sandy deposits which build accumulative forms with thickness coming up to 7 m. Bed of sandy layer is mostly composed of boulder clay and locally of Pleistocene sand. In many places in the roof of the deposits, troughs filled with muddy and silty sediments – probably old lacustrine reservoirs' residue, were noticed.

In the research region ostracoda fauna occurred in eight cores. In muddy deposits there were typical freshwater assemblages. The layer of the deposits that suggests existence of older reservoirs was sharply outlined. Research showed that the layer consists of freshwater ostracoda species such as: *Cytherissa lacustris* (Sars), *Candona angulata* Müller, *Candona neglecta* Sars, *Limnocythere inopinata* (Baird), *Ilyocypris lacustris* Kaufmann, *Cyclocypris laevis* (Müller), *Herpetocypris reptans* (Baird) – which are typical for the Preboreal period and also of the species that have higher thermal requirements: *Candona compressa* (Koch), *Ilyocypris decipiens* Masi which can evidence climate warming up in Holocene. Appearance of marine species such as: *Cyprideis torosa* (Jones) and *Cytheromorpha fuscata* (Brady) in the deposits can certainly be an indicator of changing freshwater environment into marine one. The above-mentioned marine species are euryhaline ones which show high tolerance for changes in salinity typical for Boreal climate zone.



Foraminifera from the Antarctic Peninsula: an example how the present may be the key to the past

Wojciech MAJEWSKI

Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; wmaj@twarda.pan.pl

During the last fifty years, the western Antarctic Peninsula was the most rapidly warming region in the Southern Hemisphere and it is considered to be a “hot spot” of global warming. This warming was manifested in a variety of spectacular environmental changes that attracted considerable popular and scientific attention from around the world. The 77 m sediment core from the Firth of Tay provides the first complete record of deglaciation and Holocene climate change from the Weddell Sea side of the Antarctic Peninsula. Benthic foraminiferal data indicate significant environmental changes that begun ~9400 yr BP with decoupling of glaciers from seafloor. Two of the key taxa from this record (*Criboelphidium webbi* and *Globocassidulina biora*) inhabit recently Admiralty Bay (King George Island, South Shetlands) on the NW side of Antarctic Peninsula.

The *Criboelphidium webbi* is the only adequately described sub-Recent elphidiid foraminifer from Antarctica. It was found at several locations in Admiralty Bay within inner fjord setting at water depths between 33 and 165 meters water depth (mwd), but most commonly shallower than 100 mwd. It shows a clear association with retreating tide-water glaciers, therefore it is an important sensitive glacier-proximal indicator. It appears that it shares similar ecologic affinities with *Criboelphidium excavatum clavatum*, which is widely distributed throughout the Arctic. It is significant that, in the Firth of Tay record, *C. webbi* is present only at the very base of the deglaciation sequence, in a setting much similar to its Recent habitat in Admiralty Bay.

Globocassidulina biora shows episodic high-abundances practically throughout the core. These highs are associated with coarse sedimentation and often accompanied by the presence of organogenic, calcareous detritus and mixed foraminiferal assemblages, suggesting some degree of sediment reworking. Today, *G. biora* is a common foraminifer throughout Antarctic shallow-water settings. In Admiralty Bay, it inhabits down to at least 520 mwd; however, it dominates shallow water assemblages at less than 200 mwd, much above the water depth of the Firth of Tay drill site (640 mwd). Moreover, it appears that its Recent populations show the largest average test-size (~600 µm on average) at shallow-water sites ~30 mwd, while significantly smaller test-sizes (<200 µm) are found below ~200 mwd. At least some populations of *G. biora* from the Firth of Tay record show rather large average test-size, close to those found in Admiralty Bay at ~30 mwd, which could question the *in situ* position of *G. biora* from the Firth of Tay. However, some older studies contest the bathymetric trend in test-size observed in Admiralty Bay. Because in the Firth of Tay record, the horizons of *G. biora* high-abundances are correlated with peaks in carbonate preservation, it appears that assemblages dominated by *G. biora* were rather opportunistic, thriving during episodes of more glacial sediment input when some degree of sediment remobilization was also at work.



Foraminifera as an indicator of the origin of fine-grained deposits in turbidite sequences – an example from the Magura Nappe (Polish Outer Carpathians)

Ewa MALATA, Sabina HAWRYŁKO and Stanisław LESZCZYŃSKI

*Institute of Geological Sciences, Jagiellonian University, Oleandry 2a, 30-063 Kraków, Poland;
ewa.malata@uj.edu.pl; sabineczka7@poczta.onet.pl; stan.leszczyński@uj.edu.pl*

Detailed analysis of textural and structural features of Priabonian/Rupelian fine-grained deposits in relation to their foraminiferal content has been carried out on 29 samples from three sections, situated south of Gorlice, in the Siary Zone of the Magura Nappe. The studied deposits, exposed along the Sękówka River in Ropica Górna, are distinguished by Leszczyński as the Magura Beds (see: Leszczyński & Malata, 2002; Leszczyński *et al.*, 2008). They are represented by deep-sea, siliciclastic deposits, dominated by turbidites. Their lower part, developed as sand-mud rich deposits of glauconitic facies, was the subject of our studies.

The studied sections display the varied character of fine-grained deposits within different types of lithofacies and facies associations (Leszczyński *et al.*, 2008). The first section, representing chaotic deposits, contains 2 m thick mudstone and shales occurring between thick-bedded debrites. Ten samples, collected at a few millimetre intervals, have been analysed from the topmost, 10 cm portion of the shales. The next section consists of thin- and medium-bedded turbidites with intercalations of marls and shales representing deposits of low-density turbidite currents. Ten samples were collected from green, beige, black shales and from marls at a few cm intervals. The third section reveals about 7 m thick, massive grey shales, deposited from a single suspension flow, capped by a thin-bedded turbidite and a very thin layer of grey and finally green shales. Five samples were collected from the grey, massive shales at about two-meter intervals and the other three from the topmost part, and one from the green shales.

Four of the twenty nine samples were barren of foraminifera and the others yielded a varied amount of specimens. Agglutinated deep water foraminifera are the main or entire component of impoverished assemblages, displaying low species diversity and pointing to sedimentation below or close to the local CCD. *Glomospira glomerata* (Grzybowski), *Reophax pilulifer* Brady, *Haplophragmoides* sp., *Paratrochamminoides* spp., and *Ammosphaeroidina pseudopauciloculata* (Mjatliuk) are common, apart from the relatively most abundant *Nothia excelsa* (Grzybowski). Very rare benthic and planktonic foraminifera are represented by reworked older forms found in fine-grained deposits of turbidite origin. Single specimens of *Cibicides lopjanicus* Mjatliuk, or *Tenuitella* sp. seem to be coeval in age with the analysed sediments.

The green shales of the background deposits, irrespective of lithofacies, are marked by the most abundant agglutinated assemblages. Less numerous assemblages, though of similar composition point to a turbidite origin of marls and beige, grey and black shales. The distribution of foraminifera in the massive grey shales displays gradational separation from suspension which is in accordance with the nature of these deposits.

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Living (rose Bengal stained) benthic foraminifera of the Peruvian oxygen minimum zone – discovering new proxies for oxygen reconstruction

Jürgen MALLON

Leibniz-Institute of marine sciences IFM-GEOMAR, Wischhofstr. 1–3, 24146 Kiel, Germany; jmallon@ifm-geomar.de

The aim of this study is to identify species of benthic foraminifera that can serve as proxies for quantitative reconstruction of dissolved oxygen contents of bottom waters.

Off the North-Chilean and Peruvian coast a strong upwelling zone with uprising cold and nutrient rich deep water causes oxygen depletion by microbial activity resulting in an extension of the world's most extant oxygen minimum zone (OMZ).

During an expedition on the German research vehicle "Meteor" from Oct. 21th to Dec. 22th 2008 multicorer samples were recovered from E-W transects located between 18°S and 1°S off the South American coast. Determining the living benthic foraminiferal assemblages in respect to microsensor oxygen measurement values should lead to new useful proxies for quantitative reconstruction of oxygen concentrations. More than 30 multicorer sediment cores were taken, sliced into 2 to 1 cm thick slices and directly treated with ethanol + rose Bengal for distinguishing living from dead individuals.

This presentation will give a brief overview about methodology and preliminary results.



Stratigraphical significance of Berriasian ostracods of the Southwestern and Central Crimea

Anastassiya V. MANUSHKINA¹ and Ekaterina M. TESAKOVA²

Department of Paleontology, Geological Faculty, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia;

¹msu85@mail.ru; ²ostracon@rambler.ru

Ostracods of the Southwestern and Central Crimea from the drainage basins of the rivers Chernaya, Sary-Su (Lower Berriasian), Beshterek, Zouya and Burulcha (Upper Berriasian) have been studied. Twenty two species belonging to twelve genera have been determined.

The ostracod diversity in the Upper Berriasian (19 species) is slightly higher than in the Lower Berriasian (16 species). The assemblages, along with high number of common forms, contain index-species of the Upper Berriasian (*Hechticythere belbekensis* Tesakova & Rachenskaya, *Macrodentina melnikovae* Tesakova in Tesakova & Rachenskaya, *Bairdia kuznetsovae* Tesakova & Rachenskaya, *Neocythere pyrena* Tesakova & Rachenskaya, *Cytherelloidea* sp., gen. et sp. 1), and of the Lower Berriasian (*Cytherelloidea flexuosa* Neale, *Costacythere foveata* Tesakova & Rachenskaya, and *Reticcythere marfenini* (Tesakova & Rachenskaya)).

Detailed analysis of the ostracod distribution in the substages reveals several distinct boundaries marked by taxonomic changes in the ostracod fauna. These boundaries define layers with ostracods. Sublayers are defined by changes of dominant species.

The Lower Berriasian includes layers with *Cytherelloidea blanda* found in the ammonite Subzone *ponticus* of the *Pseudosubplanites ponticus* Zone. These layers are capped by the layers with *Costacythere foveata*–*Reticcythere marfenini*, which are further subdivided into sublayers with *Valendocythere khiamii* and *Costacythere foveata* correlative with the *Pseudosubplanites ponticus* ammonite Zone, and layers with *Malbosiceras chaperi* of the Lower Berriasian. These strata are overlain by layers with *Bairdia menneri* distinguished in the ammonite Zone *Tirnovella occitanica*, Subzone *tauricum*.

The Upper Berriasian contains layers with *Hechticythere belbekensis*–*Macrodentina melnikovae* with sublayers with *Cytherelloidea mandelstami*, correlative to the ammonite Zone *Fauriella boissieri*, Subzone *euthymi*. The higher interval of the section is represented by layers with *Neocythere pyrena*–*Cytherella krimensis* with sublayers with *Valendocythere arachnoidea* and *Macrodentina melnikovae*, which are correlative with the Subzone *crassicostatum* of the *Fauriella boissieri* Zone.

In addition, the Upper Berriasian contains layers with *Bairdia kuznetsovae* that correspond to the ammonite zone *Fauriella boissieri*, and beds with brachiopods *Zeillerina baksanensis*.

The reviewed units are the first ostracod-based strata ever defined for the Berriasian of the Southwestern and Central Crimea.

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Integrated analysis of conodonts and foraminifers: a tool for recognition of the Mid Famennian Event in Western Pomerania (NW Poland)

Hanna MATYJA¹ and Anna TOMAŚ²

¹ Polish Geological Institute, Department of Deep Structures Geological Mapping, Rakowiecka 4, 00-975 Warszawa, Poland; hanna.matyja@pgi.gov.pl

² Polish Geological Institute, Carpathian Branch, Skrzatów 1, 31-560 Kraków, Poland; archiwum@pigok.com.pl

A distinct and relatively rapid regressive event affected the Pomeranian area at the beginning of the latest *marginifera* Chron (mid Famennian). The northern part of the area was then dominated by peritidal siliciclastic-carbonate deposition with local evaporites. To the south and south-west a shallow-subtidal environment developed, related to a partly restricted carbonate ramp, characterised by pale gray nodular and wavy bioclastic limestones. Small green algae (issinellids and palaeoberesellids), multilocular foraminifers, as well as calcispheres, *Girvanella* fragments and benthic ostracodes are particularly common. The organisms requiring more open marine conditions, such as conodonts, brachiopods and echinoderms, are not very abundant.

A shallowing-upward tendency has been observed within this mid Famennian succession. At the same time, a conodont biofacies shift has been observed, from the deeper polygnathid-palmatolepid biofacies during the early-late *marginifera* chrons to the very shallow-water polygnathid one in the latest *marginifera* Chron. This bioevent was also related with the definitive retreat of the offshore conodont genus *Palmatolepis* from the Pomeranian Basin at the end of the *marginifera* Chron.

There is no evidence of the *trachytera* and *postera* conodont zones throughout the entire Pomeranian area. There is a thin interval, above the uppermost *marginifera* Zone and below the lower *expansa* Zone, with conodont faunas consisting almost entirely of long-ranging taxa. This, at first sight, suggests that the inability to recognize the *trachytera* and *postera* zones within this very shallow-water part of the Famennian succession may be associated with the paucity or even absence of diagnostic conodonts. It is important to note, however, that some fragments of the mid Famennian succession contain a conodont fauna indicative of the lower *expansa* Zone but with an admixture of older elements, representative of the upper and uppermost *marginifera* zones but not the *trachytera* and *postera* zones.

Additional sampling began just above the uppermost *marginifera* conodont Zone, recorded a foraminiferal assemblage assigned to the *Quasiendothyra regularis* Zone. It provides evidence that the upper *postera* or lower *expansa* conodont zones occur just above the *marginifera* Zone. The implication is that there is no place for the *trachytera* and *postera* conodont zones.

In summary, it is important to note, that such combined biostratigraphical analysis can provide more precise age determinations for those parts of the Famennian succession which were hitherto unfavourable for individual fossil groups, and is useful to identify potential stratigraphic gap.



The occurrence of the genera *Zonocypris* and *Virgatocypris* (Crustacea, Ostracoda) in the Neogene of Central Anatolia (Turkey)

Ilaria MAZZINI

IGAG-CNR, Via Salaria Km 29,3; C.P. 10 (00016 Monterotondo Stazione, Rome, Italy; ilaria.mazzini@igag.cnr.it)

Several species belonging to the genus *Zonocypris* have been recovered from the Tuglu and Bozkir formations. Both formations are Late Miocene continental successions related to a low energy fluvial environment with sporadic lacustrine events. They outcrop in the Çankiri Basin, one of the largest intermontane Tertiary basins of the Central Anatolia Plateau (Turkey). The main characteristic of the genus *Zonocypris* is the peculiar ornamentation, made up of concentric striae and the adont hinge. *Zonocypris* was originally erected by Müller in 1898, on living specimens from Tanzania (E Africa). Since then, several *Zonocypris* fossil species have been recovered from Cretaceous to Pleistocene freshwater sediments in a wide area, from China to Europe. Some of the fossil *Zonocypris* species have been found associated to brackish ostracod associations. Such findings provide new insights on the ecology of the genus. *Zonocypris* shows strong affinities with the genus *Virgatocypris* erected by Malz & Moayedpour (1973) on specimens from the Miocene of the Rhein River. Some specimens belonging to the genus *Virgatocypris* have been recovered from the Lower Miocene Kilçak Formation, outcropping as well in the Çankiri Basin (Central Anatolia, Turkey). The Kilçak Formation is related to permanent freshwater shallow water-bodies. *Virgatocypris* is mainly characterised by an ornamentation of striae converging anteriorly and posteriorly. Browsing the existing literature, it seems that the genus *Virgatocypris* is confined to Cretaceous to Eocene continental sediments with sparse findings in Miocene sediments. Malz & Moayedpour (1973) described the convergence of striate species belonging to the genera *Virgatocypris*, *Cyprinotus*, *Paracyprretta* and *Scottia*. *Zonocypris* adds to such a group. Although the kind of ornamentation clearly separates *Zonocypris* and *Virgatocypris*, some confusion still arises between the two genera and striate species are assigned to one or the other genus indifferently. The occurrence of such taxa in the continental Neogene of Central Anatolia contribute to the knowledge of the biogeographical distribution and the palaeoecological characteristic of species belonging to both genera.



Some data on the Late Cretaceous palaeogeography of Georgia by foraminifers

Khatuna MIKADZE

Georgian National Museum, Institute of Paleobiology, Niagvris 4, Tbilisi 0108, Georgia; xatmi@mail.ru

During the Late Cretaceous, a shallow, warm water basin with normal salinity existed in the territory of Georgia. The distribution of Cretaceous deposits and their structure confirms the presence of three large sedimentary cycles: Berriassian–Lower Turonian, Upper Turonian–Campanian and Maastrichtian–Palaeogene. The first cycle includes the time interval from the Berriassian, and reaches its maximum extent in the middle Albian. The late Albian–Early Turonian regression is conditioned by the Austrian phase of tectogenesis. The second cycle covers the period from the late Turonian to the Santonian. The marine transgression coincides with the late Turonian to early Santonian interval. The late Santonian regression was provoked by the Sub-Hercynian orogenic phase. The transgressive part of the third cycle of sedimentation includes the late Senonian.

Interpretations of the planktonic foraminiferal environment are based on statistical methods proposed by different researchers (e.g. Krashenninnikov, 1960; Hofker, 1966; Mouter & Laga, 1970; Boltovskoy, 1973). Environmental reconstruction of the Late Cretaceous planktonic foraminifers is based first of all on the knowledge of foraminifer ecology in modern marine basins. Connections between the PF and environmental conditions enabled to apply quantitative and qualitative analyses of the fossil assemblages for palaeogeographic reconstructions. Composition of the PF assemblages mainly depends upon climate zonality. It is known that with increasing temperatures, the taxonomic diversity of planktonic foraminiferal assemblages also increases. It is also assumed that climatic fluctuations influence the coiling of some PF species; the right-coiling shells of globotruncanids are more widespread under the comparatively high-temperature conditions. High percentages of the right-coiling shells (90–95%) of Globorotalidae point to a tropical climate, and a high percent of left-coiling shells (75–97%) to a subtropical climate. Contemporary studies show that the PF assemblages are divided into three climatic groups: moderately-warm, subtropical and tropical. All the data have been correlated with those obtained by brachiopods and mollusks of the Late Cretaceous Epoch (Gambashidze & Iasamanov, 1980). For estimating the depth of the basin the P/B ratio and proportions of the shallow water, intermediate and deep-water forms in planktonic foraminiferal assemblages were computed.

The depth of the Cenomanian basin did not exceed 100–120 m. A rather high percent of left-coiling forms among planktonic foraminifera is specific for the comparatively low temperature (15–17°C) basins. From the beginning of Early Turonian a gradual deepening of basin and expansion of the marine basin is observed. The depth of the basin probably exceeded 200 m. Diminution of the left-coiling PF forms specifies the increase of temperature up to 20–22°C. From the second half of the Turonian stabilisation and deepening (down to about 250 m) of the basin is observed. High contents of planktonic foraminifera (80%), and also the prevalence of deep-water taxa are observed. The presence of right-coiling forms (90%) points to high temperature conditions (22–27°C). In the Coniacian, there was an open marine basin with normal salinity and depths characteristic of an external shelf (about 200 m). It is manifested in high contents of PF and prevailing quantity of deep-water taxa. Among them there are a lot of characteristic species of the Tethys area, which indicates the existence of open communication with the Mediterranean. On the other hand, the increase in percentage of left-coiling species indicates a reduction in temperatures in comparison with the Turonian. In the Santonian, the general palaeogeographic situation begins to change. The depths of the basin have remained the same, though percentage of P/B is not constant and changes from west to east, from 80/20% down to 40/60%. Percentage of deep-water taxa changes from 40% up to 75% of the total PF. Expansion of the basin took place during this time interval. At the same time, it is obvious that there were underwater rises resulting in the shallowing of the basin – more favorable conditions for the existence of BF, where the P/B relation is reduced down to 40/60%. The gradual rise of sea level smoothed the barriers enabling movement of cool Boreal waters. Evidently, the general

decrease in temperature conditioned the higher percent of left-coiling tests within the PF association (30–40%). The average water temperature was 15–17°C, and on separate sites it achieved 20°C. Foraminifera assemblages make it possible to assume that in the Campanian there was a shallow sea with a depth of 150–200 m. At the end of the Campanian depth of the basin was only 100–120 m (based on the gradual reduction of the P/B ratio from 90/10% up to 50/50%), and in the composition of foraminiferal assemblages the presence of shallow-water taxa (up to 5%) is also fixed. By the PF data it is possible to assume, that the depth of the basin was rather great. From the second half of early Maastrichtian, begins a gradual shallowing of the basin what is testified by the prevalence of the benthic oritocoenosis. The temperature changed from the lower values in the beginning of the Maastrichtian to higher values (from 17 up to 26°C) at the end of the interval.

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On some common regularities in the shell morphological development of Fusulinoida and Miliolata

Valeria I. MIKHALEVICH

Zoological Institute Russian Academy of Sciences, Universitetskaya nab., 1, 199134, St. Petersburg, Russia;
mikha@JS1238.spb.edu

The similarity of shell structure of the Palaeozoic fusulinoids and of the later (Cretaceous to Holocene) alveolinids and soritids is widely known and was previously viewed as the result of convergent development not united by common origin. The presence in fusulinoids of the chomata, fluted septa, and cuniculi as well as incomplete septation within their chambers was considered as a witness of their taxonomic specificity (along with the specificity of their shell wall ultrastructure which was discussed elsewhere by Mikhalevich, 2009). The thorough study of the details of their inner shell structure (Leppig *et al.*, 2005; Mikhalevich, 2006, 2009) permits to conclude that the septal pores of fusulinids and series of apertural foramina of alveolinids are homologous, the deposits of the shell matter at the bottom of the chambers called in fusulinoids as “chomata” could also be seen (though rarely) in higher miliolids (e.g. bottom deposits in *Periloculina*). And, from the other side, some higher fusulinoids among the Verbeekinoidea (Neoschwagerinidae) have straight not fluted septa and fully separated chamberlets. Thus the inner shell structure of fusulinoids leads to more primitive inner ways of the cytoplasmic circulation while in the higher miliolids these ways are organised in a more perfect mode (especially in alveolinids with their pre- and postseptal passages though in Fusar-chaisinidae such passages are absent) and provides the more perfect cytoplasmic circulation. All this permits to regard both groups as being closely related (rather than convergent) and developed within one phylogenetic lineage – namely the class Miliolata Saidova, 1981. The later miliolids represent the later and more advanced branch of this line. The comparative analysis of the lower less advanced groups in these both taxa (endothyrids and lower miliolids) (see Mikhalevich, 2009) also supports these conclusions. The evolutionary ways of development from the more primitive shells with glomerate or planospiral coiling and a few number of chambers to the supermultichambered large shells of fusulinoid type are similar in the both groups discussed. Such fusulinoid shells with chambers elongated from pole to pole in planospiral coiling in their final stages and planospiral or glomerate initial stages do not exist in any other foraminiferal class.

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Monograptids and retiolitids from the Gołdap IG-1 borehole (NE Poland)

Kinga MODLIŃSKA and Dagmara SZARON

Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; kmodlinska@twarda.pan.pl, dszaron@twarda.pan.pl

The Gołdap IG-1 borehole (northeast Poland) is situated in the East European Platform (EEP), within the Peribaltic Depression. The borehole was investigated with respect to lithology and stratigraphy. The Silurian is confined in the fairly complete Gołdap core to the interval between 1419.0 m and 1120.0 (Tomczyk, 1974). The present studies focus on the Silurian graptoloid fauna, both monograptids and retiolitids, using new methods. For this study the graptolites were recovered by dissolution of the samples from about 200 m of the borehole. Then specimens were transferred to glycerin using a hairbrush. The well preserved, isolated graptolites were examined under light and the scanning electron microscopes. In the examined samples nine genera of monograptids were affirmed: *Bohemograptus*, *Colonograptus*, *Cucullograptus*, *Lobograptus*, *Monoclimacis*, *Monograptus*, *Pristiograptus*, *Pseudomonoclimacis* and *Saetograptus*. Isolated Silurian monograptids were studied in detail and described (Urbanek, 1997), mostly from the Ludlow of the Mielnik IG-1 borehole. The material illustrated in the present study is examined under the scanning electron microscope.

The retiolitids were planktic graptolites that evolved through about 20 Ma of the Silurian, from the Aeronian to the Ludfordian. It was an unusual group of the last diplograptids having unique rhabdosomes built of bandages forming lists of thecal and ancora sleeve walls (Kozłowska, 2004). Up to now we received retiolitids from the Ludlow to upper Wenlock (Homerian), it is about 100 m of the Gołdap borehole. Isolated material represents six genera: *Gothograptus*, *Plectograptus*, *Spinograptus*, *Neogothograptus*, *Holoretiolites* and *Semiplectograptus*. The last one is known only in Poland, and this is the second reported occurrence of this genus. Discussed material confirms previous graptolite fauna researches from other boreholes (Mielnik, Bartoszyce and Zawada) of the Polish part of the East European Platform. The investigated fauna reflects the same environmental changes and extinction events.

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The morphological analysis and affinities of the Palaeozoic Eridostraca (Crustacea, Ostracoda)

Ewa OLEMPSKA

Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; olempska@twarda.pan.pl

The Eridostraca is a group of tiny marine bivalve crustaceans with an average adult length of about 1 mm, with fossil record from the Ordovician to the Carboniferous. They are characterised by carapaces with accumulated layers of old cuticle not shed during ecdysis.

Eichwald (1860) was the first to describe and figure small marine species under the name *Astarte socialis* from the Devonian of Russia and recognised it as Bivalvia. Twenty years later, Clarke (1882) described additional small marine multilamellar species from the marine strata of the Middle Devonian (Hamilton) of Ontario, USA, under the name *Estheria pulex* and interpreted it as Phyllopoda. Ulrich & Bassler (1923) described similar multilamellar species *Eridoconcha oboloides* from the Middle Ordovician of Minnesota and recognised it as an ostracod of the family Aparchitidae.

Since that time, more than 70 species have been described and still these small fossils have been the object of significant controversy for both Palaeozoic and post-Palaeozoic ostracod workers. They have been classified in the Ostracoda or questionably in the extinct marine Branchiopoda.

In 1961, Adamczak erected for them a new suborder Eridostraca and assigned it to the Ostracoda, however, suggested that “multilamellar” ostracod carapace has been derived from “Conchostraca” (Branchiopoda).

New Devonian fossil material from Poland and Russia provided an opportunity to study the morphology of eridostracan species. The material includes separate exuviae of the new eridostracan species of *Cryptophyllus*, with well preserved adductor muscle scars, frontal scars and a group of dorsal muscle scars. At each layer of cuticle the crenulate hinge structure is developed.

A system of “canals” attached to the internal side of the calcite layer in each exuviae has been found. Also the imprints of these structures occur on external calcite layer of a new layer secreted underneath.

The ostracod identity of the Eridostraca is confirmed by a number of features such as muscle scars pattern, hinge structure, the presence of an adductor sulcus reflected as a ridge on the internal surface, and the dorsal separation at the dorsal margin of successive valves.

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Palaeoenvironmental turnover across the Eocene–Oligocene transition in the southern Labrador Sea (ODP Hole 647A): evidence from benthic foraminifera

Silvia ORTIZ^{1,2} and Michael A. KAMINSKI¹

¹ Department of Earth Sciences, University College London, WC1E 6BT London, UK; m.kaminski@ucl.ac.uk

² Dpto. Ciencias de la Tierra, Universidad de Zaragoza, 50009 Zaragoza, Spain; silortiz@unizar.es

The Eocene–Oligocene (E–O) transition corresponds to a crucial episode in Cainozoic history, including the most profound oceanographic and climatic changes of the past 50 Ma. It has been assumed that the first major, continental-scale glaciation of the Cainozoic occurred on Antarctica (middle Eocene–earliest Oligocene) much earlier than in the northern hemisphere (Zachos *et al.*, 2001). There is more recent evidence that at least some level of glaciation in the Northern Hemisphere started at about the same time as in the southern hemisphere (e.g., Tripati *et al.*, 2008).

Deep-water circulation plays an important role in the evolution of the modern climate system and therefore, changes in its mode may have affected global climate during the E–O transition. It has been suggested that during the extreme warmth of the early Cainozoic (ca. 55 Ma), deep-water formation occurred principally in the Southern Ocean. The formation of cold deep water in the Southern Ocean and/or in the northern Atlantic may have started in the earliest Oligocene (e.g., Zachos *et al.*, 2001), but the timing and pattern of these circulation changes is under vigorous debate.

We present a high-resolution analysis of benthic foraminiferal assemblages from the E–O transition in the southern Labrador Sea (ODP hole 647A), including the samples used by Kaminski *et al.* (1989). We aim to reconstruct in detail the faunal and palaeoenvironmental changes that occurred at the seafloor (probably lower bathyal depths) at this significant setting located at high northern latitudes. Site 647 is one of the only sites in the northern Atlantic that recovered a continuous sedimentary succession across the E/O boundary. It is in the pathway of overflow water from the Norwegian Sea, and therefore it is a key location to study proxies for the flow of North Atlantic Deep Water.

We have identified a sequence of benthic foraminiferal events in Hole 647A. The E/O boundary interval is characterised by a peak in *Nuttallides umbonifera* (up to 75% of the assemblage). *Nuttallides umbonifera* is an indicator of Antarctic Bottom Water in the modern oceans and also during the E/O boundary in the South Atlantic. It has also been linked to corrosive bottom waters or to extreme oligotrophy (e.g., Thomas, 2007).

“Cylindrical” benthic foraminifera species, mainly uniserial or elongate biserial forms, decreased in abundance after the E/O boundary, which has been linked to changes in productivity (e.g., Thomas, 2007). This group of taxa, mainly stilostomellids, is very abundant at ODP Hole 647A. Due to their good preservation, it was possible to analyse their evolution across the E–O transition at specific level. This high-resolution study let us achieve a better understanding of the palaeoceanographic and climatic changes at the E–O transition in the northern Atlantic.

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Late Pleistocene and Holocene palaeoenvironmental reconstructions of the Laptev Sea based on calcareous benthic foraminifers

Yaroslav S. OVSEPYAN¹, Ekaterina E. TALDENKOVA², Irina A. POGODINA³
and Henning A. BAUCH⁴

¹ Geological Department, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia; yaovsepyan@yandex.ru

² Geography Department, Moscow State University, Vorob'evy Gory, Moscow 119992, Russia

³ Murmansk Marine Biological Institute, Murmansk, Russia

⁴ Mainz Academy for Science, Humanities and Literature c/o IFM-GEOMAR, Kiel, Germany

In order to reconstruct sedimentation and palaeoenvironmental conditions in the Laptev Sea during the postglacial sea-level rise benthic calcareous foraminifers were investigated in four AMS¹⁴C dated kasten and three box core sections from different parts of the shelf and upper continental slope within the water depth range of 20 to 270 meters.

In total, 31 species of calcareous benthic foraminifers were identified, which belong to 25 genera. Several ecological groups are distinguished in the Arctic marginal seas in dependence to offshore changes in water depth and river runoff influence (Polyak *et al.*, 2002).

The group of shallow-water species (*Elphidium incertum*, *E. bartletti*, *Haynesina orbiculare*, *Buccella frigida*, *Elphidiella groenlandica*) together with opportunistic species *Elphidium clavatum* are typical for river-proximal areas. They occur throughout the core from the modern inner shelf of the southeastern Laptev Sea which became flooded about 6 cal.ka. Similar assemblage is found in the basal parts of the cores from the outer shelf corresponding to the earliest stages of shelf flooding 12.4–10.3 cal.ka. With increasing water depths it was replaced by the assemblage with considerable admixture of species typical for river-distal areas (*Cassidulina reniforme*, *Stainforthia loeblichii*, *Nonion labradoricum*, *Islandiella* spp., *Astrononion gallowayi*, *Cibicides lobatulus*).

These river-distal species together with *E. clavatum* predominate in the sediment sequence from the upper continental slope aging back to 15.6–6 cal.ka, whereas 6–2 cal.ka also *Melonis barleeanus* becomes dominant thus evidencing the establishment of modern-like environments. The enhanced subsurface inflow of chilled Atlantic-derived waters 15.6–12 and 5–2 cal. ka is indicated by the presence of *Cassidulina neoteretis*. Its absence between 12 and 5 cal.ka could be due to the considerable freshening of the upper water column resulting from climate warming and active flooding of the adjacent outer shelf areas. The highest surface water productivity related to the average summer ice margin position is indicated by increased relative abundances of *Nonion labradoricum*, *Islandiella* spp., *Pyrgo williamsoni* between 12 and 11 cal.ka. Increasing proportion of river-proximal as well as epifaunal (*C. lobatulus*, *A. gallowayi*, *Elphidium subarcticum*) species after c. 6 cal.ka corresponds to increased IRD input as a result of the Late Holocene climate cooling and growing of iceberg-producing ice caps on Severnaya Zemlya islands.

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Albian–Cenomanian radiolarian assemblages of Russia

Tatiana N. PALECHEK

Geological Institute, Russian Academy of Sciences, Pyzhnevsky line 7, Moscow 1190117, Russia; tatiana@ilran.ru

Albian–Cenomanian radiolarians are well-known from different regions of Russia and nearest territories (Crimea, Caucasus, Carpathians, Middle Asia). We can observe distinctions such as the taxonomical composition as change in morphology of tests from studied Albian–Cenomanian radiolarians from different palaeogeographic provinces. Let of us consider some of them.

We discovered Albian–Cenomanian radiolarians from sections of Eastern Kamchatka (Palechek *et al.*, in press). The studied assemblages are dominated by Tethyan species. The radiolarian assemblages exhibit higher diversity (10–20) in comparison to those of the moderate and high latitudes. The diversity of radiolarians from the Koryak Upland, for instance, varies from 1 to 5 on average (Palechek, 1997). The studied samples are characterised by high diversity of such genera as *Xitus*, *Novixitus*, *Schaafella* with a complicated architecture of shell. In addition, spines (*Acaeniotyle*, *Triactoma*) and delicate (*Petasiforma*) forms are abundant. The Albian–Cenomanian radiolarian assemblage from Western Kamchatka is characterised by low taxonomic diversity and includes: *Holocryptocanium barbui* Dumitrica, *Squinabolum fossilis* (Squinabol), *Stichomitra communis* Squinabol, *Theocampe simplex* Smirnova & Aliev, *T. cylindrica* Smirnova & Aliev. It is colder than assemblage from Eastern Kamchatka because there are *Theocampe simplex*, *T. cylindrica*, which are present in moderate latitudes (Russian Plate) (Vishnevskaya *et al.*, 2005). There are many deposits with Late Albian radiolarians on the Russian Plate. Aliev and Smirnova (1969) first described radiolarians from this region, later an assemblage with radiolarians named by Kasintzova (1997) as *Porodiscus kavilkinensis*–*Crolanium cuneatum*. This assemblage is found in sediments in the Vladimir region. *Dictyomitra*, *Crolanium* and *Porodiscus* dominate here. Assemblage of the same age was studied in Povolzh'e, different districts of the Moscow syncline and near v. Kovulkino (southwest of Saransk) (Kasintzova, 1997).

An Albian–Cenomanian radiolarian assemblage with *Holocryptocanium barbui*–*Archaeospongoprimum praelongum* was investigated on Eastern Sakhalin (Kasintzova, 1987). This assemblage consists of more than 30 species from 22 genera. Nassellarians with two- and three segments skeletons dominate. There are a lot of sponge skeletons among Spummelaria.

A radiolarian assemblage with *Holocryptocanium barbui*–*Hemicryptocapsa tuberosa*–*Thanarla elegantissima* was studied from “dalagar” sediments in the Onora River basin on Western Sakhalin (Kasintzova & Rozhdestvenskiy, 1982). Thus, we can observe distinctions such as the taxonomical composition as change in morphology of tests from the studied Albian–Cenomanian radiolarians coming from different palaeogeographic provinces.

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The Badenian/Sarmatian (Middle Miocene) boundary in the Buda Stalowska P-7 profile (Carpathian Foredeep, Poland) in a light of bio- and chemostratigraphic studies

Jolanta PARUCH-KULCZYCKA

Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland; jolanta.paruch-kulczycka@pgi.gov.pl

The boundary between the Badenian and Sarmatian deposits in the Polish area of the Carpathian Foredeep is located within the monotonous claystone-siltstone complex, representing the lowermost part of the Machów Formation (Olszewska, 1999). The biostratigraphic boundary of these stages, defined with foraminifera assemblages, is fixed between two foram interval zones: *Hanzawaia crassiseptata* and *Anomalinoides dividens* (Łuczkowska, 1967; Cicha *et al.*, 1998).

Detailed geological studies: chemostratigraphic, sedimentological and micropalaeontological of the Buda Stalowska P-7 profile enabled the reconstruction of depositional conditions at this boundary (Gąsiewicz *et al.*, 2004).

Chemical analyses determined the content of: main and trace elements, total organic carbon (TOC) and isotopes of carbon and oxygen. Sedimentological profiling defined facies changes and registered possible discontinuity surfaces (hard grounds, erosion surfaces). Micropalaeontological study concentrated on palaeontological analysis of foraminifera assemblages.

Results of geochemical and sedimentological studies provide evidence in the Buda Stalowska P-7 profile continuous deposition, but also three successive geochemical complexes (A, B and C) were distinguished. The lowermost geochemical complex A differs distinctly in chemical data from the overlying B and C units, being quite similar. Isotope (oxygen and carbon) characteristics and chemical content data as well as sedimentological observations suggest the Badenian age of unit A, but the two overlying complexes (B and C) are attributed to the Sarmatian. Comparison of biostratigraphic and chemostratigraphic results indicated that in the profile studied the Badenian/Sarmatian boundary, is defined by a chemical change (depth 216.5 m), and is located significantly higher than the biostratigraphic boundary (233.1 m), marked by the *Anomalinoides dividens* zone.

This position inconformity of both boundaries resulted probably from the ecological change, eliminating the Badenian foraminifera assemblage much earlier than the distinct change of environment chemistry have been recorded in deposits. Differently protected various pyritization of *Anomalinoides dividens* shells observed at a depth of 233.1–231.5 m, could be interpreted as a result of such first chemistry change, registered in the A geochemical complex by the fluctuating content distribution of chemical components.

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Environmental changes in the declining middle Miocene Badenian evaporite basin of the Ukrainian Carpathian Foredeep (Kudryntsi section)

Danuta PERYT¹ and Tadeusz MAREK PERYT²

¹ Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; d.peryt@twarda.pan.pl

² Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland; tadeusz.peryt@pgi.gov.pl

The Kudryntsi quarry section in the West Ukraine documents a major environmental change from hypersaline to marine conditions. There are very few (or no) specimens of foraminifers in all samples of the siliciclastic series (4 m thick) with limestone intercalations which occurs above the gypsum (and below the transgressive deposits) in the southern part of the quarry. The limestone intercalations are first sparitic and microsparitic, and then pelletal. The pelletal depositional textures are interpreted as originated in restricted environments in contrast to mixed-fossil lithoclastic packstones/grainstones which overlie the siliciclastic series. The diversity of the preserved fauna increases up section, and first foraminifers, bivalves, ostracods and gastropods appear and then additionally brachiopods, bryozoans, crinoids, and echinoids occur. Foraminiferal assemblages are dominated by elphidiids, forming 70 to 90% of the assemblage; the most common species are *Elphidium crispum* (Linné) and *E. macellum* (Fichtel & Moll). Limestone samples show a big spread of $\delta^{13}\text{C}$ values (from -1.6‰ to -18.2‰) and $\delta^{18}\text{O}$ values (from -0.2‰ to -9.4‰) indicating that the cementation and some recrystallisation had to take place in meteoric-water-dominated fluid but the restriction-controlled trend can be recognised in limestones. The siliciclastic series was deposited in evaporitic lagoon influenced by large inflows of continental waters carrying siliciclastic and other detrital material from the older Badenian rocks as well as from their substrate. The Kudryntsi section documents a step-wise decrease in water salinity – from ca. 150–300 g/l during the Badenian gypsum precipitation, through ca. 80–150 g/l during the deposition of the siliciclastic series to ca. 35 g/l during sedimentation of the basal transgressive deposits which originated in shallow subtidal (0–20 m) environments of normal marine salinity (30–35‰) and temperate to warm waters (8–18°C) as indicated by requirements of the *E. crispum* association in Recent seas.



Distribution of microfossils in the Upper Ordovician and the Lower Silurian of eastern part of the Baltic Basin with implication for the Hirnantian climatic changes

Teresa PODHALAŃSKA

Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland; teresa.podhalanska@pgi.gov.pl

The Late Ordovician and the Ordovician/Silurian boundary interval were characterised by important global events linked with climatic and eustatic changes. The switch from greenhouse to icehouse climate mode in the Hirnantian and the return to greenhouse conditions during the Early Silurian is considered to be one of the most spectacular biotic extinction and recovery changes in Earth history resulting in faunal crisis as well as in lithofacies changes and shifts in the carbon and oxygen isotope curves. This study concentrates on the fossil assemblage and sedimentary facies from the Upper Katian, Hirnantian and Rhuddanian succession from selected sections in the eastern part of the Baltic Basin. Lithofacies and biofacies analyses as well as stable isotope data of the Upper Ordovician and the Lower Silurian in the area studied show high similarities to other areas of central Baltoscandia, i.e. central Sweden, northwestern Lithuania and southern Estonia. The Upper Katian (Pirgu stage) and the Hirnantian (Porkuni stage) lowstand deposits represent the Morag and the Orneta formations. The latter one, assigned to the Hirnantian, is composed of marls and thin-laminated marly limestones, with strong bioturbation and shallow-marine trace-fossils, in some cases with cross-bedding. The deposits features suggest the proximal part of the outer shelf sedimentary environment with oxygenated conditions. These deposits known e.g. from the Bartoszyce IG 1, Barciany 4, and Lidzbark Warmiński 3 well cores reflect a maximum lowstand in the Central Baltoscandian facies zone.

Microfossils are rare in these deposits. Numerous conodonts occur in the Vormsi stage. The conodonts recognised in the Lidzbark Warmiński 3 and Bartoszyce IG 1 sections include ones of *Amorphognathus tvaerensis* and *Amorphognathus superbus* Biozones. The Hirnantian (Porkuni) part of these sections is the interval relatively poor in microfossils similarly as in the other parts of the Baltic Basin. Lack of conodonts may be linked with unstable ecological and sedimentary conditions during the relative sea-level lowstand.

Scolecodonts and melonokleritoidea are the only microfossils recognised in the upper part of the Orneta Formation of the Porkuni stage. Scolecodonts found in the Polish part of the Baltic Basin are known in Estonia from the Kuldiga Formation (Olle Hints, Institute of Geology, Tallinn University of Technology) of the lower Porkuni stage.

Simple conical conodonts of the genus *Panderodus* and Chitinozoa occur in the Barciany Nodular Limestones Formation of the Juuru stage. These microfossils are accompanied by single graptolites representing early stages of *?Normalograptus* sp. These diplograptids represent the *normalis* type, the only that survived the Late Ordovician climatic perturbation and they are characterised by the Upper Ordovician and the Lower Silurian assemblages in the western part of the Baltic Basin.

Carbon and oxygen isotope curves pointing to a global climatic-ecological event in the Hirnantian were obtained for the first time from the area of Poland. General trends of the carbon isotope curves in all studied sections from the Polish part of Baltica are analogous to curves from other parts of Baltoscandia, particularly Estonia. This is the case of sections located within the Central Baltoscandian, North Estonian and Lithuanian confacies, as well as in the Scanian confacies representing the most distal part of the basin.

The record of lithofacies, palaeontological and geochemical (isotope) changes from the Baltic Basin is a crucial element of knowledge about the Upper Ordovician and the Lower Silurian history during environmental changes and the mass extinction, confirming the global character of these climatic, eustatic and ecological events in the Late Ordovician.

Foraminiferal assemblages and biostratigraphy of Palaeocene and Eocene of the South-East of Western Siberia

Vera M. PODOBINA

Tomsk State University, 36, Lenin ave., Tomsk, 634050, Russia; podobina@ggf.tsu.ru

The paper presents the findings on the Palaeocene and Eocene biostratigraphy based on foraminifera. These microorganisms have been recovered from numerous core samples when studying the borehole T-29 section (the suburbs of towns Tomsk and Seversk – Podobina, 2007).

The Talitskian (Palaeocene) and Lyulinvorskian (Eocene) horizons lack the continuous clay rich deposits as compared with the central district, and the alternation of argillaceous and arenaceous bands is observed.

Tests of the Selandian assemblage recovered from the depth of 234.0–230.0 m are well preserved in comparison with superjacent ones. Among them the characteristic benthic and planktonic forms of the *Cibicidoides proprius* Assemblage are recognised. The beds containing this assemblage are replaced by deep-sea facies of the *Ammoscalaria friabilis* Zone. Within the overlying Thanetian beds (at 229.4–228.0 m) the sparse sugary-white tests of the *Glomospira gordialis*–*Cyclammina cok-suvorovae* Assemblage have been encountered along with pseudomorphs. This assemblage is of widespread occurrence throughout the eastern part of Western Siberia.

Of interest are findings of calcareous benthic and planktonic forms preserved satisfactorily in the Lower Eocene deposits. Here (at 227.5–224.0 m; the lowermost Lyulinvorskian horizon), the characteristic Ypresian species of Planorotalitae have been distinguished along with the species *Textularia* cf. *sibirica* Podobina, *Anomalinoides* cf. *ypresiensis* (ten Dam) *ovatus* Podobina and other forms. The beds bearing these species can be correlated with the Ypresian beds with the *Textularia sibirica*–*Anomalinoides ypresiensis ovatus* Zone of the central district (Podobina, 1998, 2004).

The Lutetian *Eponides candidulus*–*Cibicides tenellus* Assemblage has been encountered within the overlying yellowish-gray clays (218.4–214.6 m) of the middle beds of the Lyulinvorskian horizon. Along with the index species, *Cibicides carinatus* Terquem, *Rotalia discoides* Orbigny, *Bolivina* cf. *crenulata* Cushman are the characteristic Lutetian species. This assemblage has been found to correspond to that of the Lutetian Stage of Northern Europe (Doppert and Neele, 1983; Murray and Wright, 1974). As to the position within the section, the beds bearing the stated assemblage can be correlated in the central district with the middle beds of the Lyulinvorskian horizon containing the *Bolivinopsis spectabilis* Assemblage.

The dark-gray silty clays of the overlying beds of the Lyulinvorskian horizon bear the characteristic Bartonian species at depth 214.6–206.0 m: *Cibicidoides* cf. *ungerianus* (Orbigny), *Pararotalia* cf. *spinigera* (Le Calvez) and others. In the central district they correspond to the deposits bearing the agglutinated forms of the *Gaudryinopsis subbotinae* Assemblage.

The pseudomorphs of Rotaliidae, Nonionidae, Elphidiidae of the presumed Priabonian age have been encountered within the overlying gray siltstones and sandstones of the uppermost Lyulinvorskian horizon (206.0–197.0 m). The similar systematic composition is observed in the stratotype sections of the Priabonian Stage (Upper Eocene) of Northern Europe. This indicates the common uplifting of the territories of Northern Europe and Western Siberia and the shallowing of the basins resulting in changes, principally the impoverishment, of the systematic and numeric composition of foraminifera.

Evidence for precursors to the PETM displayed by the Palaeocene foraminiferal record in the Contessa Road Section, Umbria-Marche Basin (Italy)

Kimberley POOL and Michael A. KAMINSKI

Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, UK; m.kaminski@ucl.ac.uk

Faunal abundance and diversity changes were documented leading up to the Palaeocene–Eocene Thermal Maximum (PETM) in the Scaglia Rossa Formation at Contessa Road, Umbria-Marche Basin, Italy. Analysis was carried out to determine whether there were any sedimentological and faunal precursors to the PETM event by documenting the Palaeocene Deep-water Agglutinated Foraminifera (DWAf) and faunal changes up to the boundary. Sampling was carried out in the Contessa Road section near Gubbio, Italy. Morphogroup analysis, Cluster Analysis, and Principal Components Analysis were carried out. Data show relative abundance and diversity changes in the DWAf within the Palaeocene. Rapid faunal changes associated with Milankovitch cycles within the upper Palaeocene their relationship to the PETM were also investigated. Results were then linked into previous studies (Galeotti *et al.*, 2004) to build up the longer time record up to and above the P/E boundary in Contessa.

The pelagic sediments of the Scaglia Rossa Formation at Contessa were deposited in a deep water continental margin basin well above the Calcite Compensation Depth (CCD). These sediments characteristically lack macrofauna, but are dominated by planktonic foraminifera. Benthic foraminifera from the study area represent sediment deposition at a lower bathyal depth, not deeper than 1000–1500 m (Giusberti, 2009).

Mostly infaunal foraminiferal taxa disappear at the P/E boundary; agglutinated foraminifera are well preserved in the Contessa sections. Deep-sea calcareous forms were badly affected, as the ocean became corrosive to CaCO₃ when the CCD shallowed. Within the Contessa section the P/E event is manifested by changes in abundance, size, diversity and shifts in the proportions of agglutinated foraminiferal morphogroups. Agglutinated forms display a turnover of 17% compared to 50% of the calcareous benthics (Galeotti *et al.*, 2004; Giusberti, 2009).

The main purpose of this study is to increase our understanding of the DWAf palaeoecology and to construct a longer record of events leading up to this mass important extinction event, and assess whether or not this mass extinction was unique, or just a more dramatic example of late Palaeocene faunal change. Previous to this investigation, the Contessa Road section of the Palaeocene had not been investigated in sufficient detail to address this question.

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A preliminary report of Silurian graptolites from erratic boulders of Mokrzyszów quarry (Lower Silesia, Poland)

Sigitas RADZEVIČIUS¹, Paweł RACZYŃSKI² and Kamil PLUTA²

¹ Vilnius University, Department of Geology and Mineralogy, M.K. Čiurlionio 21/27, LT-03101 Vilnius, Lithuania; sigitas.radzevicius@gf.vu.lt

² Wrocław University, Department of Stratigraphy, Institute of Geological Sciences, Cybulskiego 30, 50-205 Wrocław, Poland; pawel.raczynski@ing.uni.wroc.pl

Mokrzyszów quarry is situated 3 km to the east of Świebodzice in the area of the Cainozoic tectonic graben Roztoka-Mokrzyszów separating the Świebodzice depression from the Fore-Sudetic Block. The quarry lies over 1 km to the north of the Sudetic Marginal Fault. In this area the thickness of the Cainozoic formation runs over 400 m, tens of meters of which are composed of glacial gravel connected with the Odranian glacier. In the thick crumbly fraction (gravel and boulder) to 3 meters in diameter Lower Palaeozoic “Baltic limestone” pebbles dominate (35–45%) with Scandinavian crystalline rocks (32–39%). The remaining part consists of quartzites, white sandstones, Mesozoic limestones, flints and grey granites. Some of them may come from the Sudetes.

Silurian graptolites occur in the “Baltic limestone” rocks, found in the Mokrzyszów quarry. Their variety is enough wide both in species quantity and age. *Monograptus flemingi* and *Pristiograptus pseudodubius* are the oldest graptolites found in Mokrzyszów quarry. They are from the middle Wenlock (*radians*–*lundgreni* biozones). *Gothograptus nassa* and *Pristiograptus parvus* (*parvus*–*nassa* biozones), *P. praedeubeli*, *P. deubeli* (*praedeubeli*–*deubeli* biozones) are found in the upper Wenlock. *P. parvus* and *G. nassa* (*parvus* biozone) were found on one side of a boulder, and the younger *P. praedeubeli* (*praedeubeli* biozone) species – on the other side. Mostly boulders with lower Ludlow graptolites were found: *Neodiversograptus nilssoni*, *Colonograptus colonus*, *Saetograptus varians*, *S. chimaera*, *Bohemograptus bohemicus*, *Monograptus uncinatus*, *P. dubius frequens*, *Lobograptus progenitor* and *L. scanicus*. These graptolites are from the *nilssoni*–*scanicus* biozones. *Formosograptus formosus* from the *formosus* biozone (uppermost Ludlow) was found. In summary in Mokrzyszów quarry the middle Wenlock–uppermost Ludlow (the lower Ludlow graptolites dominate) graptolites were determined.



The stratigraphic role of *Stensioeina* (benthic foraminifera), its phylogenetic evolution and palaeobiogeography in the Turonian–Santonian of the East European Platform and Mangyshlak Peninsula

Aleksey Yu. SADEKOV¹ and Vladimir N. BENYAMOVSKIY²

¹ University of Edinburgh, Grant Institute of GeoSciences, The King's Buildings, West Mains Road, Edinburgh EH 9 3JW, UK; aleksey.sadekov@ed.ac.uk

² Geological Institute, Russian Academy of Sciences, Pyzhnevskiy line 7, Moscow 1190117, Russia; ben36@mail.ru

Taxa of the genus *Stensioeina* play a significant role in the zonal stratigraphy of the middle Turonian–Santonian of the East European Platform and in the neighbouring Mangyshlak peninsula (Beniamovski, 2008a, b).

The middle–upper Turonian Subzone LC5a includes *Stensioeina praeexsculpta* (Keller, 1935), and *S. laevigata* Akimetz, 1961 (= *S. polonica* Witwicka, 1958).

The Lower Coniacian Subzone LC6a is characterised by the first appearance of *S. granulata* (Olbertz, 1942) and single rare specimens of *S. emscherica* Baryshnikova, 1959. *Stensioeina praeexsculpta* and *S. laevigata* continue to be present.

The middle Coniacian Subzone LC7 contains a mass occurrence of *S. emscherica* (acme), the disappearance of *S. praeexsculpta*, and the first rare appearance of *S. exsculpta* (Reuss).

The upper middle Coniacian–Lower Santonian Zone LC8 is characterised by an acme of *S. exsculpta*, and the disappearance *S. emscherica* and *S. laevigata*.

The upper lower Santonian Subzone LC8c: the mass occurrence of *S. exsculpta*, first appearances of rare *S. gracilis* Brotzen, 1945 and *S. incondita* Koch, 1977 are observed.

The middle Santonian Zone LC9 is characterised by the mass occurrence of *S. incondita* (acme) and *S. exsculpta* and the appearance of rare *S. perfecta* Koch, 1977.

The upper Santonian Zone LC211 is denoted by the first occurrence of *S. pommerana* Brotzen, 1945, and the continued wide distribution of *S. exsculpta*, *S. gracilis*, and *S. incondita*.

Revision of the different *Stensioeina* species allows us to distinguish two stages of the phylogenetic evolution of this genus:

Stage I (middle Turonian–middle Coniacian). All species from this interval are characterised by the “*praeexsculpta*” type of umbilical morphology. Subdivision of species is based on the spiral side morphology, which has two different trends in evolution:

- gradation from “*praeexsculpta*” to “*granulata*”, and
- gradation from “*laevigata*” to “*emsherica*”.

Stage II (Middle Coniacian–Santonian) species differentiation is based on the construction of the umbilical area on ventral side of the test. This stage can be subdivided into three phases according to the evolution of the umbilical area:

- Middle Coniacian to beginning of Santonian: domination of species with the “*exsculpta*” type of umbilical area.
- Middle Santonian to beginning of Campanian: widespread occurrence of species with “*incondita*” and “*exsculpta*” type of umbilical area.
- Late Santonian to Early Campanian: domination of taxa with “*pommerana*” and continued widespread occurrence of the “*exsculpta*” type of umbilical area.

According to the phylogeny of *Stensioeina*, we suggest subdividing this genus into three subgenera:

1) *Laevigatia* subgen. nov. (type species – *Stensioeina laevigata* Akimetz, 1961) – includes *S. praeexsculpta*, *S. laevigata*, *S. emscherica*.

2) *Exsculptia* subgen. nov. (type species – *Stensioeina exsculpta* (Reuss, 1860) – includes *S. exsculpta*, *S. gracilis*, *S. incondita*, *S. perfecta*.

3) *Pommerania* subgen. nov. (type species – *Stensioeina pommerana* Brotzen, 1936) – includes *S. pommerana*.

Palaeobiogeographical distribution of *Stensioina* species based on this study and data from existing literature suggest that first members of *Stensioina* lineage appeared in the Early Turonian in NW Germany. Late in the second half of the mid Turonian, the geographic range of *Stensioina* extended south of the Eastern European Platform and the Crimean peninsula. During the Coniacian, *Stensioina* species migrated eastwards and reached the Mangyshlak peninsula area (Western Kazakhstan). This research was supported by SS-4185.2008.5.

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A palaeobathymetric study of the Upper Cretaceous of the southwestern Barents Sea based on analyses of foraminiferal assemblages

Eiichi SETOYAMA¹, Jarosław TYSZKA¹ and Michael A. KAMINSKI²

¹ Polish Academy of Sciences, Institute of Geological Sciences, Cracow Research Centre, ul. Senacka 1, 31-002, Kraków, Poland; ndsetoya@cyf-kr.edu.pl; ndtyszka@cyf-kr.edu.pl

² Department of Earth Sciences, University College London, Gower Street, London WC1E 6BT, UK; m.kaminski@ucl.ac.uk

The southwestern Barents Sea, located adjacent to the northern terminus of the Norwegian Sea, has served as a part of seaway connecting the Atlantic Ocean with the Arctic Ocean through much of Mesozoic and Cainozoic times. In this study, we analysed foraminiferal assemblages recovered from the Upper Cretaceous of the southwestern Barents Sea, the Kveite Formation (wells 7119/9-1, 7119/12-1 and 7120/7-3) and the Kviting Formation (wells 7120/5-1 and 7121/5-1). Thick sequences of the Kveite Formation, consisting of mudstones and claystones, are found in the Tromsø Basin and the Ringvassøy-Loppa Fault Complex thinning eastwards into the Hammerfest Basin and changing laterally into the more sandy, carbonaceous and condensed Kviting Formation. In both formations, the foraminiferal assemblages consist of a diverse “flysch type” fauna. In the Kveite Formation, foraminifera are abundant, and specimens are well-preserved, while assemblages in the Kviting Formation are less abundant, and the preservation of foraminifera is more variable.

During the Late Cretaceous, both formations were probably deposited at bathyal depth, but not deeper, because of frequent occurrences of *Caudammina* spp., *Glomospira* spp., *Paratrochammina* spp., *Recurvoides* spp. and *Rzehakina* spp., which are characteristic of bathyal environments, and the absence of unique species of the Late Cretaceous abyssal “Krashenninikov fauna”. The palaeogeographic position and the history of this epicontinental sea indicate an upper bathyal environment for the same time interval. The higher abundance and diversity of foraminifera and the higher proportion of tubular agglutinated forms in the Kveite Formation suggest that this formation was probably deposited deeper than the Kviting Formation.

There is no flux of opportunistic taxa nor a sudden increase in the proportion of intermediate to deep infaunal taxa recorded in the Kveite Formation. Along with this fact, consistent domination of the assemblages by tubular forms and epifaunal forms with complex trophic relationships and fully occupied niches suggest that the Kveite Formation was deposited in a well-oxygenated, meso-oligotrophic normal marine environment.

In the lower portion of the Kveite Formation, much increased abundances of planktonic foraminifera, not found in the upper portion, are recorded in all three wells. This planktonic event might be a response to regression that began in the late Campanian. This event is, however, not observed in the shallow-facies Kviting Formation due to the virtual absence of planktonic foraminifera.



Conodont faunas from the Lower to Middle Ordovician (Volkhov Stage) in Lithuania

Auksė ŠILEIKYTĖ

Institute of Geology and Geography, Ševčenkos 13, 03223 Vilnius, Lithuania; aukse@geo.lt

In Lithuania, the multielement classification of Ordovician conodonts has been used in the study only episodically. No preserved conodont apparatuses have been found, and often difficulties arise in determination to which apparatus a particular specimen belongs. Recently, an attempt was made by the author to apply the multielement taxonomy to the Lower and Middle Ordovician (Volkhov Stage) conodonts of the Sutkai-86, Bliūdžiai-96, Pamituvys-98 and Graužai-105 borehole cores (from middle and southwestern Lithuania). The conodont samples from the last three boring points were collected by V. Saladžius (before 1994). Thus these samples were newly revised under the multielement classification.

Twenty two samples were studied, two of which (from the depths 1379.0 and 968.2 m) belong to the Salantai Formation of the Lower Ordovician Pakerort Regional Stage (RS). In these samples, *Cordylodus angulatus* and *Paroistodus numarcuatus* have been established (the *Cordylodus angulatus* Zone).

In the glauconitic sandstones from the Latorp RS (Leetse Formation), *Cordylodus angulatus*, *Paltodus deltifer pristinus*, *P. cf. P. subaequalis*, *Oistodus lanceolatus*, *Drepanodus arcuatus*, *Drepanoistodus forceps*, *D. basiovalis*, *D. suberectus*, *Paroistodus parallelus*, *P. proteus*, *Scolopodus rex*, *Semiacontiodus cornuformis* and *Protopanderodus rectus* were identified. Sutkai-86 borehole core has yielded *Microzarkodina flabellum* at a depth of 1127.6 m, the Armonys Formation (upper Latorp Substage). This species, according to literature sources, is characteristic of the Volkhov Stage. The conodont-based dating of rocks is still an open question due to scarce materials. The Armonys Fm. of the Graužai-105 borehole is distinguished by the entry of *Decoriconus peselephantis* (at 966.7 m.).

Conodonts of the Volkhov RS are predominantly represented by the mentioned earlier (Latorp RS) and ranged through *Paroistodus parallelus*, *Drepanoistodus basiovalis*, *D. suberectus* and *Protopanderodus rectus*. *Paroistodus originalis* appears in only one sample from the Spalviškiai Formation (upper Volkhov), as well as *Scalpellodus gracilis* that was discovered in the Gindviliai Formation.

The most diverse conodont association is established in the Leetse Fm. of the Sutkai-86 borehole. In the Baltic region, basing on publications the appearance of *Protopanderodus rectus* is marked in the *Oepicodus evae* Zone of the late Latorp, whereas *Scolopodus rex* ranges through the entire Latorp.



Biostratigraphic significance of foraminifera in the Oxfordian and Kimmeridgian boundary deposits in the Peribaltic Syncline (NE Poland) – preliminary results

Jolanta SMOLEŃ

Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland; jolanta.smolen@pgi.gov.pl

Micropalaeontological studies were based on investigation of the assemblages of foraminifera from the Bartoszyce IG 1, Pasłęk IG 1 and Gołdap IG 1 wells located in the Peribaltic Syncline (NE Poland). The study interval consists of a succession of Łyna Formation mudstones, marly mudstones, clayey or arenaceous deposits. The study is the revision of previous work in this region (Bielecka & Styk, 1966) in connection with the revision of ammonite stratigraphy and the proposition of the new position of the Oxfordian/Kimmeridgian boundary. The most significant results were obtained in the Bartoszyce IG 1 well where detailed biostratigraphy based on ammonites and dinoflagellates were defined (Barski *et al.*, 2005). The Oxfordian/Kimmeridgian boundary in this well is established within the Submediterranean ammonite Zone *Bimammatum* and it is correlated with the lower boundary of the Subboreal *Baylei* Zone and lower boundary of the Boreal *Bauhini* Zone.

The micropalaeontological study based on foraminifera in well Bartoszyce IG 1 showed that changes of the foraminiferal assemblages correspond with the ammonites and dinoflagellates zonation (Smoleń, 2008). The first occurrence of Kimmeridgian foraminiferal species is observed within the ammonite *Bimammatum* Zone (probably near boundary of the *Hypselum* and *Bimammatum* Subzones) in the deposits at a depth of 606.2 m. The index species of the Lower Kimmeridgian are: *Trocholina solecensis* Bielecka & Pożaryski, *Tristix suprajurassica* (Paalzow), *Fronidularia lingulaeformis* Schwager and *Epistomina stelicostata* Bielecka & Pożaryski, *Quinqueloculina jurassica* Bielecka & Styk and *Conorboides marginata* Lloyd.

Unfortunately in the Pasłęk IG 1 and Gołdap IG 1 wells the revision of the ammonite stratigraphy has not been done. Consequently in these sections biostratigraphy based on foraminifera was preliminary established by comparison with the Bartoszyce IG 1 well. In the Gołdap IG 1 well Kimmeridgian species such as: *Ophthalmidium milioliniforme* (Paalzow), *Eoguttulina liassica* (Strickland), *Quinqueloculina jurassica* Bielecka & Styk and *Conorboides cf. marginata* Lloyd were observed in a sample from a depth of 539.8 m in the deposits included hitherto in the uppermost Oxfordian (Dembowska & Malinowska, 1974). In the Pasłęk IG 1 well the Kimmeridgian foraminifera occur in a sample from a depth of 757.0 m. This association contains many species characteristic for the deposits of the upper part of the Lower Kimmeridgian. Below a depth of 757.0 m typical Oxfordian assemblages of foraminifera are present. The observations of the changes in foraminifera assemblages in the Pasłęk IG 1 section can suggest some gap near the Oxfordian/Kimmeridgian boundary.

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The foraminifera of the Karpatian Garáb Schlier Formation (North Hungary) in the Mátraverebély 122 borehole

András Szabolc SÓRON

*Eötvös Loránd University, Department of Physical and Applied Geology, 1117 Budapest, Pázmány Péter sétány 1/C, Hungary;
soron.andras@gmail.com.*

The aim of this study was the taxonomical, palaeoecological and biostratigraphical analysis of the foraminiferal assemblages of the Garáb Schlier Formation. The additional purpose was a palaeogeographic interpretation by the usage of earlier studies.

The Mátraverebély (Mv.) 122 borehole was studied in detail. The Mv. 122 borehole was drilled in 1977, and cut through the Garáb Schlier Formation between 177.0 m and 698.0 m. A total of 127 samples were collected, each 500 g. Of these 87 samples contained a convenient number of specimens for quantitative foraminiferal analysis.

Diversity indices, palaeobathymetric and temperature estimation and BFOI were used for the palaeoecological investigations. The studied fauna was compared with recent and other Karpatian Northern Hungarian assemblages, and the following conclusions can be drawn:

- The age of the studied interval is Karpatian, and corresponds to the the M4b planktonic foraminiferal zone.
- The foraminiferal fauna lived in normal salinity, cool, marine environment. The bottom water was well oxygenated.

Palaeoecological data indicate deep-water, transitional, and shallow-water assemblages. The assemblages corresponds to the Recent faunas of the northeastern Atlantic and the western Mediterranean areas.

The sedimentation rate was high.

Further study will refine the interpretations of the palaeogeographical and palaeoecological conditions of Karpatian sea (e.g. the hypothetic connection between North Hungary and the Mecsek area).

A later aims will be the complex analysis and comparison of the Cainozoic schlier foraminifera faunas from the Central Paratethys.



Calcareous foraminiferal assemblages in flysch series as a record of submarine mass movements in the Northern Carpathian Basin (Subsilesian, Silesian and Skole units)

Andrzej SZYDŁO

Polish Geological Institute, Carpathian Branch, Skrzatów 1, 31-560 Kraków, Poland; andrzej.szydlo@chello.pl

Slumped and olistostrome series have been widely reported from many localities along the northern margins of the Czech, Polish and Ukrainian Outer Carpathians. They are composed of deformed masses/bodies including heterogeneous blocks (olistolites, exotics) and mud (marls, marly shales, calcareous and arenaceous shales) that accumulated as semi fluid bodies by submarine gravity sliding and erosional reworking by currents. These submarine depositional processes were generated by the tectonic transformation of the Outer Carpathian Basin during Jurassic–Neogene times.

The facies influenced by tectonic events include specific shallow water foraminiferal assemblages, which consist of calcareous benthic and planktonic forms. In many cases, the calcareous microfauna also included forms presenting agglutinated calcareous cement. Highly diverse benthic foraminiferal assemblages, dominated by shallow and deep infaunal morphogroups occur in the Tithonian and upper Senonian marls. These deposits were previously accumulated on shelves, and then totally slumped on the slope. A remarkably well-developed epifaunal component was recognised in deposits distributed by submarine flows (Senonian marls, Palaeocene and Eocene clays, Oligocene mudstones with olistolites) and turbidite currents (Albian–Cenomanian and Palaeocene turbidites). In the last case calcareous benthic microfauna occurred episodically. The benthic forms were usually accompanied by plankton foraminifers (Cenomanian Hedbergellidae and Heterohelicidae, Late Senonian Heterohelicidae, Globotruncanidae, and Abathomphalidae or Palaeogene globigerinids). The tests of the studied foraminifers were usually small, and poorly preserved, showing dissolution traces, and abraded and corroded surfaces. The number, taphonomic variability and preservation of foraminifers correspond to depositional and environmental instabilities on the shelves and submarine rises, which were frequently rebuilt during the geotectonic evolution of the Northern Carpathian.



The microbiostratigraphy of the Bathonian–Valanginian formations of Georgia

Vakhtang TODRIA

Georgian National Museum, Institute of Paleobiology, Niagvris 4, Tbilisi 0108, Georgia; vaxtangtodria@yahoo.com

It was ascertained that at the end of the Middle Jurassic epoch, starting from Late Bajocian till almost Early Oxfordian stage inclusive, the ammodiscid-nodosariid and epistomid-spirillinid associations of the Subboreal type were predominantly present in the basins of the region and they resemble the synchronic association of Central and Eastern Europe. In the Late Jurassic and at the beginning of the Early Cretaceous epochs, particularly in the Middle Oxfordian–Valanginian, a typically Mediterranean foraminiferal association mostly of lituolid-pavonitid type spread here. Moreover, in the Middle Tithonian–Early Hauterivian stages planktonic tintinnids, so characteristic of the Mediterranean, spread in the region. The stratigraphic position of the microfaunal assemblages described above allowed for a somewhat innovative approach to the interpretation, supplementation and development of common biostratigraphical schemes of the Bathonian–Valanginian sediments on the territory of Georgia. In Middle–Upper Jurassic and Lower Cretaceous flysch, mainly in carbonate sediments it was possible to achieve a biostratigraphic division of the lithological suite into cycles or less frequently into semicycles for the first time. Thus, a boundary between the Jurassic and Cretaceous systems was defined. In epicontinental formations in the Gagra-Djava zone of the same Ford system, at least in Racha, the transgression age was ascertained as Late Bathonian (possibly Middle Bathonian) whereas earlier it had been considered to be Late Jurassic (Callovian). Accordingly the age of the carbonate-terrigenous suite of Tsesi (determined earlier mainly on the basis of ammonites) was confirmed as Middle–Late Bathonian to Early Oxfordian. The predominantly Lusitanian age of the reef formations (Veluantha suite) in the Racha epicontinental basin, which earlier had been established by a coral study (Bendukidze, 1982), was also confirmed. Further, by means of an examination of the microfauna (foraminifers and tintinnids), this formation was dated as Middle Oxfordian–Middle Tithonian (Todria, 2000). Accordingly, the backreef, lagoon-epicontinental suite of Racha appears to be from the same period. The Bzibian suite formed in the backreef lagoon of the West-Abkhasian epicontinental basin is considered to be of the same age. In accordance with this information, it was established for the first time that in the Racha epicontinental basin the process of reef genesis ended and the so called “Early Cretaceous” transgression started in the Late Tithonian time. Also in Racha, an examination of mollusks (Kakabadze & Keleprishvili, 1991), foraminifers and calpionellids (defined by Todria) made it possible to establish the age of the lower layers of the Tskhanari and Khidikari carbonate suits as Berriasian–Valanginian. It was discovered that the northern periphery of the Dzirula massif of the Georgian Block, as well as the Arthvin-Bolnisi Blok underwent Early Cretaceous transgression in Late Berriasian–Early Valanginian time. At that time the carbonate sediments with undulating incongruousness and a strong base formations in the foundation covered the Okriba formation of the lagoon-continental suite, whereas the sediments similar to these on the Khrami crystalline protuberance gradually turned into quite hard crystalline limestone (Todria, 2004). In contrast to the Racha and Bzibian reefal, lagoon-epicontinental, suite in the Transcaucasian intermontane region Okribian lagoon-continental suite was deposited over considerably longer period—from Early or Middle Callovian till the end of the Tithonian (or the beginning of the Early Berriasian).

Palaeoenvironmental reconstruction of the Sarmatian (Middle Miocene) Central Paratethys based on palaeontological and geochemical analyses of foraminifera, ostracods, gastropods and rodents

Emöke TOTH¹, Ágnes GÖRÖG², Christophe LECUYER³, Pierre MOISSETTE³,
Vincent BALTER⁴ and Miklos MONOSTORI²

¹ HAS-HNHM Research Group for Paleontology, H-1431 Budapest, POB 137, Hungary; cypridina1981@yahoo.com

² Department of Palaeontology, Eötvös University, H-1117 Budapest, Pázmány Péter sétány 1/c, Hungary;
gorog@ludens.elte.hu

³ UMR 5125 PEPS CNRS; Université Lyon I, Campus de la Doua, 69622 Villeurbanne cedex, France

⁴ UMR 5570 LST CNRS; Université Lyon I, Ecole Normale Supérieure de Lyon, 45 Allée d'Italie, 69364 Lyon Cedex 07, France

Palaeoenvironmental changes in the upper Middle Miocene Central Paratethys were reconstructed by using qualitative and quantitative palaeontological analyses of foraminifera and ostracods coupled with trace elemental (Mg/Ca) and stable isotope ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) analyses of their carbonate skeletons and of gastropod shells. Mean annual air temperature were estimated using the oxygen isotope composition of contemporaneous rodent teeth. The studied aquatic fossils come from two boreholes in the Zsámbék Basin (northern central Hungary), whereas the terrestrial ones are from localities in north-eastern Hungary and eastern Romania. In the studied Sarmatian successions three zones could be distinguished based on palaeontological and geochemical results. At the Badenian/Sarmatian boundary, faunal diversity decreased markedly. In the lower zone a transgressive event culminated in a seawater incursion into the semi-open basin system of the Central Paratethys. Stable bottom water temperature ($\sim 15^\circ\text{C}$) and variable salinities (20–32‰) are estimated for the Early Sarmatian Sea. The faunal changes (notably a strong reduction in biodiversity) occurring at the boundary between the lower and the middle zone can be explained by a sea-level highstand with dysoxic conditions. A relative sea-level fall is documented at the end of this middle zone. After a short regressive event, a marine connection between the Paratethys and the Mediterranean was established at the beginning of the upper zone. This is indicated by an increased microfaunal diversity and the re-appearance of marine Badenian ostracods and foraminifera which are completely absent from the older Sarmatian succession. During the upper zone, the temperatures and salinities are estimated to have fluctuated from 15°C to 21°C and from 15‰ to 43‰, respectively.



Self-organisation of reticulopodia: towards an emergent model of foraminiferal morphogenesis

Jarosław TYSZKA¹, Samuel S. BOWSER², Jeffrey L. TRAVIS³ and Paweł TOPA⁴

¹ Instytut Nauk Geologicznych PAN, Ośrodek Badawczy w Krakowie, Senacka 1, 31-002 Kraków, Poland, ndtyszka@cyf-kr.edu.pl

² Wadsworth Center, NYS Department of Health, P.O. Box 509 Albany, New York 12201, USA

³ Dept. of Biological Sci., University at Albany, SUNY, 1400 Washington Ave., NY 12222 Albany, USA

⁴ Akademia Górniczo-Hutnicza, Katedra Informatyki, Al. Mickiewicza 24, 30-059 Kraków, Poland

Foraminiferal shell morphology is genetically controlled through self-organisation of hierarchical processes mainly controlled by the genotype and just partly by environment. Therefore, shapes of foraminiferal tests emerge from the cascade of complex morphogenetic processes, basically controlled by genetic information. The key structure responsible for morphogenesis of foraminiferal shells is the cytoskeleton, thus, understanding of cytoskeletal organisation in foraminifera is our essential goal. We want to construct an emergent model describing self-organisation of granuloreticulopodia as the key structure responsible for morphogenesis of foraminiferal shells. We carry on a series of empirical studies in collaboration with cell biologists on *Allogromia laticollaris* Arnold which is treated as a model organism for studying complex pseudopodial networks. This lecture presents a brief overview of observation, problems and new ideas.

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Empirical morphospace of foraminifera: let's start from Globigerinida and Rotaliida

Jarosław TYSZKA¹, Dagmara SZEWC² and Magda SERBIAN²

¹ Instytut Nauk Geologicznych PAN, Ośrodek Badawczy w Krakowie, Senacka 1, 31-002 Kraków, Poland;
ndtyszka@cyf-kr.edu.pl

² Instytut Nauk Geologicznych, Uniwersytet Jagielloński, Oleandry 2a, 30-063 Kraków, Poland

Empirical morphospace is a space including all morphologies of a real group of organisms described by variables or characters. We have extended McGhee's (1991) definition which describes that morphospace as a n-dimensional space produced from the mathematical analysis of actual measurement data (using such techniques as PCA, FA, fractal metrics). This way binary character states, such as existence or nonexistence of characters, e.g. a basal aperture, biserial growth pattern, keel etc., can be described in binary numeral system (1 or 0). "Actual measurement data" are therefore any characters used for description of foraminiferal tests. Our aim is to test this semiquantitative system defining empirical morphospaces based on a very similar approach we use in the taxonomy.

Foraminiferal orders Globigerinida and Rotaliida (*sensu* Loeblich & Tappan, 1992) were selected because both groups share similar test morphologies and molecular phylogenetic characteristics. We do not separate Buliminida (*sensu* Sen Gupta, 2002) from Rotaliida following recent molecular results (Schweizer *et al.*, 2008). Chamber growth patterns are treated as "evolutionary inventions" or main "Baupläne". Empirical morphospaces of both groups were dominated by trochospiral forms, including 70–80% of genera on average in Globigerinida and 50–60% in Rotaliida. A streptospiral growth pattern was probably never invented by Rotaliida and is still very uncertain in Globigerinida. Proportions of growth patterns were analysed (based on genera) at different time intervals, giving an impression of a morphospace at that time. Planktonic foraminifera (Globigerinida) show their maximum expansion into the morphospace in the Cretaceous and the strongest crisis at the Cretaceous/Palaeogene boundary. Benthic Rotaliida gradually explored the morphospace with their maxima in the Neogene and Holocene. Mass extinction events did not severely impoverish the Rotaliida which means most of their growth patterns went through all critical boundaries.

Basal apertures dominate in all these groups because they are morphogenetically responsible for trocho/planispiral growth patterns. Globigerinida were nearly exclusively constructing the basal aperture in contrast to benthic groups which successfully introduced areal and terminal apertures. These apertures enabled them to explore new areas of the morphospace, e.g. uniserial growth pattern.

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Planktonic foraminiferal assemblages and biostratigraphy of the Upper Cretaceous in Lithuania

Agnė VENCKUTĖ-ALEKSIENĖ

Institute of Geology and Geography, Ševčenkos 13, 03223 Vilnius, Lithuania

The changes in the planktonic foraminiferal assemblages are examined from the Cenomanian to Maastrichtian stages in Lithuania. The main goal of this study is to present the stratigraphic distribution of the planktonic foraminifera in the Upper Cretaceous succession from Lithuania. Material for studies was sampled from nine boreholes and 244 samples were investigated.

The Upper Cretaceous sedimentary rocks (marine terrigenous and calcareous) are encountered in boreholes along the southern and the southwestern parts of Lithuania.

The continental deposition prevailed until the middle Albian and ended when new tectonic submergences began in the Polish-Lithuanian Depression. A widespread marine transgression developed from the southwest and should have occupied the area as far as the present Lithuania – Latvia border (whole northeastern part of Lithuania was eroded by glaciers in Quaternary). As a result an epicontinental comparatively shallow marine basin was formed and the maritime regime lasted uninterruptedly during the whole Late Cretaceous.

The earliest planktonic foraminiferal association from Cenomanian age is poor, monospecific and is represented by simple morphotypes as genus *Hedbergella*. Hedbergellids are widely distributed in space and time. Also there were found: *Heterohelix globulosa* (Ehrenberg), *Globigerinelloides caseyi* (Bolli, Loeblich & Tappan), *Praeglobotruncana delrioensis* (Plummer), *P. stephani* (Gandolfi), *P. gibba* Klaus, *Whiteinella baltica* (Douglas & Rankin), *W. archaeocretacea* Pessagno.

Heterohelicids and whiteinelids appear in Upper Cenomanian. Hedbergellids and heterohelicids are more abundant in samples from western part of the studied area where sedimentation was influenced by a visible influx of terrigenous particles into a shallower basin.

The listed species are of little stratigraphic value and can be used only for the regional correlation. Marker species of the genus *Rotalipora* are absent in the studied Cenomanian planktonic foraminiferal assemblages.

The gradual deepening to an 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 more diverse. Taxonomically the assemblages are largely composed of following double-keeled genera: *Helvetoglobotruncana*, *Dicarinella*, *Marginotruncana*. The highest foraminifera radiation in Lithuania was during the Middle–Late Turonian times. Marginotruncanids start to predominate in the Coniacian strata.

The evolution of planktonic foraminifera from Turonian to Campanian is characterised by increasing species richness and diversity. Foraminiferal fauna succession shows a short period of rapid diversification in the Turonian with the appearance of the genus *Marginotruncana*. Long period of stasis was interrupted in the Santonian by the disappearance of the marginotruncanids and the contemporary increasing importance and diversification of another group of more complex taxa, the globotruncanids.

The analysis of the taxonomical and morphological diversity shows that the regression-transgression cycles influence planktonic foraminiferal assemblages and produce characteristic faunal succession. Biostratigraphical zones were established according to this data. The investigation of planktonic foraminifera indicated that Upper Cretaceous assemblages have some specific peculiarities that evolved by adapting to particular environmental conditions.



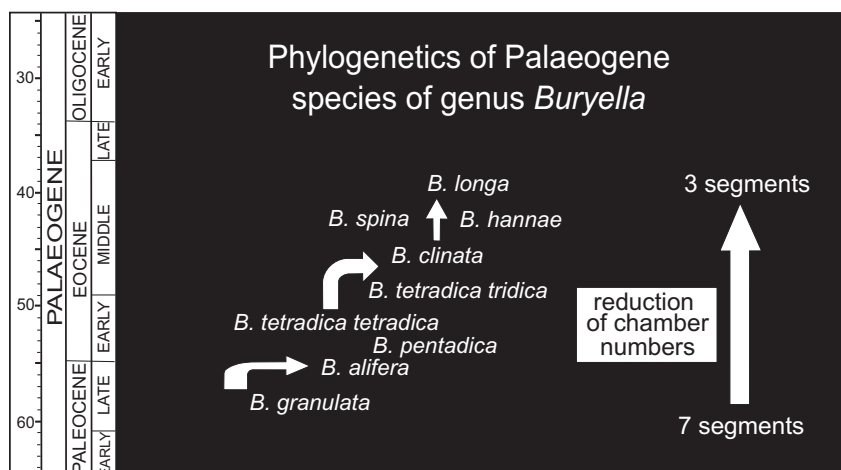
The evolution of Cretaceous–Palaeocene radiolarians

Valentina S. VISHNEVSKAYA

Geological Institute RAN, Pyzhevsky pereulok, 7, Moscow 119017, Russia; valentine@ilran.ru

The radiolarian family *Hsuidae* well represented in the Jurassic (Vishnevskaya, 2001) became extinct in the early Aptian (O'Dogherty, 1994). The arming of the radiolarian skeletons, as well as the decrease of volume size and chamber number took place in the genera *Parvicingula* and *Stichocapsa* at the Jurassic/Cretaceous boundary. Probably it was caused by hydrological changes and cooling. The extinction datum of the family *Hsuidae* coincides with extinction of the family *Parvicingulidae*. The last event corresponds to the first global oceanic anoxia event (OAE 1).

An intense speciation of the radiolarian genus *Crolanium* with first appearance in the late Barremian and last occurrences of most its species, the index species *C. cuneatum* included, was characteristic of the terminal Albian. Spheroid and discoid radiolarians were dominant in the Cenomanian. This event is in good correlation with OAE 2. The Turonian was marked by the intense development of all the radiolarian morphotypes. Within the long living conservative family *Amphipyndacidae* (Mid Jurassic–Cretaceous to Palaeocene) a mesh-like evolutionary phylogeny can be observed. Within the *Thanarla* group we have a tree-like evolutionary phylogeny. The species *T. gutta*, *T. pacifica* became extinct in the middle–late Aptian, whereas *T. brouweri* and *T. conica* became extinct to the end of Albian, *T. pulchra* appears to be restricted to the middle Albian–latest Cenomanian and *T. praeveneta*, *T. veneta* survived to the Santonian. The strong change of radiolarian assemblages took place at the Santonian/Campanian boundary: the warmer late Santonian *Pseudoaulophacus floresensis* assemblage changed by cold water early Campanian *Prunobrachium crassum*. This event corresponds to OAE 3. Cretaceous/Palaeogene boundary as typical crisis level (inside of early Palaeocene) also is characterised by the dominance of only primitive spherical tests (Basov, Vishnevskaya, 1998; Hollis 1997; Vishnevskaya, 1997; Vishnevskaya *et al.*, 2006). Genus *Buryella* demonstrates decrease in the number of chambers from 7 to 3 and an increase in the volume and size of pores (figure).



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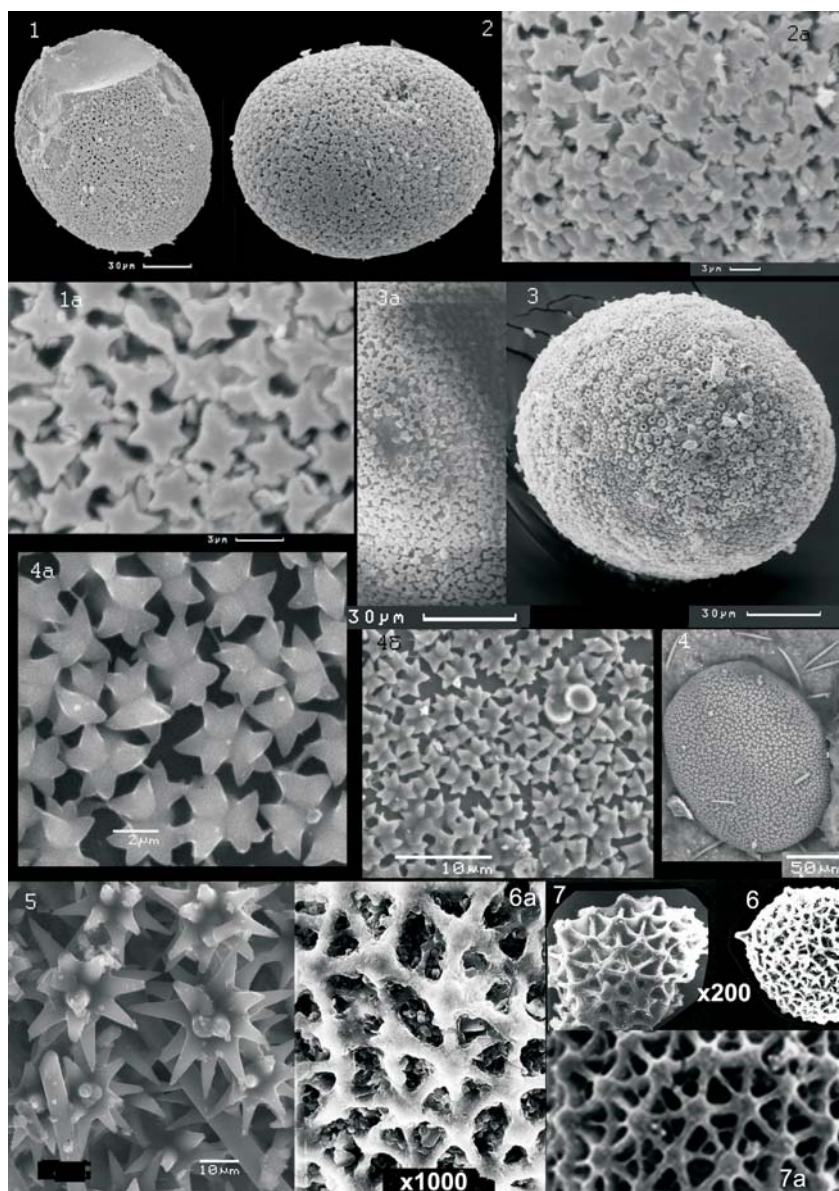


Some phenomenal structure of spicule elements of sponges and radiolarians

Valentina S. VISHNEVSKAYA

Geological Institute RAN, Pyzhevsky pereulok, 7, Moscow 119017, Russia; valentine@ilran.ru

Huang (1967) described a new genus of Radiolaria *Hataina* with type species *Hataina ovata* Huang, 1967 from the Miocene of Japan. The range was indicated as Upper Miocene to Recent, geographic distribution – bottom sediments from the seas of Japan and Taiwan. These radiolarians (*Hataina* or “OST”) are sterrasters of sponge, which were considered as problematic microorganisms (Inoue & Iwasaki, 1975) or radiolarians (Huang, 1967; Benson, 1983). Only Alexandrovich (1992) showed: sponge spicules (sterrasters) have been erroneously identified and classified as a Radiolaria by several workers because sterraster sponge spicules are greater than 63 µm and sometime are common in radiolarian samples.



Sterrasters (1–5) and radiolarians structures (6–7) [1–3 – Upper Cretaceous, Siberia, Russia; 4, 5 – Recent, Lost-City, Atlantic; 6 – Upper Cretaceous, Russian Plate, 7 – Vale Mare, Romania). 1 – Sterraster sp. 1a – detail of Sterraster. 2 – Sterraster with depression. 2a – detail of Sterraster. 3, 3a – Sterraster with canals. 4 – Sterraster and monaxon spicules. 4a, 4b – details of Sterraster. 5, 5a – siliceous sponge spines of micrasters. 6, 6a – Alievium from Boreal and 7, 7a – Alievium from Tropical provinces.

Sponges of class Hexactinellida (Müller *et al.*, 2004) represent a group of the most ancient fauna, whose siliceous fossil remains (spicules) have been traced back to Early Proterozoic (800 Ma). Sterrasters of sponges have the same sizes as radiolaria. The main peculiarity of sterraster is orientation of miriade microspicules to center of body similar to point-centered rays of the most ancient Cambrian radiolarians of family Echidninnidae. Bengtson (1986) proposed to assign Echidninnidae (radiolarians) to the Porifera (sponges). Ancient radiolarians of family Echidninnidae have one isolated or four to numerous spicules aggregated by interlocking and/or fusing to form a shell with spicules consisting of as many as about thirty point-centered rays (Won & Below, 1999). The comparison of some siliceous sponge spicules and radiolarian spines from different age intervals of Cambrian, Ordovician, Devonian, Jurassic, Cretaceous and recent sediments has been carried out. The decrease of radiolarian spicule elements in volume, loss of siliceous type of inner spicules, the change of circular spines to triangular ones and back into circular and etc., as well as decrease in the number of chambers took place during millions of years. Some detail structures of microspicules and radiolarian spines have been illustrated and their similarity, difference, connections and evolution are considered. The process of corrosion of sponge spicules and radiolarians during different stages of HF etching is discussed. The suggested approach can be important for the comparative study of the skeleton structural organization in silica-containing marine organisms. It can also find applications in developing new methods of obtaining optic silicon materials.

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Campanian cooling time and evolution of microorganisms (radiolarians and planktonic foraminifers)

Valentina VISHNEVSKAYA¹ and Ludmila KOPAEVICH²

¹ Geological Institute RAN, Pyzhevsky pereulok, 7, Moscow 119017, Russia; valentine@ilran.ru

² Moscow State University, Leninskie Gory 1, Moscow, Russia; lkopaev@geol.msu.ru

Significant changes in many groups of marine organisms (e.g., ammonites) were characteristic for the Santonian/Campanian boundary. Almost half of ammonoids became extinct at the time of the Santonian–Campanian crisis, when thin-walled genera *Canadoceras* and *Pachydiscus* replaced the thick-walled Santonian genera *Texanites*, *Menuites* among others. As it is mentioned for Radiolaria, the phylogenetic lineage of the radiolarian family Pseudoaulophacidae was interrupted in the Boreal province close to the Santonian/Campanian boundary, at the level characterised by an acme of the family Prunobrachidae and the appearance of radiolarians with multilayered spongy walls well adapted to cold-water environments.

Mass abundance of prunobrachids recorded in the lowermost Campanian is indicative of cold-water environments in the Russian Platform, Siberian, Koryak-Kamchatka regions and Vatyra seas, and also in the southern Palaeopacific. The late Santonian comparatively diverse warm-water assemblage with *Pseudoaulophacus xoresensis* gives place upward to the early Campanian less diverse cold-water assemblage with *Prunobrachium crassum*. Analysis of Prunobrachidae palaeogeography during the Santonian–Campanian time shows that practically all species of this family characteristic of temperate and high latitudes had distinct bipolar distribution. Most species of the genus *Prunobrachium* were amphiboreal, occurring now in the North Atlantic and Pacific provinces. Their distribution areas are almost symmetrical relative to the equator: 35°–62°N in the Northern Hemisphere and 50°–52°S in the Southern Hemisphere. The extinction of warm taxa of marginotruncanids (late Cretaceous planktonic foraminifers) is also connected with Santonian–Campanian boundary. Analyses of this faunal turnover have to be ascribed to a cooling event. Huber *et al.* (2002) recorded that the early Campanian marked the boundary between “hot greenhouse” and “cool greenhouse” regimes.

Microfossils data from Sakhalin and Koryak-Kamchatka regions imply that the Santonian–Campanian boundary is well recognisable in south-western circum-Pacific region in terms of biostratigraphy. As in northeastern circum-Pacific regions, it can be identified based on the compositional changes in assemblages of cold- and warm-water micropalaeontological remains. The Santonian radiolarian assemblages appear to be more thermophilic than the Campanian ones, but they all are certainly more cryophilic than the concurrent Californian assemblages. Especially abundant in the Santonian of California are diverse species of the genus *Alievium*, and many of them have high stratigraphic significance. Analysing stratigraphic ranges of these representative species, Pessagno (1976) distinguished the Turonian *Alievium superbum*, the Coniacian *Alievium praegallowayi* and the Santonian *Alievium gallowayi* radiolarian Zones. The next *Crucella espartoensis* Zone was distinguished in the Campanian, because evolution of the genus *Alievium* ceased in the early Campanian under influence of cooling. As Californian radiolarians occur more frequently in association with foraminifers, it is possible to correlate biostratigraphic zonations of both fossil groups. The Santonian *Alievium gallowayi* Zone is identical in range to the Californian foraminiferal zone *Globotruncana coronata* or to *Globotruncana bulloides* Zone of Caribbean region, whereas the lower Campanian *Crucella espartoensis* Zone of radiolarians is correlative with *Archaeoglobigerina blowi* Zone of Boreal foraminiferal scale.

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Skeletal elements of the Cambrian marine roundworms Palaeoscolecida: structure and affinities

Ryszard WRONA

*Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, 00-818 Warszawa, Poland;
wrona@twarda.pan.pl*

The scanning electron microscope (SEM) has been used to analyse internal microstructural and external morphological characters of the dissociated button-like sclerites, with special attention to the enigmatic thimble-like *Utahphospha* sclerites. This evidenced that phosphatic microfossils of the *Hadi-mopanella–Kaimenella–Milaculum–Utahphospha* morphotype are disarticulated elements of the exocuticular skeleton (scleritome) covering the entire body of the Cambrian marine roundworms Palaeoscolecida. Sclerite internal microstructure shows perpendicularly oriented horizontal canals or their mineralised infillings, which probably represent free spaces after collagen cords typical of the Recent nematomorphs (Bresciani, 1991: 204, fig. 11). The Cambrian fossil worms have elongated, cylindrical unsegmented body covered by papillate epidermis and cuticle. Papillae are arranged in transverse rows separated by an intercalation or furrow which gives their annular surface pattern, although this does not reflect an internal metameric segmentation. Epidermis may have contained apatite forming sclerotised structures, sclerites covering the entire body. Palaeoscolecoid worms were a common constituent of Cambrian marine communities (Wrona and Hamdi, 2001; Wrona, 2004; Ivantsov & Wrona, 2004), and most of them were probably infaunal, but some, with differentiated dorsal and ventral sides (seen by nipple-like? appendages or spiny sclerites) may have been adapted for a vagile epifaunal mode of life and were probably scavengers, feeding on dead animals (Müller & Hinz-Schallreuter, 1993; Zhang & Pratt, 1996; Conway Morris, 1997). Their taxonomic relationships are still incompletely resolved. Their systematic position has been considered to be within the Nematomorpha (e.g., Hou & Bergström, 1994, 2003), based mainly on the worm shape, or the Priapulida (e.g., Conway Morris, 1993, 1997), based on the existence of introvert and pharynx. Palaeoscolecids can be also included into the clade (superphylum?) Ecdysozoa containing moulting animals, such as arthropods, tardigrades, onychophorans, nematodes, nematomorphs, kinorhynchans and priapulids (e.g., Aguinaldo *et al.*, 1997; Garey and Schmidt-Rhaesa, 1998).

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Chitinozoan palaeoecological dynamics across the Silurian–Devonian transition in the Dnister Basin (Podolia, Ukraine)

Ryszard WRONA

Institute of Paleobiology, Polish Academy of Sciences, Twarda 51/55, 00-818 Warszawa, Poland; wrona@twarda.pan.pl

Chitinozoans are organic-walled microfossils of uncertain biological affinity, although the idea that they represent the egg-capsules of soft-bodied marine animals is most acceptable to date. Despite their effective application for biostratigraphy of lower Palaeozoic deposits, the palaeoecology of these organisms remains enigmatic. Stratigraphically well-documented Silurian–Devonian sequences of the Dnister River sections in Podolia, Ukraine (Nikiforova *et al.*, 1972) were studied palynologically with special attention paid to the precise biostratigraphy and palaeoecology in the framework of a multidisciplinary approach, including sedimentology and geochemistry (Małkowski *et al.*, in press). Chitinozoans reported previously from the same sections have been now collected bed-by-bed, chemically extracted and re-examined in scanning electron microscope (Wrona, 2008). The Přídolí chitinozoan assemblage recognised in the uppermost Skala horizon of the continuous S/D sediments at the Dnestrovo section, comprises *Urnochitina urna*, *Calpichitina annulata*, and *C. velata*, *Linochitina* cf. *klonkensis*, *Eisenackitina* aff. *krizi*, *Vinnalochitina* cf. *suchomastensis*, *Cingulochitina* sp., *Ancyrochitina* cf. *ancyrea*. The Lochkovian chitinozoan assemblage recovered in the Borshchiv horizon includes: *Eisenackitina bohémica*, *E. elongata*, *Cingulochitina* sp., *Calpichitina annulata*, *Margachitina catenaria*, *Ancyrochitina lemniscata*, *Ancyrochitina* aff. *aurita*, *Pterochitina megavelata*, *Linochitina* ex. gr. *ervensis*, *Angochitina tsegel'nyuki*, *Anthochitina* ex. gr. *superba*, and *A. radiata*. The Silurian–Devonian boundary in Dnister Basin were established on the base of the first appearance of the index species *M. uniformis angustidens*, within the shales and marls of the Dzvenygorod and Khudykyvtsi beds, and now can be also fixed by the occurrence of the chitinozoan index species *Eisenackitina bohémica*, and *Margachitina catenaria*, and the last appearance of *Urnochitina urna*, and *Linochitina* cf. *klonkensis*. The occurrence of characteristic chitinozoans such as *C. annulata*, *C. velata*, and *E. bohémica*, *E. elongata*, *M. catenaria*, *Anthochitina* ex. gr. *superba*, and *A. radiata* represent a clear accumulation zone within the Silurian–Devonian transition. Chitinozoan assemblages recognised in this study provide potential for the accurate correlation with other localities worldwide, and in particular with the international stratotype section at Klonk, Barrandian area, Czech Republic, and subsurface sequences in Poland. The frequency distribution of chitinozoans from Podolia demonstrates specific pattern and dynamics across the S/D transition. The results of the study confirmed opinion that chitinozoans were planktonic organisms, and could be potential for investigating environmental conditions. Most diversified and abundant chitinozoans have been documented in the uppermost Přídolí (Dzvenygorod beds) and in the lower Lochkovian (Khudykyvtsi and Mytkiv beds) of the Silurian–Devonian sequences in Podolia. The boundary interval contains relatively less diversified chitinozoan assemblages, with dominance of thick-walled, unornamented vesicles, such as: *Urnochitina* and *Linochitina*. The Lochkovian chitinozoan assemblage is dominated by thin-walled, highly ornamented vesicles, such as: *Ancyrochitina*, *Angochitina* and *Anthochitina*, accompanied by scolecodonts and numerous plant tubular filaments. Palynological results from Podolian sections are consistent with sedimentological and geochemical factors and similar to those observed in the GSSP section at Klonk (Fatka *et al.*, 2003), that can be correlated with global biogeochemical perturbation at the Silurian–Devonian boundary (Małkowski & Racki, 2009).

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Serpukhovian foraminifers of the Precaspian syncline

Elena L. ZAYTSEVA

Moscow State University, Department of Geology, GSP-1, Leninskiye Gory, 119991, Moscow, Russia; ezaitseva@mail.ru

The Serpukhovian stage (Upper Mississippian) is widely spread in Precaspian syncline and is remarkable for different composition and various fullness of section. It is mainly composed of carbonates, and it is terrigenous locally in the eastern peripheral zone. The base of the detailed stratification and correlation are foraminiferal associations. The foraminiferal zones of the General Stratigraphic Scale are recognised in the Serpukhovian of Precaspian (Resolutions..., 2003).

The lower boundary of the Serpukhovian is indistinct and shows the gradual renovation of foraminifers composition, as well as the sharp impoverishment of the fauna and increase of its diversity in the middle of the Tarussian and in the Steshevian time.

The *Neoarchaediscus postrugosus* Zone corresponds to the Tarussian and Steshevian horizons (Lower Serpukhovian). It is traced in all the peripheral parts of the Precaspian area. This Zone is determined by the appearance of the species *Neoarchaediscus postrugosus* (Reitl.), *N. parvus regularis* (Raus.) as well as rarely met in the Precaspian sections subspherical *Pseudoendothyra illustrata grandis* Reitl., *P. globosa* Ros. The typical complex includes various species (up to 85%) spread in the underlying Upper Viséan, as well as *Neoarchaediscus incertus* (Groz. & Leb.), *Loeblechia ammonoides paraammonoides* Brazhn., *Eostaffella pseudostruvei* Raus. & Bel. The *Eostaffellina paraprotvae* Zone corresponds to the protvian horizon (Upper Serpukhovian). The foraminiferal Zone is notable for the appearance of the index-species. The foraminiferal association shows the development succession: many species of *Archaeodiscus*, *Asteroarchaediscus*, *Neoarchaediscus*, *Endothyra*, *Omphalotis*, *Mediocris*, *Tetrataxis*, *Eostaffella* crossover from the underlying Zone. This level is marked by the appearance of *Eostaffellina paraprotvae* (Raus.), *E. protvae* (Raus.), *Betpakodiscus cornuspiroides* (Vdov.) as well as sporadic *Eosigmoilina* and various *Monotaxinoides*, *Bradyina cribrostomata* Raus. & Reitl. The *Monotaxinoides transitorius* Zone corresponds to the Zapaltjubian horizon of the Upper Serpukhovian. Its distribution is limited and the palaeontological evidences are documented in a number of the sections in the northern (boreholes Pavlovskaya 3, Chinarevskaya 9), eastern (Sinelnikovskaya 2, Kozhasay 2), south-eastern (Tengiz 7, 8, 42, Korolevskaya 16) and south-western (Ashunskaya 2, Nikolayevskaya 200) parts of the Precaspian area. The foraminiferal association of this zone stands out for its high taxonomic diversity. The appearance of *Monotaxinoides transitorius* (Brazhn. & Jartz.) as well as a number of species: *Globivalvulina bulloides* (Brady), *G. kamensis* Reitl., *G. scaphoidea* Reitl. and rare *Plectostaffella* cf. *varvariensis* (Brazhn. & Pot.) are typical for this level. The remarkable feature of the association is widespread occurrence of the attached forms of *Palaeonubecularia*, *Tolypammina*, *Pseudoglomospira*.

The Upper Serpukhovian boundary (Mississippian/Pennsylvanian), which coincides with the Middle Carboniferous boundary in the planetary scale, corresponds to palaeobiological events, namely the appearance of ammonoids of the *Homoceras* Zone, the conodont *Declinognathodus noduliferus* and foraminifer *Plectostaffella bogdanovkensis*. In the Precaspian area this level is stated by the appearance of the conodonts *Declinognathodus noduliferus* and foraminifers *Plectostaffella bogdanovkensis*. The strong, but gradual changes in the structure of the boundary foraminiferal assemblages are notable there. The extinction takes place of the genus and species as of higher taxonomic level. The representatives of two families (Endothyranopsidae and Janischewskinae) and the subfamily (Omphalotinae) do not survive this boundary. The sharp impoverishment above the boundary with the following increase in diversity and return of the Early Carboniferous forms is registered. Among them some 60–65 species get to survive. Three Protvian genera and seven species as well as five Zapaltjubian genera and nine species occur above the boundary. One new genus and four species (among them *Plectostaffella bogdanovkensis*) occur.

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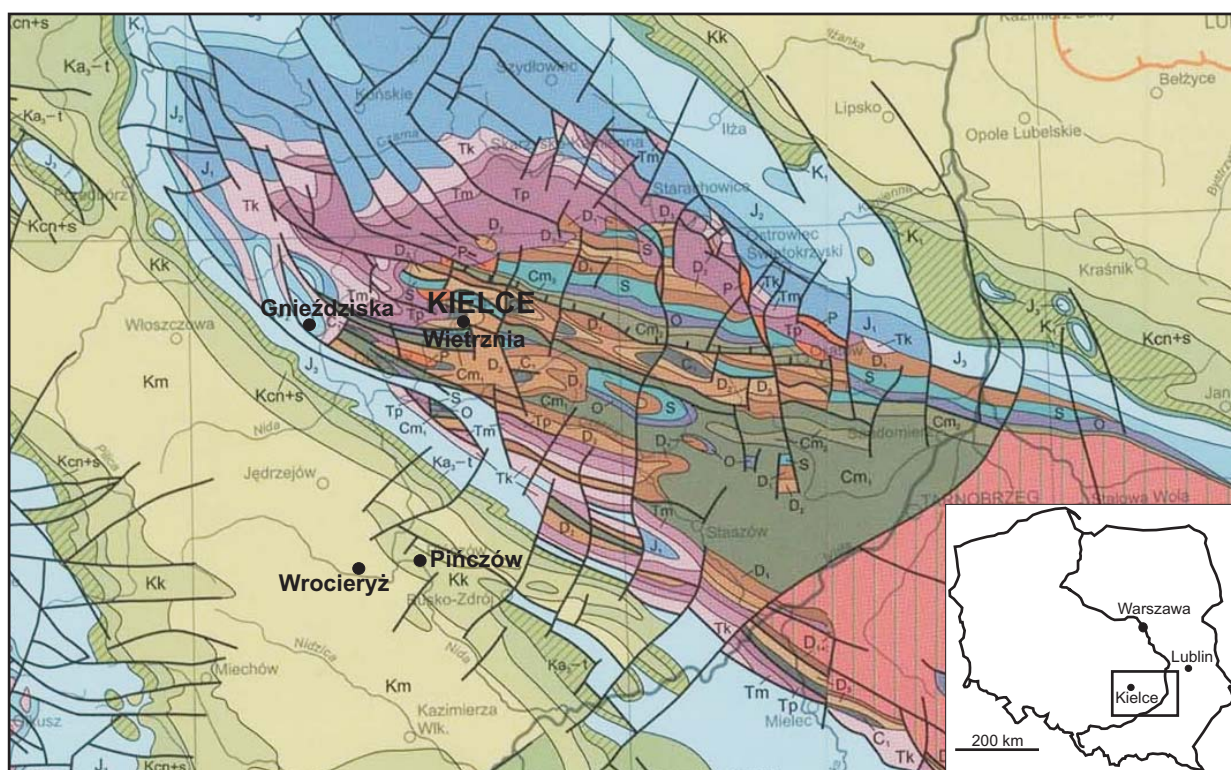
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EXCURSIONS

A BRIEF INTRODUCTION INTO THE GEOLOGY OF THE HOLY CROSS MOUNTAINS, CENTRAL POLAND

Poland is the geological heart of Europe as it lies at the contact of the main tectonic units of Europe: East European Precambrian Platform, Palaeozoic foldbelt, and Alpine foldbelt of southern Poland. The East European Precambrian Platform and Palaeozoic foldbelt are mostly covered by thick cover of Permian–Mesozoic and Cainozoic deposits of the Southern Permian Basin of Europe.

The Holy Cross Mts. region, uplifted in Miocene times (Kutek & Głazek, 1972), contains Palaeozoic and late Neoproterozoic rocks outcropping beneath the thick Permian–Mesozoic cover. It includes two different tectonostratigraphic domains: Łysogóry to the north and Kielce to the south, separated by major Holy Cross Fault which represents a terrane boundary, between the Łysogóry and Małopolska Blocks (Kroner *et al.*, 2008, with references herein). In the Łysogóry domain, Early Devonian (Pragian) clastics were deposited conformably on late Silurian rocks (Mizerski, 1995, with references herein), and in the Kielce Domain, Early Devonian (Siegenian–Emsian) sediments unconformably overlie folded Lower Palaeozoic basement (including Silurian rocks – Szulczewski, 1995, with references herein). In both domains Emsian clastic sediments are followed by Eifelian shallow-marine sediments and the sedimentary facies became spatially diversified beginning in Givetian times, however, in both domains the sedimentary record indicates progressively deeper-marine conditions from the Late Devonian (when a carbonate platform was formed) to the Visean (when basinal



Location map of studied exposures. Geological map of the Holy Cross Mountains and adjacent areas without Cainozoic cover (after Dadlez *et al.*, 2000)

and clastic deposits originated following the disintegration and submergence of the carbonate platform). The youngest rocks involved in the Variscan folding are of Visean age; the folding itself developed in a transpressional regime during the Late Carboniferous (Kroner *et al.*, 2008).

The Permian–Cretaceous tectonic evolution of the Holy Cross Mts. region was, as in the entire Central Europe, the transition from a period of thermally related subsidence to one of active rifting followed by compression (Scheck-Wenderoth *et al.*, 2008), and it was controlled by the Teisseyre–Tornquist Zone. During the Late Permian it was the marginal part of the basin, but already during the Early Triassic the depositional area was considerably widened. Intensive subsidence of the axial part of the Polish Basin lasted until the onset of inversion activity which may have commenced as early as the Late Turonian, although in the Nida Trough basement fault zones were first inverted in Early Palaeogene times (Scheck-Wenderoth *et al.*, 2008, p. 1024).

During the Middle Miocene, the region located south of the Holy Cross Mts. constituted a marginal part of the Carpathian Foredeep Basin, where mostly shallow-marine limestones and siliciclastic deposits of the Badenian and Sarmatian were formed, as well as characteristic evaporitic deposits (e.g. famous gypsum deposits of the Nida River Valley) (Peryt & Piwocki, 2004, with references herein).

The highest peak in the Holy Cross Mts. – Łysogóry (which rise up to 300 m above surrounding plains) – belongs to the large Variscan structure – Łysogóry Anticline – asymmetric fold striking WNW-ESE and overturned (overthrust) to the south. The Łysogóry Range is famous because of block fields composed of big angular blocks of quartzitic sandstones, which cover the slopes. They developed in periglacial environment of the Late Pleistocene glacials, mainly last one (Vistulian, Würm), due to mechanical weathering and subsequent solifluction and pluvial erosion.

Danuta Peryt

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STOP 1

The Early/Middle Frasnian boundary interval and biogeochemical signals of the *punctata* Zone Isotopic Event at Wietrznia quarry (Holy Cross Mountains, Central Poland)

Agnieszka PISARZOWSKA

Institute of Geological Sciences, Polish Academy of Sciences, Cracow Research Centre, ul. Senacka 1, 31-002, Kraków, Poland; ndpisarz@cyf-kr.edu.pl

The abandoned quarry Wietrznia-I situated three kilometers southeast of Kielce city centre, on the Wietrznia Hill, within the southern limb of the Kielce Syncline (see map of p. 85; Figs 1, 2).

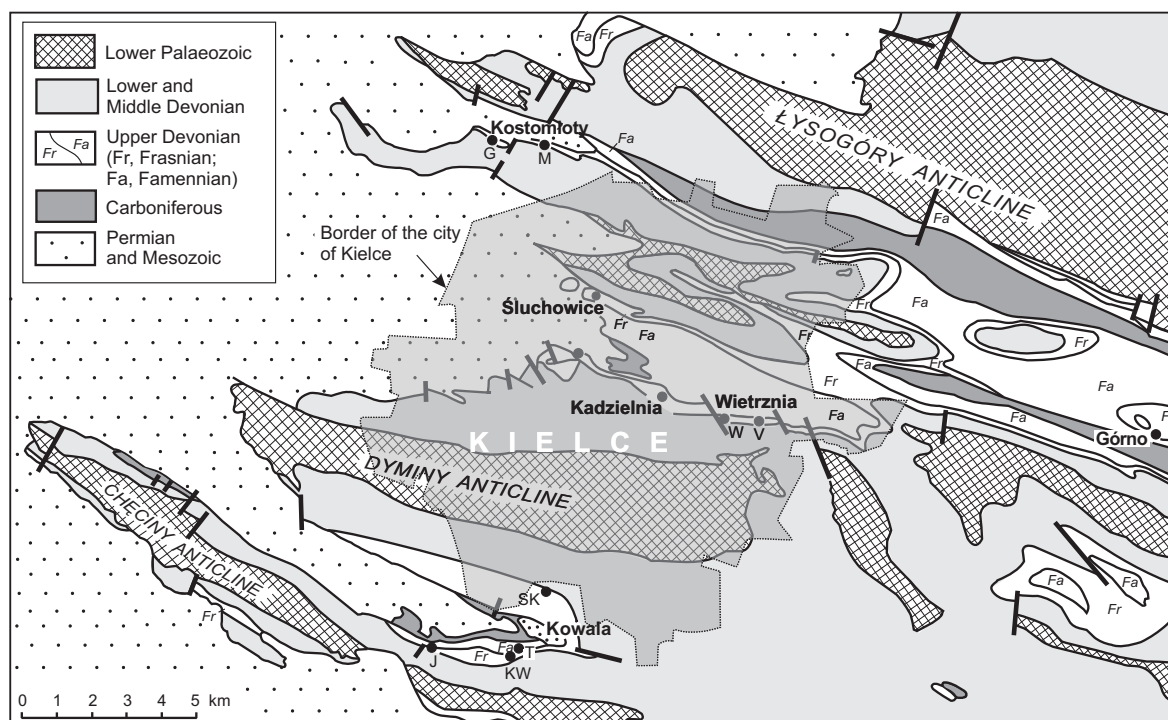


Fig. 1. Location map of studied Early to Middle Frasnian exposures in the Holy Cross Mountains (based on Szulczewski 1971: fig. 1; from Pisarzowska *et al.*, 2006).

Geological setting: The inactive Wietrznia quarry, preserved as the Zbigniew Rubinowski Reserve, is located in the eastern Kadzielnia Chain, in the southern part of Kielce (Fig. 2). The outcrop forms three quarries: Wietrznia (Wietrznia-I in Szulczewski, 1971), Międzygórz and Eastern Międzygórz (designated after Szulczewski, 1971 as Wietrznia-II).

Lithology: In exposed Frasnian limestones, Szulczewski (1971) distinguished five lithological units (A through E). Lithological unit A consists of thin-bedded detrital limestones intercalated with *Amphipora*-bearing marly intercalations (Racki & Bultynck, 1993) as well as thick-bedded to almost massive biorudites (set B) including tabular and rugose corals, stromatoporoids, brachiopods, and crinoid debris belonging to the lower Wietrznia Beds (Szulczewski, 1971; Racki *et al.*, 1993).

The middle to upper Wietrznia beds were studied in detail by Racki & Bultynck (1993), Racki *et al.* (1993), Pisarzowska *et al.* (2006) and Vierek (2007a, b). Lithological units C and D are very well exposed in sections WId-W and Wle (Fig. 3) located in the northern part of the Wietrznia-I quarry. Units C and D exhibit a distinct lateral variation traced over a distance of ca. 100 m. In the proximal WId-W section, Unit C comprises thin beds of knobby and/or wavy-bedded bituminous micrites intercalated with

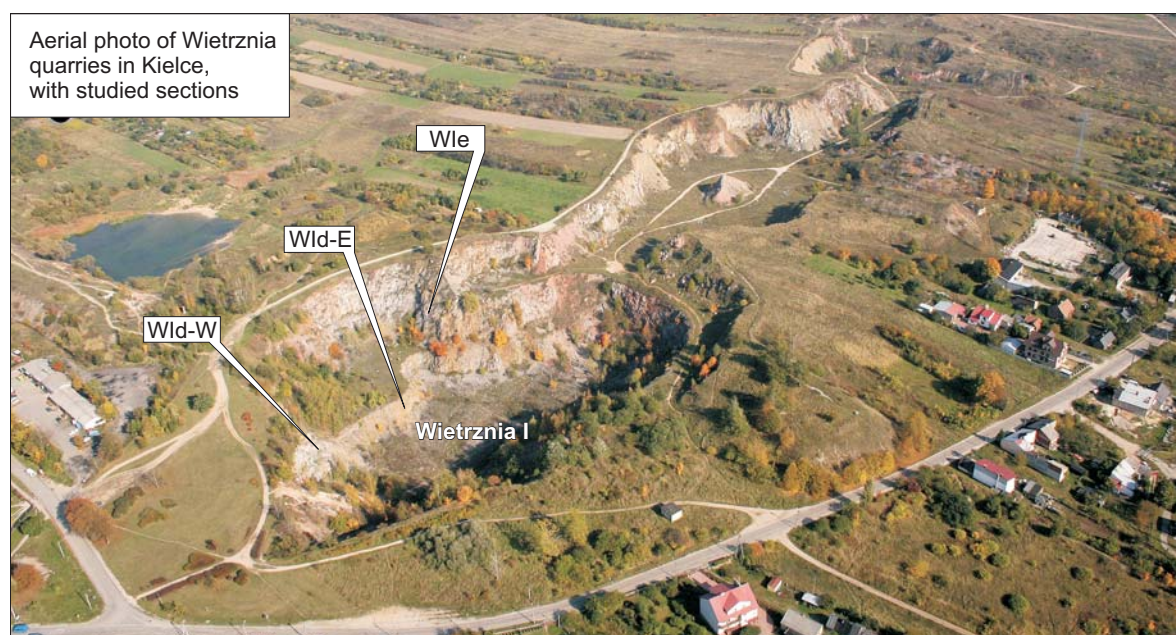


Fig. 2. Aerial photo of Wietrznia quarries in Kielce, with studied sections (from Baliński *et al.*, 2006).

marly shales. The second dominant lithology are thicker layers of biorudites with erosional bottom surfaces, including flat-pebble conglomerates. Successions of alternating fossil-impooverished very thin-bedded micrites and marly shales, form the uppermost part of Unit C (the Śluchowice Marly Level; *sensu* Pisarzowska *et al.*, 2006). At the distal Wle section, Unit C comprises rhythmically stratified, platy bituminous calcilutites and marly shale as well as thin layers of intraclastic biorudites.

At the Wid-W section Unit D is distinguished by the appearance of thick-bedded calcirudites with redeposited reef-builders and renalcid-*Stachyodes* buildups. Alternating thin-bedded, poorly fossiliferous micrites and shales with styliolinids occur as subordinate partings. Unit D splits eastward into D₁ and D₂ subunits at the Wle section. The thin-bedded subunit D₁ is a transitional unit between Units C and D, as defined by Szulczewski (1971), while the thick layers of subunit D₂ corresponds well with Unit D of the Wid-W section. The subunit D₁ is characterised by the absence of fossils except broken reef-builders and styliolinids in a few horizons. Unit D₂ comprises thick-bedded massive detrital limestones with many intraclasts and fragmented reef-builders, brachiopods, crinoids and also renalcid thrombolites.

The middle Wietrznia beds were episodically deposited on the northern, storm-affected flank of the Kielce carbonate platform. They comprise both coarse-grained, proximal tempestite layers (i.e., mostly episodic, storm-generated sediment-gravity flows from the Dyminy Reef margin) and micritic-marly (basinal) sediments (see the Transitional Facies of Szulczewski, 1971; Vierek, 2007a); the latter “background” lithofacies represents distal muddy tempestites (Vierek, 2007b). The region was affected by synsedimentary tectonic activity (Racki & Narkiewicz, 2000), recorded in a drastically different, locally somewhat condensed stratigraphic succession of the Early–Middle Frasnian (= *transitans–punctata* conodont Zones; E–MF; Ziegler & Sandberg, 2001) boundary beds in adjacent tectonic blocks recognised to the east, in the middle part of the Wietrznia exposure (see Szulczewski, 1989; Lamarche *et al.*, 2003). Middle Frasnian deposition of the upper Wietrznia beds is marked by talus-like sediments in the upper foreslope setting, locally with a microbial and/or *Stachyodes*-dominated buildups.

Early–Middle Frasnian boundary

The Wietrznia sections are the most representative of the Early–Middle Frasnian interval in the Holy Cross Mountains. Due to the high-resolution conodont and isotopic study (inorganic and organic carbon isotope, Sr-isotope and O-isotope from biotic apatite; Fig. 4), supplemented by palaeontological, geochemical, sedimentological and magnetosusceptibility works (Baliński, 2006; Głuchowski *et al.*, 2006; Pisarzowska *et al.*, 2006; Sobstel *et al.*, 2006; Vierek, 2007a; Nawrocki *et al.*, 2008) the Wietrznia Ie section was recommended as an Early–Middle Frasnian stratotype. The correlations of the Wietrznia sec-

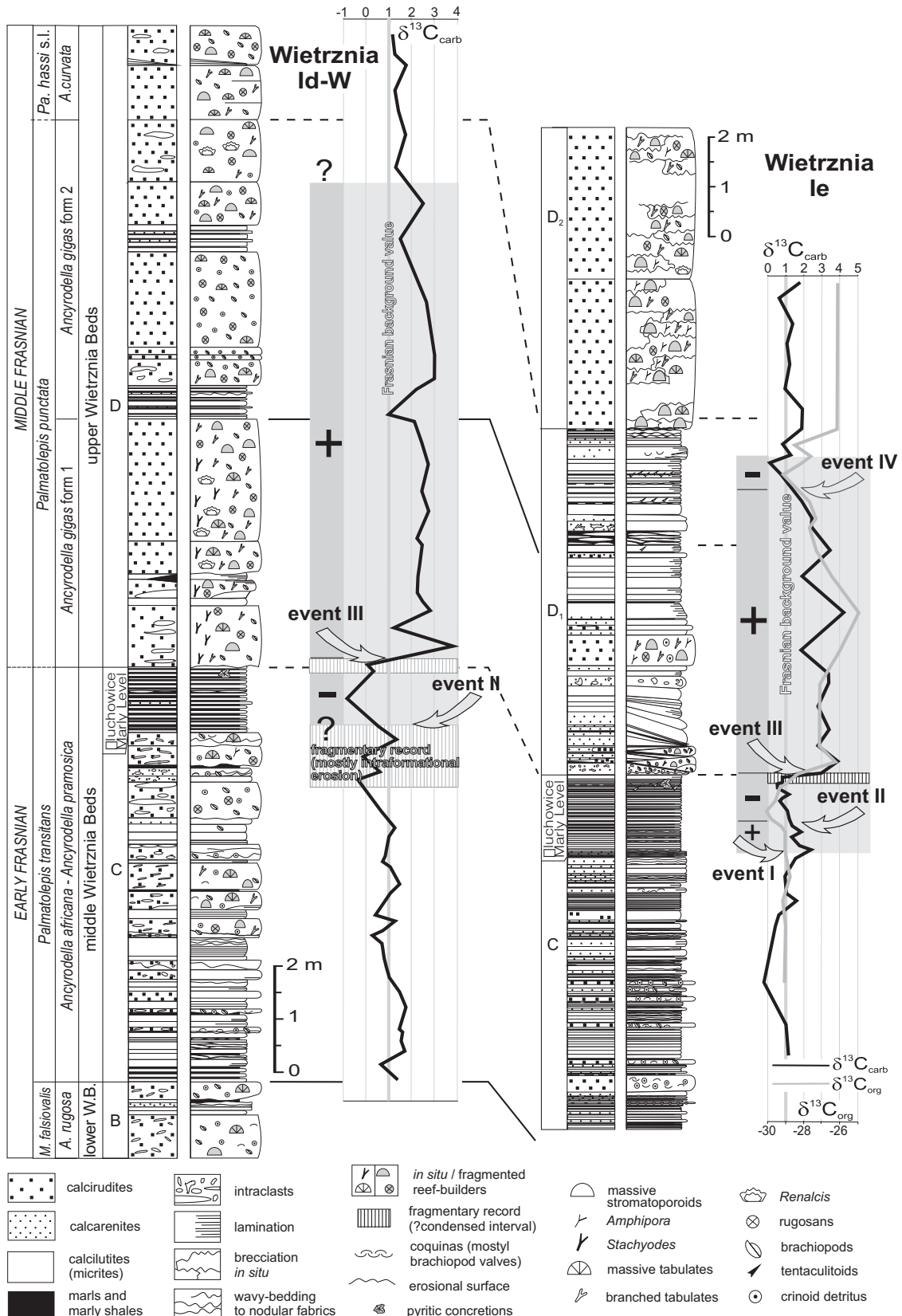


Fig. 3. Lithology, conodont biostratigraphy and stable carbon isotope geochemistry (both carbonates $\delta^{13}C_{carb}$ and organic matter $\delta^{13}C_{org}$; the results in per mil deviation from the Vienna Pee Dee belemnite standard, V-PDB) for the Lower to Middle Frasnian strata in the Wietrznia-Ie and Wietrznia-Id-W sections in Kielce. The geochemical anomaly interval is marked as grey interval, subdivided in positive (+) and negative (-) parts determined by four isotopic events I-IV (based on Pisarzowska *et al.*, 2006: figs 8-9). Abbreviations: A., *Ancyrodella*; M., *Mesotaxis*; Pa., *Palmitolepis*; Po., *Polygnathus*; W.B., Wietrznia Beds; s.l., *sensu lato*.

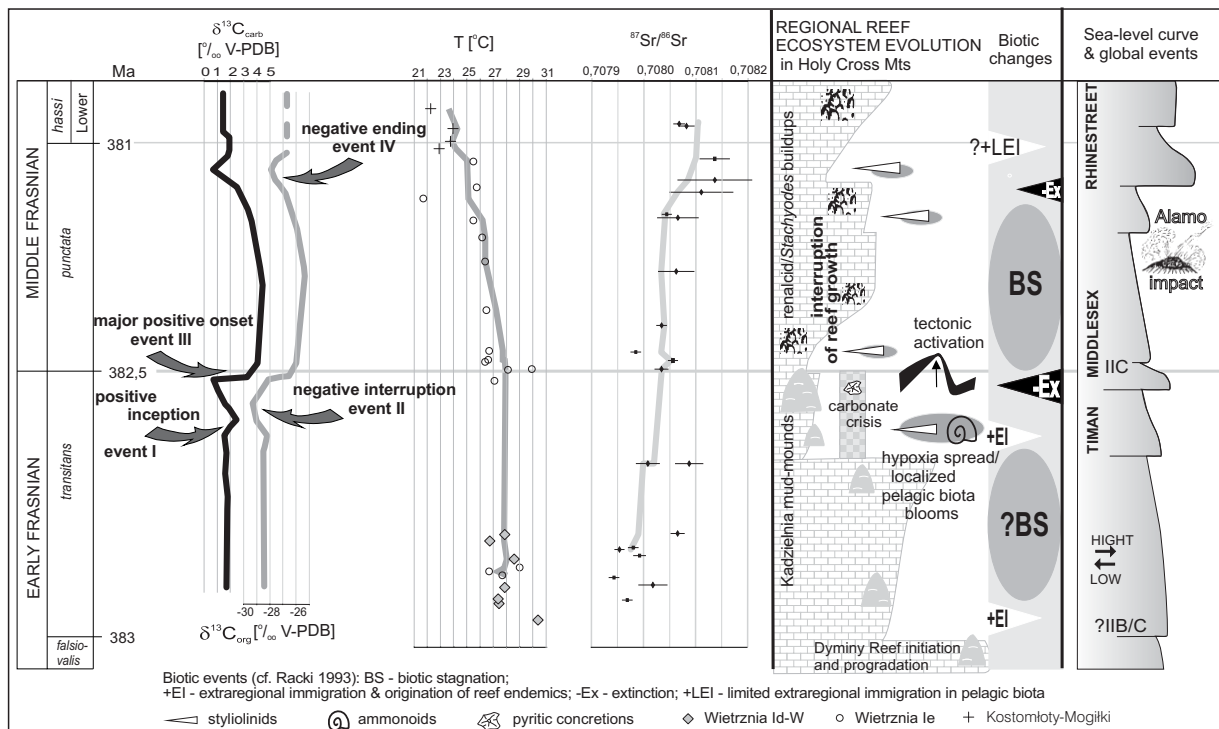


Fig. 4. Compilation of biogeochemical events, temperature and sea-level changes as well as conodont biostratigraphy of the Holy Cross Mountains across the Early–Middle Frasnian interval (based on Pisarzowska *et al.*, 2006: fig. 18). The regional geobiological history follows mainly conodont diversity dynamics and frequency patterns (Sobstel *et al.*, 2006); time after Kaufmann (2006).

tions with the standard conodont biozonation of Ziegler & Sandberg (1990) is difficult because of the absence or delay of index palmatolepid species, i.e. *Palmatolepis transitans*, *Pa. punctata* and *Pa. hassi* (Racki & Bultynck, 1993; Sobstel *et al.*, 2006). Polygnathid and polygnathid-ancyrrodelid faunas represent typical conodont association from the Early–Middle Frasnian interval. Therefore, four ancyrodelid levels are distinguished across the *transitans*–*hassi* interval in the Holy Cross Mountains: *Ancyrodelia africana*–*A. pramosica* belonging to the *transitans* biozone, *A. gigas* form 1 and *A. gigas* form 2 assigned to the *punctata* Zone and *A. curvata* (early form) in the earliest *hassi* Zone (Fig. 3). The base of the *punctata* Zone (Montagne Noire Zone 5; Klapper, 1988) determines the first appearance of *A. gigas*, whilst the position of the *punctata*–*hassi* zonal boundary is tied with the entry of *A. curvata* (for details see Pisarzowska *et al.*, 2006 and Sobstel *et al.*, 2006). The palynofacies study at the Wietrzna sections is impossible due to too high thermal maturation (Marynowski *et al.*, 2008).

Biogeochemical perturbation in the C-cycle across the E–MF transition

The high-resolution carbon isotope data of the Early to Middle Frasnian transition reveal the large scale perturbation in carbon cycling in the South Polish part of Laurussian shelf (Pisarzowska *et al.*, 2006; Yans *et al.*, 2006). This global *punctata* Zone Isotopic Event, lasting ca. 0.8 Ma (see Kauffman, 2006), is subdivided into two positive-to-negative excursions (Pisarzowska *et al.*, 2006), encompassing four isotopic events, perfectly recorded in the Wietrzna-Ie section (Figs 3–4). Comparison of biogeochemical signals and stratigraphical dates from Wietrzna as well as the sea-level fluctuations (Fig. 4) leads to the following conclusions:

The $\delta^{13}\text{C}$ values obtained through most of the *Pa. transitans* Zone show the Frasnian background values, which average ca. 1‰ (Yans *et al.*, 2006).

The $\delta^{13}\text{C}_{\text{carb}}$ record indicates a slight positive peak about 2‰ visible across the *A. africana*–*A. pramosica* level (inception event I *sensu* Racki *et al.*, 2004 and Pisarzowska *et al.*, 2006) and coincides with the Timan Event of Becker & House (1997). This excursion correlates with the deepening and disappearance of shallow-water (Baliński, 2006; Głuchowski *et al.*, 2006) and reef-related (Sobstel *et al.*, 2006) faunal assemblages in aid of pelagic biota (Jagt-Yazykova *et al.*, 2006).

The both $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{13}\text{C}_{\text{org}}$ data suggest a negative excursions by ca. 2‰ (with $\delta^{13}\text{C}_{\text{carb}}$ as low as nearly -1‰ at Wietrzna-Id) primarily in the latest part of the *Pa. transitans* Zone (interruption event II). This shift noticeably coincides with the abrupt disappearance of the macrofauna and microfauna except of styliolinids and lingulid brachiopods (Baliński, 2006; Głuchowski *et al.*, 2006; Piszczowska *et al.*, 2006) as well as with the crisis of shallow water carbonate production (Śluchowice Marly Level).

The overall pattern represented by $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{13}\text{C}_{\text{org}}$ values shows an abrupt, distinctive positive excursion (major onset event III) of about 4–5‰ through the *punctata* Zone. The positive shift in $\delta^{13}\text{C}$ linked with the rapid and extensive transgressive episode (Cycle IIc of Johnson *et al.*, 1985 and the Middlesex deepening in eastern North America; Ziegler & Sandberg, 2001) and coincides with the last appearance some reef-related brachiopod (Szulczewski & Racki, 1981; Baliński, 2006), gastropod (Krawczyński, 2002, 2006) and conodont (Sobstel *et al.*, 2006) species.

This isotopic “plateau” is followed in the latest part of the *Pa. punctata* Zone (*A. gigas* form 2 level) by a return to negative $\delta^{13}\text{C}$ values (the ending step IV), and then to background or even higher values in the *Pa. hassi* Zone. Two vast transgressions in the late *punctata* are recorded by styliolinid-rich marly litofacies (initiation of the multiphase Rhinestreet Event; House, 2002). The deepening pulses resulted in return to off-shore conditions and consequently to rebuilding and/or replacement of conodont assemblages (Sobstel *et al.*, 2006).

Block movements are recorded at the Wietrzna sections by rapid lateral thickness and fore-reef facies changes (Szulczewski, 1989; Dzik, 2002), as well as by an abrupt increase of carbonate mud and fine detritus depositional rates (Vierek, 2007a). In addition, wedge-shaped lithologies in the basal part of the *Pa. punctata* Zone are a signature of mass movements (?sliding) probably promoted by faulting and/or seismic shocks. The tectonic factors certainly modified benthic habitats in a local scale, influencing morphological differentiation and thus circulation patterns particularly over the northern slope of Dyminy Reef. More importantly, this activity was responsible for masking the IIc deepening pulse in most of the Holy Cross localities and for episodic development only of anoxia during the Middlesex sea-level rise.

The late *Pa. transitans* – early *Pa. punctata* time interval is not considered as a time of significant faunal turnover (see Baliński, 2006; Głuchowski *et al.*, 2006; Sobstel *et al.*, 2006; Yans *et al.*, 2006). Moreover, the *Pa. punctata* Zone is regarded as representing optimum environmental conditions for development of the marine biota, at least for conodonts and phytoplankton (Zhuravlev *et al.*, 2006; Marynowski *et al.*, 2008). However, only the stress-resistant conodonts, which went through the Early–Middle Frasnian perturbational interval, bloomed during the long-term stabilization phase in the early Middle Frasnian. The Early–Middle Frasnian conodont biodiversity crisis has definitely a stepwise nature, alongside with biogeochemical cycling changes, as refined by Sobstel *et al.* (2006), and may be partly correlated with the obviously more fragmentary recognized macrofaunal changes.

The long-lasting positive excursion in $\delta^{13}\text{C}$ is paired with enhanced bioproductivity and organic matter burial in anoxic conditions reaching the photic zone (Marynowski *et al.*, 2008), which suggests fluctuations of the chemocline during the early to middle Frasnian intermittently rising sea-level (basal IIc transgression; Timan and Middlesex global events). High rates of continental weathering around the *transitans*–*punctata* boundary have been confirmed by an increase in the $^{87}\text{Sr}/^{86}\text{Sr}$ isotopic ratio (John *et al.*, 2008; Fig. 4), an increase in detrital quartz content, and fluctuation of the magnetic susceptibility record (Nawrocki *et al.*, 2008). The oxygen isotope ratios based on analysis of conodont apatite from the coeval E–MF succession suggest a climatic cooling by 5°C over this time span (Fig. 4). Such a cooling trend may have been promoted by the accelerated burial of organic matter.

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STOP 2

Badenian (Middle Miocene) Foraminifera from organodetrital limestones of the Pińczów quarry (the southern part of the Holy Cross Mountains)

Anna CHRUSZCZ

*Institute of Biology, The Jan Kochanowski University of Humanities and Sciences, Świętokrzyska 15, 25-406 Kielce, Poland;
anna.chruszcz@ujk.edu.pl*

The Pińczów quarry is located within the Wójcza and Pińczów Range (in the southern part of the Holy Cross Mountains) (see map of p. 85) and the Badenian organodetrital limestone deposits, called the Pińczów Limestone, are exposed there (Fig. 1).

The limestone deposit is at present exploited and it is formed by light cream bedded limestones 18 m thick (Bugajska-Pajak, 1974). Its bottom part, which lies upon the Cretaceous marls, is composed of fine-grained organodetrital limestone. Higher up in the section medium-grained deposits occur, and then coarse-grained deposits appear (Kozłowski, *et al.*, 1971) (Fig. 1).



Fig. 1. The quarry in Pińczów with three Badenian organodetrital limestone types; from the bottom upwards: fine-grained, medium-grained, coarse-grained limestones (Photo by A. Chruszcz).

The organodetrital limestone consists of well-preserved fossils and limestone fragments cemented by calcareous material with argillaceous particles (Oterman, 1980). In the Pińczów quarry, a rich and diverse assemblage of fossil micro- and macrofauna is observed. Among the microfossils, Rhodophyta are well known (Studencki, 1988). Foraminifera have not been studied prior to the initial study by Chruszcz (2002). Vertebrates are represented by *Scorpoena ensiger* Jordan & Gilbert, the teleostean fish (Jerzmańska, 1958) and a cetacean species *Pinocetus polonicus* (Czyżewska & Ryziewicz, 1976). In addition, other groups became subject to study: brachiopods (Studencki, 1987), bivalves (Studencka & Studencki, 1988), and echinoids (Mączyńska, 1993).

Facies types of organodetrital limestone

In the area of the Wójcza and Pińczów Range, Studencki (1988) distinguished four facies types of the Pińczów Limestone: rhodolith pavement facies, branching algae facies, algal bryozoan facies and organodetrital facies, on the basis of different forms of red algae growth.

In Pińczów, which is located in the western part of the Wójcza and Pińczów Range (Fig. 2), Studencki (1988) distinguished two kinds of facies: an algal-bryozoan facies and an organodetrital facies.

In the algal-bryozoan facies, apart from the predominant rhodophyta and bryozoans, larger foraminifera, i.e., *Amphistegina mamilla* (Fichtel & Moll) and *Heterostegina costata* d'Orbigny ap-

pear. Those components of the facies occur in various proportions, they are most often mixed with one another, however, there are local tendencies of gathering only one of the components. Rhodophyta appear at all stages of growth: rhodoliths, crusts, branching thalli. They are represented by *Archaeolithamnium keenai* Howe, "*Lithothamnium*" *ramosissimum* (Gümbel), *Mesophyllum ingestum* Conti, *M. laffittei* Lemoine, *M. rigidum* Mastrorilli, *Litophyllum prelichenoides* Lemoine, "*Lithothamnium*" *praefruticulosum* Maslov and *Litophyllum albaense* Lemoine.

According to Studencki (1988), "the typical features of the algal-bryozan facies are the lack of bioclasts sorting of, their chaotic arrangement and broken, non-rounded edges of fragmented grains. Locally observed horizontal textures result from the arrangement of flat heterosteginid tests and crustose algal thalli". The fauna in the facies is abundant and diversified; there occur corals, polychaetes, brachiopods, bivalves, gastropods, cirripedes, crustaceans, and echinoids.

In the organodetrital facies, Studencki (1988) and then Kuleta (2000) recorded fossils whose skeletons are preserved in fragments: rhodophyta, bryozoans, larger foraminifera, as well as other organisms, which occur in the algal-bryozoan facies. According to Kuleta (2000), the main components of the fine-grained organodetrital limestone are the fine bioclasts of foraminifera (from 0.1 mm to 0.3 mm across, either fragmented or complete tests) as well as small fragments of larger foraminifera (*Heterostegina*) and micritic irregular fragments of lithothamnia that are from 0.05 mm to 0.2 mm across. The main components constitute from 75% to 80%, and the secondary and accessory components (15%) are larger foraminifera (*Heterostegina*) – either complete or crushed tests (4–5 mm), fragments of bryozoans, tubes of *Serpula* and small lithothamnia. The grains of quartz, which are poorly rounded, isometric and slightly elongated form the terrigenous admixture (from 2 to 3%).

The cement (approximately 5%) of the contact and pore type is formed by carbonate micrite with an admixture of black organic matter. All components of the rock, i.e., alloigenic – bioclasts and the terrigenous – quartz are homogeneously mixed and their arrangement is random, although rarely it follows the direction of the elongated components. The low porosity (from 2 to 5%) has an intragranular nature (Fig. 3A.I, A.II).

In the medium-grained type of limestone, the main components (75–80%) are larger foraminifera (*Heterostegina*) preserved as the complete forms or their final detritus as well as the fragments of oval and elongated rhodoliths (3 mm in size). The secondary and accessory components (approximately 15%) are small foraminifera, of various preservation, small fragments of large foraminifera, single specimens of *Amphistegina* and rare fragments of *Serpula* and possibly bryozoans. The cement (approximately 5%) is calcitic micrite of contact and pore types, with a small admixture of black organic matter. The porosity of the rock (2–3%) is mainly intragranular and occurs within both foraminifera and lithothamnia (Fig. 3B).

In the coarse-grained limestone, the main components (approximately 85%) are fragments of lithothamnian rhodoliths, which are most often irregular in shape, and bryozoans and larger foraminifer *Amphistegina*. The secondary and accessory components (approximately 5%) are fine detritus, fragments of larger foraminifera and bryozoans as well as the small foraminifera. The cement (approximately 5%) is calcitic, micritic. The porosity range is 10–15% (Fig. 3C).

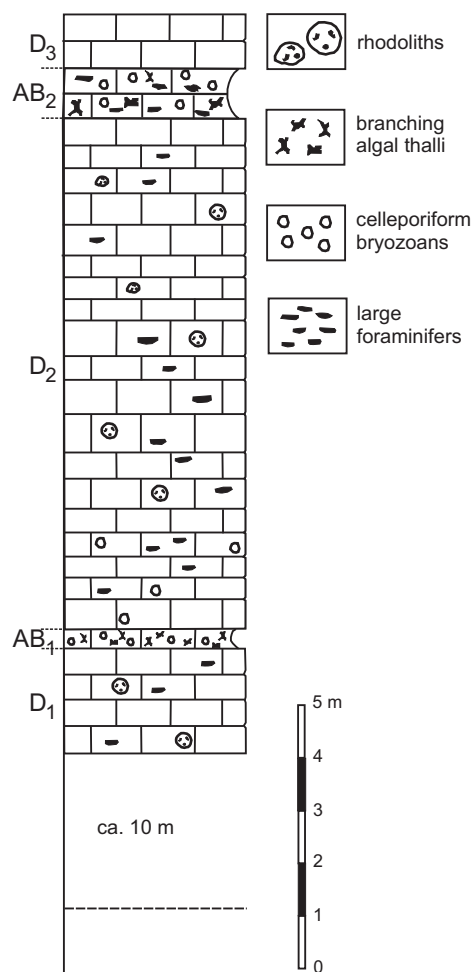


Fig. 2. Geological column of the Pińczów limestone types: AB – algal-bryozoan facies, D – organodetrital facies (Studencki, 1988).

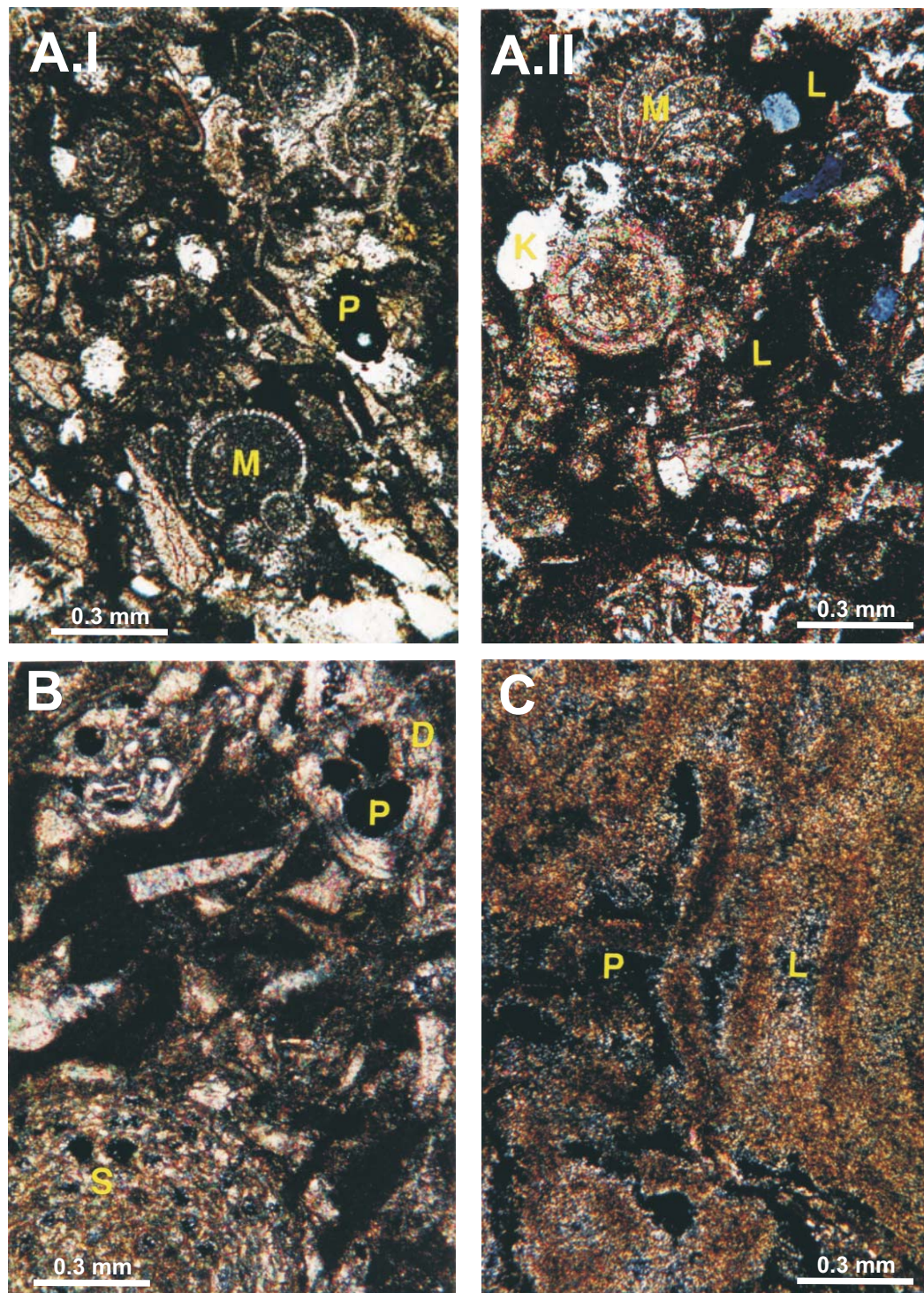


Fig. 3. The grain structure of organodetrital limestone types: fine-grained (A), medium-grained (B), and coarse-grained (C) occurring in the Pińczów quarry (Kuleta, 2000). A.I. Fine-grained organodetrital limestone: M – small foraminifera (*Globigerina*), P – intragranular pores. A.II. Fine-grained organodetrital limestone: M – foraminifera (*Elphidium*), P – intragranular pores, K – quartz, L – fragments of lithothamnia. B. Medium-grained organodetrital limestone: D – larger foraminifera, L – lithothamnia, S – bryozoa, P – pores. C. Coarse-grained organodetrital limestone: P – pores, L – lithothamnia.

Foraminifera of organodetrital limestone

The foraminiferal assemblage in the organodetrital limestone is very rich and shows significant taxonomical variation. The occurrence of 30 families represented by 84 species was recorded there (Table 1).

In the fine-grained limestone type, there are 66 species representing 20 families: *Cibicididae* (15%), *Elphidiidae* (14%), and *Nonionidae* (12%) are the most common (Fig. 4A). These families show the greatest variation in number of species and are characterised by the largest numbers of specimens. The greatest species diversity is observed in the youngest part of the succession (40 species); in the older part of the succession, the number is smaller (24–38 species). Species such as *Cibicides ungerianus*, *C. pseudungerianus*, *Lobatula lobatula*, *Elphidium macellum*, *E. fichtelianum*, and *Nonion scaphum* appeared in the greatest number.

Table 1. Foraminiferal species occurring in fine-grained, medium-grained and coarse-grained organodetrital limestones in the Pińczów quarry (foraminiferal species were identified largely following Odrzywolska-Bieńkowska & Olszewska, 1996)

No.	Species	Fine-grained	Medium-grained	Coarse-grained
1	<i>Saccorhiza ramosa</i> Brady	–	R	R
2	<i>Spiroplectammina scaligera</i> Łuczkowska	–	R	R
3	<i>Quinqueloculina badenensis</i> d'Orbigny	–	R	R
4	<i>Borelis melo</i> Fichtel & Moll	–	–	R
5	<i>Spirolina pusilla</i> Schwager	R	–	R
6	<i>Amphicoryna scalaroides</i> ten Dam & Reinhold	R	R	R
7	<i>Lenticulina calcar</i> (Linne)	–	R	F
8	<i>Lenticulina echinata</i> (d'Orbigny)	–	–	R
9	<i>Globulina gibba</i> (d'Orbigny)	F	F	F
10	<i>Guttulina austriaca</i> d'Orbigny	–	–	R
11	<i>Glandulina laevigata</i> d'Orbigny	–	R	R
12	<i>Globorotalia pseudocontiniosa</i> Jenkins	–	–	R
13	<i>Paragloborotalia mayeri</i> (Cushman & Ellisar)	–	–	R
14	<i>Globigerina bulloides</i> d'Orbigny	R	R	R
15	<i>Globigerina dutertrei</i> d'Orbigny	R	R	R
16	<i>Globigerina</i> sp.	R	R	R
17	<i>Globigerinoides trilobus</i> (Reuss)	R	R	R
18	<i>Globigerinoides</i> sp.	–	R	R
19	<i>Candorbulina suturalis</i> (Brönnimann)	–	R	R
20	<i>Bolivina dilatata</i> Reuss	R	R	R
21	<i>Bolivina polonica</i> Bieda	R	R	R
22	<i>Bolivina</i> sp.	R	R	R
23	<i>Brizalina antiqua</i> (d'Orbigny)	R	R	R
24	<i>Brizalina hyalina</i> (Śmigielska)	R	R	R
25	<i>Cassidulina punctata</i> Reuss	R	R	R
26	<i>Bulimina gibba</i> Fornasini	R	R	R
27	<i>Bulimina buchiana</i> d'Orbigny	R	R	R
28	<i>Bulimina pupoides</i> d'Orbigny	R	R	R
29	<i>Bulimina</i> sp.	R	R	R
30	<i>Uvigerina tenuistriata</i> (Reuss)	R	R	R
31	<i>Uvigerina howei</i> Garret	R	R	R
32	<i>Uvigerina brunnesis</i> Karrer	R	R	R
33	<i>Uvigerina pygmoides</i> Papp & Turnovsky	R	R	R
34	<i>Uvigerina</i> sp.	R	R	R
35	<i>Reussella spinulosa</i> (Reuss)	–	R	R
36	<i>Coryphostoma sinuosa</i> (Cushman)	R	–	R
37	<i>Coryphostoma digitalis</i> (d'Orbigny)	R	–	R

38	<i>Valvulineria marmaroschensis</i> Pishvanowa	R	–	R
39	<i>Valvulineria complanata</i> (d'Orbigny)	–	–	R
40	<i>Eponides nanus</i> (Reuss)	R	R	R
41	<i>Eponides bradyi</i> (Trauth)	R	R	R
42	<i>Eponides praecinctus</i> (Karrer)	R	R	R
43	<i>Eponides</i> sp.	R	R	R
44	<i>Discorbis mira</i> (Cushman)	R	R	R
45	<i>Discorbis golbularis</i> (d'Orbigny)	R	R	R
46	<i>Discorbis</i> sp.	R	R	R
47	<i>Sphaeroidina bulloides</i> d'Orbigny	–	R	R
48	<i>Planulina ariminensis</i> d'Orbigny	–	R	R
49	<i>Cibicides ungerianus</i> (d'Orbigny)	A	C	A
50	<i>Cibicides ungerianus</i> var. <i>ornatus</i> (Cushman)	C	F	R
51	<i>Cibicides ungerianus</i> var. <i>laevis</i> (Rzehak)	R	R	R
52	<i>Cibicides pseudoungerianus</i> (Cushman)	A	C	A
53	<i>Cibicides austriacus</i> (d'Orbigny)	R	R	R
54	<i>Cibicides boueanus</i> (d'Orbigny)	C	F	F
55	<i>Cibicides letkesiensis</i> (Franzenau)	R	R	R
56	<i>Cibicides</i> sp.	R	R	R
57	<i>Lobatula lobatula</i> (Walker & Jacob)	A	A	C
58	<i>Lobatula lobatula</i> var. <i>ornata</i> (Cushman)	R	R	R
59	<i>Sphaerogypsina globulus</i> (Reuss)	–	R	R
60	<i>Asterigerinata planorbis</i> (d'Orbigny)	F	F	F
61	<i>Amphistegina lessoni</i> (d'Orbigny)	C	C	A
62	<i>Amphistegina hauerina</i> (d'Orbigny)	R	F	A
63	<i>Amphistegina mamilla</i> (Fichtel & Moll)	F	C	A
64	<i>Nonion scapha</i> (Fichtel et Moll)	A	F	F
65	<i>Nonion elongatum</i> (d'Orbigny)	A	F	F
66	<i>Nonion boueanum</i> (d'Orbigny)	F	R	R
67	<i>Nonion depressulum</i> (Walker & Jacob)	F	R	R
68	<i>Nonion commune</i> (d'Orbigny)	C	F	R
69	<i>Nonion granosum</i> (d'Orbigny)	R	R	R
70	<i>Nonion</i> sp.	R	R	R
71	<i>Melonis pompilioides</i> (Fichtel & Moll)	R	R	R
72	<i>Heterolepa dutemplei</i> (d'Orbigny)	F	F	R
73	<i>Ammonia beccari</i> (Linne)	F	F	F
74	<i>Ammonia supera</i> Belford	–	R	R
75	<i>Elphidium crispum</i> (Linné)	C	A	A
76	<i>Elphidium macellum</i> (Fichtel & Moll)	A	C	A
77	<i>Elphidium fichtelianum</i> (d'Orbigny)	A	A	A
78	<i>Elphidium listeri</i> (d'Orbigny)	R	F	F
79	<i>Elphidium advenum</i> (Cushman)	R	R	F
80	<i>Elphidium antoninum</i> (d'Orbigny)	R	R	R
81	<i>Elphidium flexuosum</i> (d'Orbigny)	C	F	C
82	<i>Elphidium lessoni</i> (d'Orbigny)	R	F	R
83	<i>Elphidium</i> sp.	R	R	R
84	<i>Heterostegina costata</i> d'Orbigny	C	A	C

Other microfauna	Fine-grained	Medium-grained	Coarse-grained
Sponge spicules (<i>Porifera</i>)	R	R	R
Tubes of <i>Annelida</i>	F	F	F
<i>Bryozoa</i>	C	A	A
<i>Amphineura</i>	R	R	R
<i>Bivalvia</i>	F	F	F
<i>Gastropoda</i>	F	F	F
<i>Ostracoda</i>	C	C	C
<i>Holothuria</i>	R	R	R
Spines and fragments of plates of <i>Echinoidea</i>	R	R	R

Glossary: R – rare (1–5 specimens), F – few (6–10 specimens), C – common (10–15 specimens), A – abundant (more than 15 specimens).

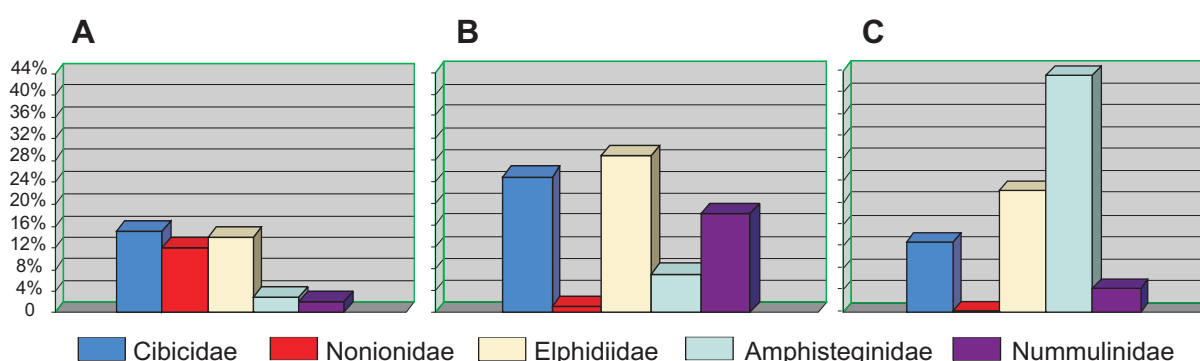


Fig. 4. The occurrence of the most common families of foraminifera in the the Badenian organodetrital limestone deposits in the Pińczów quarry: A – fine-grained limestone, B – medium-grained limestone, C – coarse-grained limestone.

The fine-grained limestone is characterised by *Cibicides*–*Elphidium*–*Nonionidae* assemblages and the species *Amphistegina lessoni* and *Heterostegina costata*. *Bolivina polonica* is the guide form of the oldest part of Badenian, i.e., the Moravian (Olszewska *et al.*, 1996).

The foraminiferal assemblage in the medium-grained limestone is more varied than in the fine-grained limestone. There were 74 species belonging to 25 families recorded in it. There occur all families found in the fine-grained limestone type except the *Peneroplidae*, *Fursenkoinidae*, and *Bagginidae* families, and additionally the following families occur: *Hippocrepinidae*, *Textularidae*, *Glandulinidae*, *Acervulinidae*, *Sphaeroidinidae*, *Hauerinidae*, *Planulinidae*, *Reussellidae*. The most common are *Elphidiidae* (28.7%), *Cibicididae* (24.9%), *Nummulitidae* (18%), *Amphisteginidae* (7.4%) (Fig. 4B). The species characterised by the greatest number of specimens were: *Elphidium crispum*, *Lobatula lobatula*, *Elphidium fichtelianum*. *Heterostegina costata*, *Amphistegina lessoni* and *Cibicides ungerianus* also occur quite common.

The medium-grained limestone type is characterised by the *Elphidium*–*Cibicides* assemblage and the species *Amphistegina lessoni* and *Heterostegina costata*. The species *Candorbulina suturalis* occurs, which is a guide form for the Moravian (Łuczowska, 1974; Olszewska *et al.*, 1996).

In the coarse-grained limestone type, 84 species representing 30 families were found. In addition to the families that appeared in the fine-grained and medium-grained limestone types, the families *Alveolinidae* and *Globorotaliidae* occurred. The following families dominate: *Amphisteginidae* (43.4%), *Elphidiidae* (22.1%), *Cibicididae* (12.7%) (Fig. 4C). In the vertical section, the greatest species variety occurs in the oldest part of the section (63 species), in the younger parts of the section the number of species is lower (21 species). The species showing the greatest abundance are: *Amphistegina lessoni*, *Elphidium macellum*, *Elphidium fichtelianum*, *Elphidium crispum*, *Cibicides pseudo-ungerianus*.

The coarse-grained limestone is characterised by the *Amphistegina*–*Elphidium*–*Cibicides* assemblage. In addition, *Candorbulina suturalis* and *Lenticulina echinata* occur there; they are guide fossils for the Moravian (Olszewska *et al.*, 1996). In the vertical section of the deposit, the proportion of the most frequent families of foraminifera: *Cibicididae*, *Nonionidae*, *Elphidiidae*, *Amphisteginidae*, *Nummulinidae* is varying.

From the bottom towards the top of the organodetrital limestone deposit the share of *Amphisteginidae* increases and the share of *Nonionidae* decreases. The number of species increases up section: there are 66 species in the fine-grained limestone, 74 species in the medium-grained limestone, and 84 species in the coarse-grained limestone. In turn, the families *Cibicididae*, *Elphidiidae*, and *Nummulitidae* are the greatest in number in the medium-grained limestone located in the middle part of the limestone deposit (Fig. 4).

The foraminiferal assemblage in the organodetrital limestones of the Pińczów quarry is dominated by the benthic species (93%) with sparse plankton (7%). Foraminifera represent littoral zone (as indicated by a great proportion of taxa indicating the littoral zone, i.e., *Ammonia*, *Elphidium*). The water temperature is supposedly to be within the range of 18 to 23°C (as indicated by the genera: *Amphistegina* – 18–24°C, *Cibicides* – 18–23°C, *Elphidium* – 18–23°C, *Heterostegina* – 22–27°C; Gonera, 2001). The bottom surface was characterized by good oxygenation (as indicated by the proportion of the epifauna, i.e., *Eponides*, *Cibicides*, *Elphidium* – approximately 22%, and an insignificant proportion of *Bolivina* – 0.07%). The dynamics of the water appeared to be considerably high, which resulted in the damage and coating of the shells.

This estimation of the palaeoecological conditions agrees with the conclusions of Jerzmańska (1958), Pawłowska (1960) and Radwański (1965), who described fish fossils characteristic for sub-tropical climate.

Summarizing, the organodetrital limestones in the Pińczów quarry are characterised by the significant species diversity of foraminifera and the dominance of several genera in the assemblages: *Cibicides*, *Elphidium*, *Amphistegina*, *Heterostegina*. According to Murray (1991), this indicates an environment of considerable variability. Only some species were able to assimilate to it, and not having any competition then, they could develop intensively. In stable environments all species have similar possibilities.

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STOP 3

Palaeoenvironmental changes in the early Maastrichtian of the Nida Trough (Southern Poland): foraminiferal evidence

Danuta PERYT and Zofia DUBICKA

Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, 00-818 Warszawa

Cretaceous deposits outcropping at the Wrocieryż quarry (southern Poland) occur within the Miechów (Nida) Trough which forms the southernmost part of the Szczecin–Łódź–Miechów synclorium (see map of p. 85). Starting from the Early Permian, the area was located in the southern part of the Mid-Polish Trough developed at the boundary between the Precambrian and Palaeozoic platforms. The axial part of the Mid-Polish Trough underwent fast subsidence until the inversion commenced during late Turonian–Maastrichtian times (Walaszczyk in Voigt *et al.*, 2008, with references herein). In the Miechów Trough, the Cretaceous sequence (up to 600 m thick) is divided into two parts, a lower portion comprising Albian to Santonian strata, and an upper one comprising the

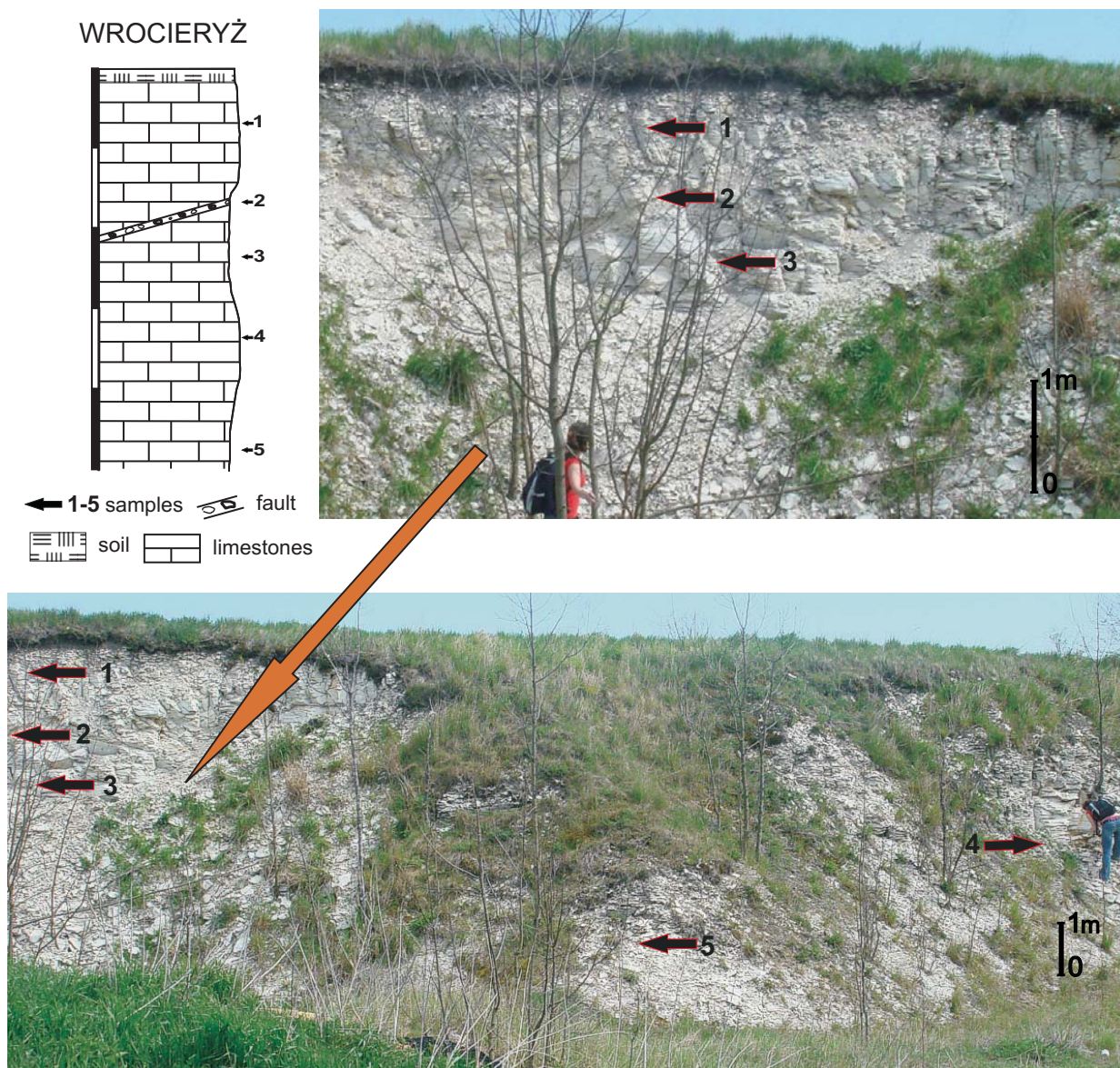


Fig. 1. Lithological column and location of samples in the Wrocieryż quarry section.

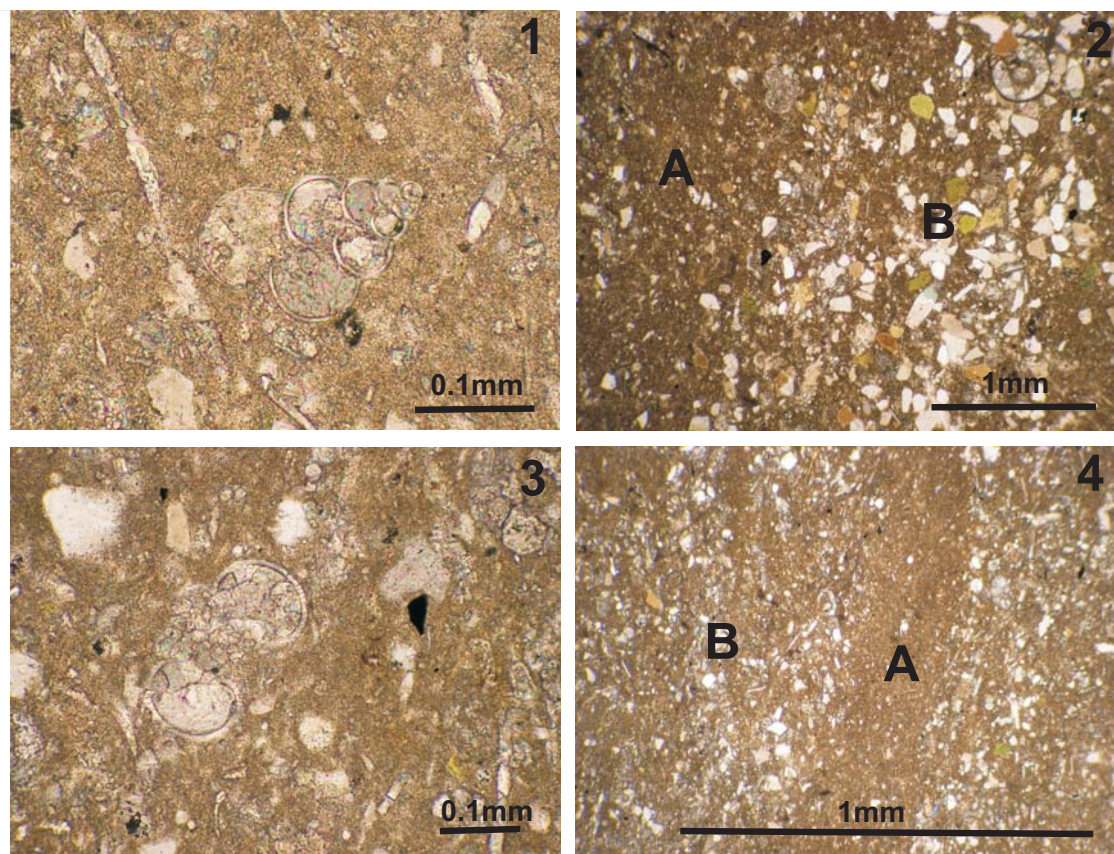


Fig. 2. Microfacies aspects of the Wrocieryż rocks. 1, 3 – bioclastic wackestone (the most common are planktonic foraminifers) containing quartz grains; 2, 4 – intercalations of laminae of carbonate mudstone and of granular deposit composed of quartz grains, glauconite, and bioclasts of foraminifers and sponges.

Campanian and lower Maastrichtian (Rutkowski, 1965; Cieśliński, 1973). Late Campanian through Maastrichtian is an interval characterized by three second-order marine regressions and several cooling events (Barrera & Savin, 1999; Friedrich *et al.*, 2005).

Geological setting and lithology

Wrocieryż is located about 20 km west of Busko Zdrój from where Machalski *et al.* (2004) described ammonites and assigned the ammonite-bearing deposits to lower part of the Upper Campanian *Neancyloceras phaleratum* Zone.

About 8 meters of sandy limestones outcrop in the old, non active quarry at Wrocieryż (Fig. 1). The rock is hard, gray in colour, massive, with no apparent bedding. In the upper part of the outcrop there is a fault and a 2-cm-thick marly layer on which a portion of Maastrichtian rock slid down.

Petrographically the sediment from the Wrocieryż section is a marly lithoclast mudstone (Fig. 2/2A, Fig. 2/4A) / wackestone (Fig. 2/2B, Fig. 2/4B). The rock is thus mud-supported with micritic cement. The grains include (mainly) fine-sand sized, angular quartz (white) and glauconite as well as some allochems (foraminifers and echinoid spines – Fig. 2/1, Fig. 2/3). The angular quartz grains are moderately sorted. Very thin dark and light laminae (Fig. 2/2, Fig. 2/4) lacking bioturbation and the low diversity (or lack) of benthic organisms altogether reflect poorly oxygenated bottom waters.

Foraminifera have not been studied in this area prior to this work. For the purpose of this study five samples were taken from the upper part of the Wrocieryż quarry (Fig. 3). 200–300 specimens from the >100 µm size fraction were picked up and all species in each sample were identified.

Results

Foraminifera are abundant and moderately well preserved. Both planktonic and benthic forms are present (Figs 3, 4, 5). Over 40 taxa were identified at the generic or specific level.

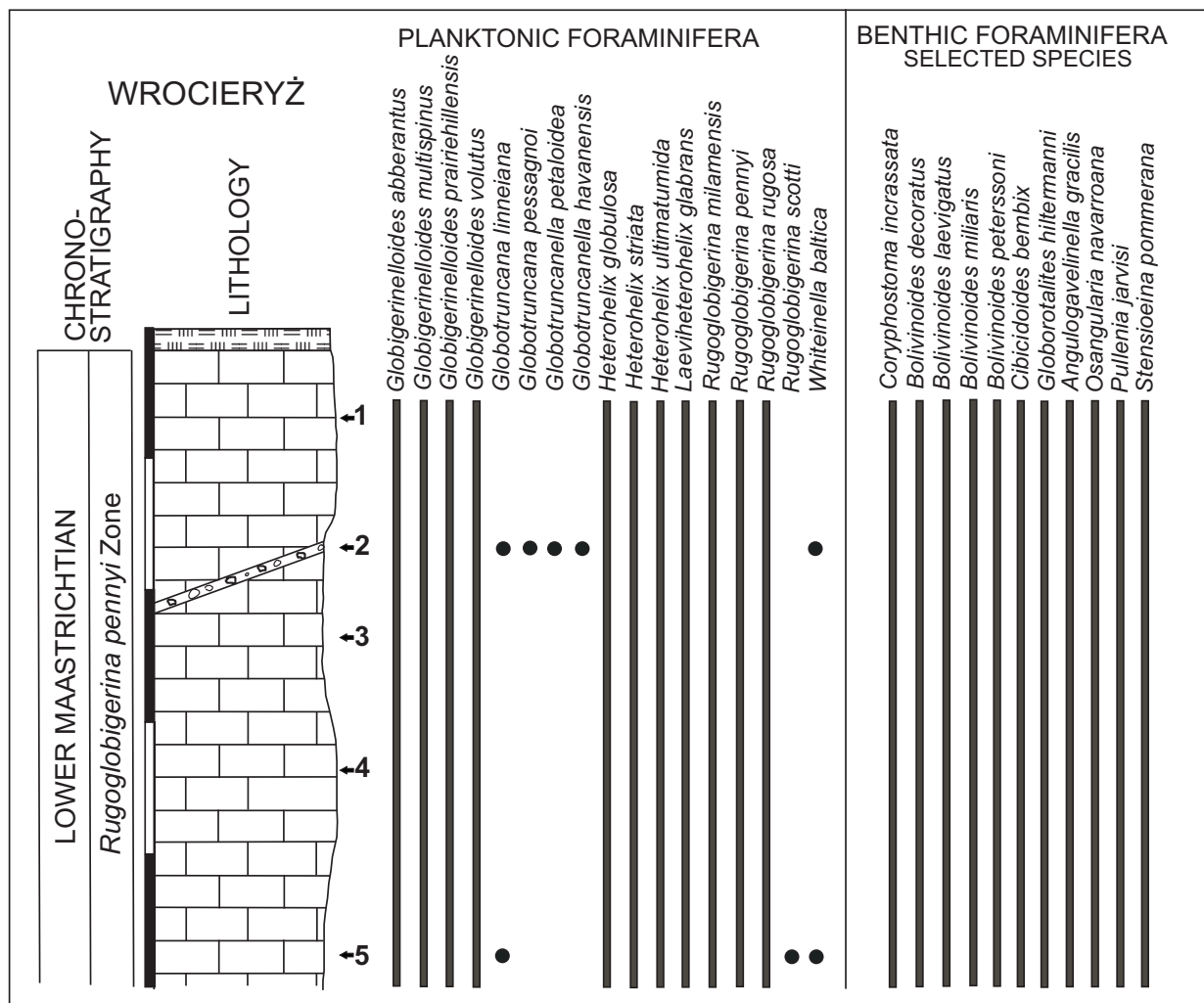


Fig. 3. Stratigraphy and distribution of foraminifers in the Wrocieryż profile. A – planktonic foraminifers, B – selected species of benthic foraminifers.

Contribution of planktonic foraminifera to the assemblages varies in the studied interval (Fig. 6A). They form from 25 to 70% of assemblages. Assemblages with low P/B ratio values (25 to 30%) alternate with the ones having high P/B ratio values (from 55 to 70%) (Fig. 6). 17 species of planktonic foraminifera are identified in the studied material (Fig. 3). *Heterohelix* (*H. globulosa*, *H. planata*, *H. punctulata*, *H. ultimatimida*) dominate planktonic foraminiferal assemblages. *Rugoglobigerina* (*R. pennyi*, *R. milamensis*, *R. rotundata*, *R. rugosa*, *R. scotti*) and *Globigerinelloides* (*G. prairiehillensis*, *G. multispinus*, *G. aberrantus*) are common contributors of the assemblages. *Globotruncana* (*G. linneiana*), *Globotruncanella* (*G. pessagnoii*), *Globotruncanella* (*G. havanensis*, *G. petaloidea*) and *Whiteinella* (*W. baltica*) represent rare species.

Over 20 genera of benthic foraminifers representing both calcareous and agglutinated forms are recorded in the studied section. Agglutinated foraminifers are very rare. Within benthic foraminiferal assemblages epifaunal morphogroups dominate. They form 55 to 75% of the assemblages (Fig. 6B). They are represented by *Stensioeina*, *Valvulineria*, *Angulogavelinella*, *Osangularia*, *Cibicidoides*, *Gavelinella*, *Gyroidinoides*, *Globorotalites*, *Lenticulina*.

Dentalina, *Marginulina*, *Praeulimina*, *Coryphostoma*, *Bolivinoidea*, *Neoflabellina*, *Nonion*, *Pullenia*, *Oolina*, *Glandulina*, *Guttulina*, *Marssonella*, *Gaudryina*, *Heterostomella* and *Spiroplectammina* are interpreted as living dominantly infaunally. In the studied section infaunal morphogroups increase in abundance cyclically. Foraminiferal assemblages with higher share of infaunal morphogroups alternate with the ones where their contribution to the assemblages decreases (Fig. 6B).

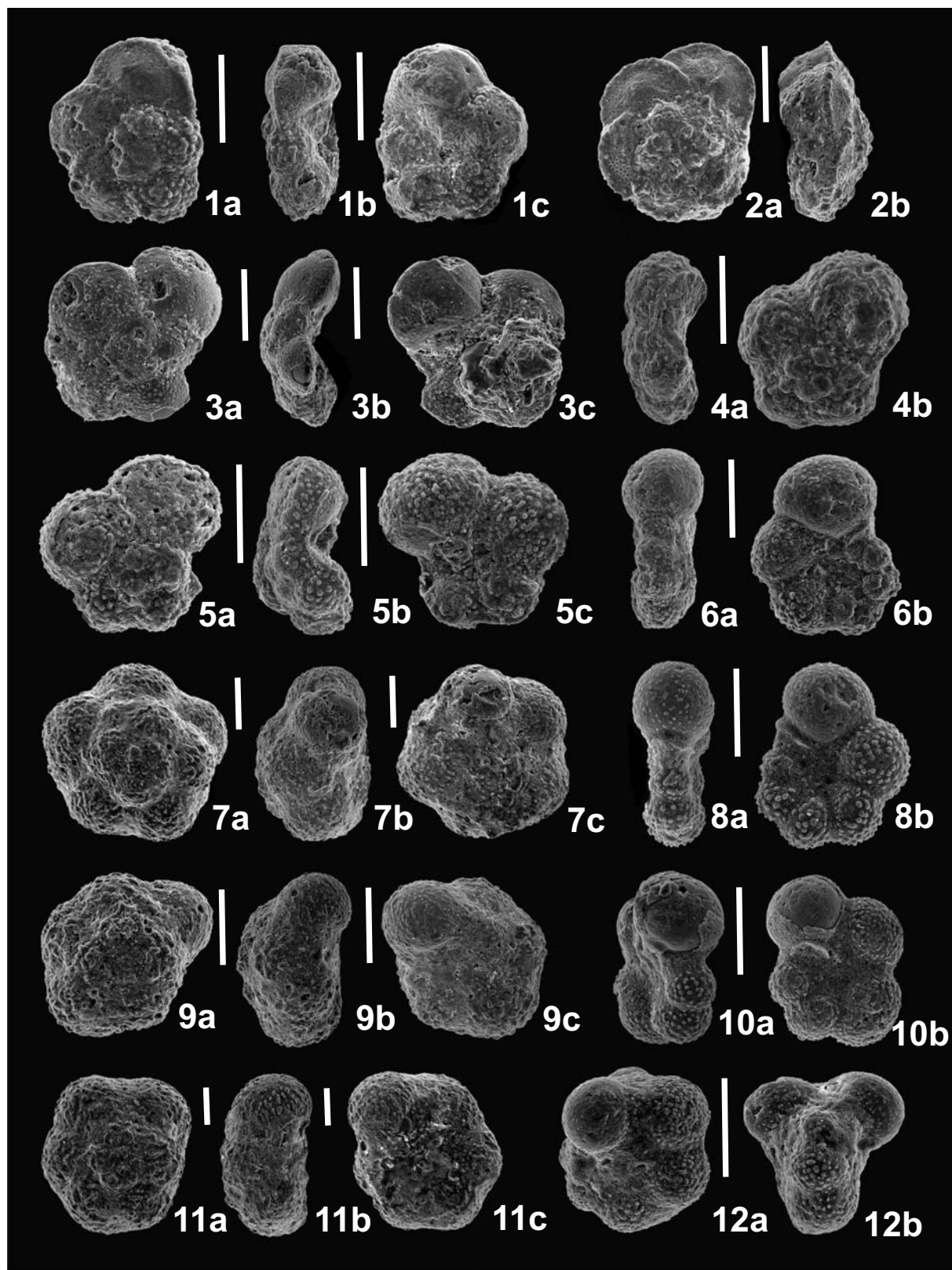


Fig. 4 Lower Maastrichtian planktonic foraminifera from the Wrocieryż quarry section. Scale bar – 100 μ m. 1a–c. *Globotruncana linneiana* (d'Orbigny); 2 a–b. *Globotruncana pessagno* Longoria; 3a–c. *Globotruncanella havanensis* (Voorvijk); 4a–b. *Whiteinella baltica* Douglas & Rankin; 5a–c. *Globotruncanella petaloidea* (Gandolfi); 6a–b. *Globigerinelloides prairiehillensis* Pessagno; 7a–c. *Rugoglobigerina milamensis* Smith & Pessagno; 8a–b. *Globigerinelloides prairiehillensis* Pessagno; 8a–c. *Globigerinelloides prairiehillensis* Pessagno; 9a–c. *Rugoglobigerina milamensis* Smith & Pessagno; 10a–b. *Globigerinelloides abberantus* (Neckaja); 11a–c. *Rugoglobigerina pennyi* Bronnimann; 12a–b. *Globigerinelloides multispinus* (Lalicker).

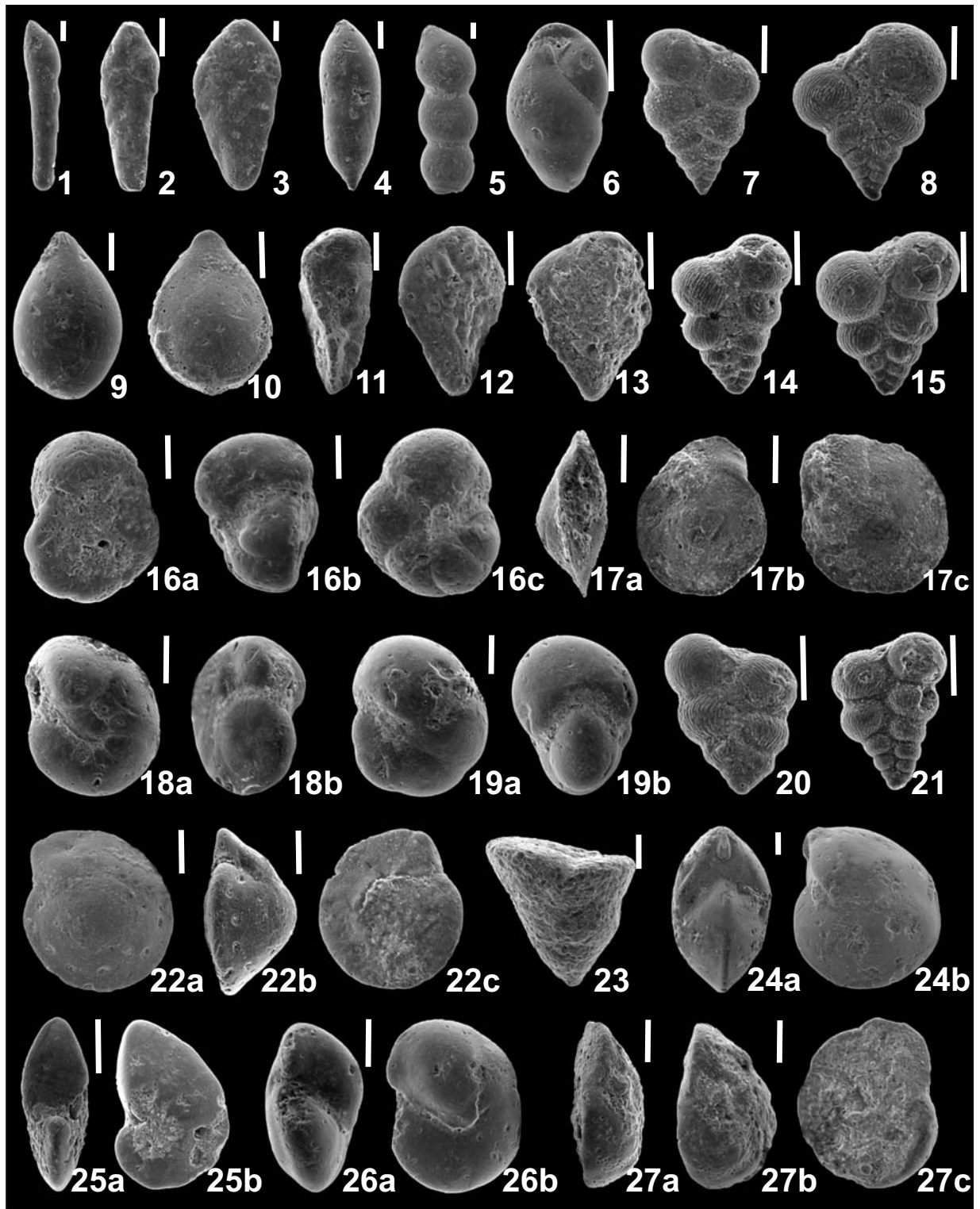


Fig. 5 Lower Maastrichtian foraminifera from the Wrocieryż quarry section. Scale bar – 100 µm. 1. *Laevidentalina nana* (Reuss); 2. *Coryphostoma incrassata* (Reuss); 3. *Coryphostoma crassa* (Vasilenko & Mjatluk); 4. *Cribrebella ovata* Gawor-Biedowa; 5. *Laevidentalina catenula* (Reuss); 6. *Praebulimina carseyae* (Plummer); 7. *Heterohelix planata* (Cushman); 8. *Heterohelix ultimumida* (White); 9. *Lagenella globosa ovalis* Reuss; 10. *Fissurina marginata* (Walker & Boys); 11. *Heterostomella carinata* (Franke); 12. *Bolivinoidea decoratus* (Jones); 13. *Bolivinoidea miliaris* Hiltermann & Koch; 14. *Heterohelix globulosa* (Ehrenberg); 15. *Heterohelix globulosa* (Ehrenberg); 16a–c. *Cibicides excavatus* Brotzen; 17a–c. *Osangulatia navarroana* (Cushman); 18a–b. *Valvulabamina* sp.; 19a–b. *Nonionella perdita* Haynes; 20. *Heterohelix punctulata* (Cushman); 21. *Heterohelix striata* (Ehrenberg); 22a–c. *Cibicidoides bembix* (Marsson); 23. *Marssonella oxycona* (Reuss); 24a–b. *Lenticulina* sp.; 25a–b. *Nonion troostae* Visser; 26a–b. *Valvulabamina lenticula* (Reuss); 27a–c. *Stensioeina pommerana* Brotzen.

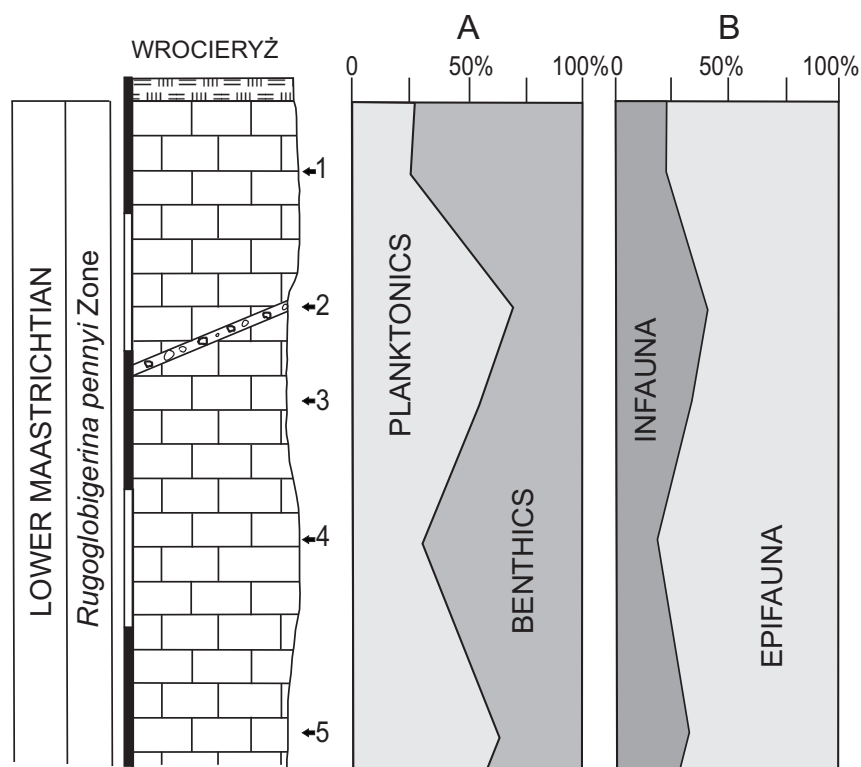


Fig. 6. Changes in foraminiferal assemblage composition in the Wrocieryż profile. A – relative abundances of planktonic and benthic foraminifera within assemblages. B – proportion of infaunal and epifaunal morphogroups within benthic foraminiferal assemblages.

There is a positive correlation between abundance fluctuations of planktonic foraminifera and infaunal morphogroups within benthic foraminiferal assemblages. Increasing abundance of planktonic forms is associated with increasing abundance of infaunal morphogroups. Higher values of both groups correspond with more muddy sediment.

Biostratigraphy

Planktonic foraminifera recorded in the studied material indicate that the sandy marls outcropping in the Wrocieryż section belong to the *Rugoglobigerina pennyi* Interval Zone established by Peryt (1980) in the lower Maastrichtian from the Middle Vistula River Valley. The lower boundary of the zone is defined by the FO of the index taxon, and the upper boundary by the FO of *Guembelitra cretacea* (Peryt, 1980). The continual presence of *Rugoglobigerina pennyi* accompanied by *Globigerinelloides multispinus* and lack of *Guembelitra cretacea* in the studied interval enable us to assign it to the lower part of the *R. pennyi* Zone. Peryt (1980) correlated the *R. pennyi* Zone in the Middle Vistula River Valley with the Lower Maastrichtian *Belemnella occidentalis* Zone (Błaszczewicz, 1980). According to Peryt (2007) the FOs of *Rugoglobigerina pennyi* and *Rugoglobigerina milamensis* are a good proxy for the Campanian/Maastrichtian boundary, as defined in the Middle Vistula River section by Walaszczyk (2004).

Palaeoenvironment

The abundance of planktonic foraminifera is controlled by the occurrence and amount of the phytoplankton including bacteria and is believed to reflect primary productivity (Hemleben *et al.*, 1989; Arnold & Parker, 2002). Planktonic forms are very important components of foraminiferal assemblages in the studied section. They are composed mainly by simple, small-sized, opportunistic, r-strategists taxa (*Heterohelix*) and by low to medium trochospiral morphotypes with subglobular chambers without keels, representatives of the more r-selected of the of r/k-intermediates: *Rugoglobigerina*, *Whiteinella* and planispiral *Globigerinelloides* (Caron & Homewood, 1983; Premoli Silva & Sliter, 1994; Petrizzo, 2002). In general opportunistic planktonic species are supposed to have

high reproductive potential and inhabit more nutrient-rich waters as well as can be considered indicators of cooler and/or unstable environments. The r/k intermediate morphotypes typify mesotrophic environments and the least complex (more r-selected r/k intermediates) closer to the eutrophic end of the spectrum (Petrizzo, 2002).

The depth in the sediment down to which foraminifers can live is determined by oxygen availability, and in the presence of oxygen, the vertical distribution of organisms is controlled by food availability (Jorissen *et al.*, 1995). A high flux of organic matter to the sea floor causes low oxygen concentrations within the sediment pore waters because oxygen is used in oxidation of the organic material. High abundance of infaunal forms in foraminiferal assemblages typifies aerobic/dysaerobic and mesotrophic/eutrophic environments (Corliss, 1985; Jorissen *et al.*, 1995; Murray, 2007).

Moderate to high P/B ratio, high percentage of epifaunal forms within benthic foraminiferal assemblages and dominance of *Heterohelix* along with *Rugoglobigerina* and *Globigerinelloides* within the planktonic foraminiferal assemblages indicate 100–150 m deep, cool, mesotrophic marine environment during the early Maastrichtian in the Nida Trough.

Parallel changes in abundance of planktonic foraminifera and infaunal morphogroups of benthic ones reflect probably short-term palaeoenvironmental changes resulting in changes in primary productivity. High P/B ratio and higher percentage of infaunal forms within benthic foraminiferal assemblages are indicative of mesotrophic, close to eutrophic marine environment, higher organic matter flux and lower oxygenation at the seafloor. Intervals characterized by low P/B ratio values and low abundance of infaunal morphogroups reflect mesotrophic, close to oligotrophic surface waters, low organic matter flux and environment with well oxygenated bottom waters.

Several cooling events are described from the late Campanian through Maastrichtian (Barrera & Savin, 1999). We suppose that palaeoclimatic changes were responsible for cyclic changes in foraminiferal assemblages during early Maastrichtian in the Nida Trough. Cooling was accompanied by stronger wind stress, leading to enhanced surface-water mixing and increasing primary productivity. This resulted in enhanced organic matter flux to the seafloor and low oxygen concentrations within the sediment pore waters because oxygen was used in oxidation of the organic material. Friedrich *et al.* (2005) applied similar explanation to Late Campanian–Early Maastrichtian changes in calcareous nannoplankton and foraminiferal assemblages and stable isotopes during formation of the homogeneous chalk sedimentation in epicontinental North German Basin. High P/B ratio values and increase in abundance of infaunal morphogroups reflect this situation. On the contrary, warming was responsible for decreasing of surface water mixing, low nutrient levels and low phytoplankton productivity. In highly oligotrophic regions all food particles are consumed or oxidised at the sediment surface.

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STOP 4

Callovian to Middle Oxfordian succession at Gnieździska quarry (Holy Cross Mountains, Central Poland)

Ewa GŁOWNIAK

Faculty of Geology, University of Warsaw, Al. Żwirki i Wigury 93, 02-089 Warszawa, Poland; glowniak_ek@uw.edu.pl

The Gnieździska quarry (40 km SW of Kielce) is situated at the Permo-Mesozoic margin of the Holy Cross Mountains (see map of p. 85). This area is a part of the Mid-Polish Anticlinorium, which stretches from NW to SE across the territory of Poland. The Anticlinorium is a Laramide structure, which exists since the late Cretaceous/Palaeogene.

The section exposes ca. 60 m thick Callovian to Middle Oxfordian siliceous and carbonate rock. Beds dip 130°/22°S to 160°/22°S and belong to the northern limb of the Mnin Syncline.

Callovian to Middle Oxfordian succession

The whole Callovian–Middle Oxfordian succession thickness exposed in Gnieździska quarry is nearly 60 m.

The E and NE side of the quarry exposes 25 m thick Callovian (Middle Jurassic) succession of siliceous gaizes. The lower part of the succession (2 m) consist of marls and marly gaizes of the Lower Callovian *Herveyi* Zone (Drewniak & Matyja, 1996). They are overlain by thickly bedded gaizes with cherts and in the uppermost part – by a layer of green claystone (0.35 m). Gaizes of this section are rich in detritic quartz. The latter constitutes ca. 20% of grains in the lower, and 5% in the upper part of the succession. Bioclasts are represented mainly by sponge spicules (up to 55%), less commonly by echinoderm plates (ca. 5%) and foraminifers.

Gaizes are strongly bioturbated. *Thalassinoides* burrows, which appear here in abundance (Pieńkowski *et al.*, 2008), were interpreted as privileged paths of migration of early diagenetic siliceous solutions (Drewniak, 1996). The *Thalassinoides* fill is silicified, which results in a certain nodular fabric of the rock.

Above the gaizes and green claystone there is a massive layer (0.8 m) (Figs 2–3) of two-part lithology: spiculite in the lower- and sponge-bearing limestone in the upper part. The layer contains some intraformational erosional surfaces.

The time of its forming spans from the late Middle or (?) early Late Callovian (ammonite of the genus *Hecticoceras* sp. occurs in the lower part of the layer, author's collection) to the earliest Oxfordian. The ammonites of the genus *Choffatia* sp. and early representative of *Cardioceras* (*Scarburgiceras*) sp. found in a single level (author's collection) indicates that the condensation and/or non-deposition across the Callovian/Oxfordian boundary comprises the *Lamberti* Zone and *Mariae* Zone respectively.

The limestones overlying the massive layer are Early to Middle Oxfordian in age (Fig. 1). They are sponge-bearing, bedded and attain a thickness of nearly 35 m in the Gnieździska quarry. The lithostratigraphical scheme used is that proposed for the Oxfordian of the Holy Cross Mountains by Matyja (1977) and characterised as follows:

Jasna Góra beds (Figs 1–3)

They represent an alternation of marly limestones and marls. They are mainly packstones or wackstones. They are rich in benthic and pelagic fauna (mainly sponges and ammonites). Microfossils consist of spongy spicules, echinoderm plates, foraminifers and mollusks. The thickness of this unit in Gnieździska is of ca. 5.5 m.

Grey limestones (Figs 1–3).

These are pelitic limestones impoverished of benthic macrofauna. Ammonites are very rare. The grey limestones contain dispersed ferrous sulphates which are responsible for its grey color. The

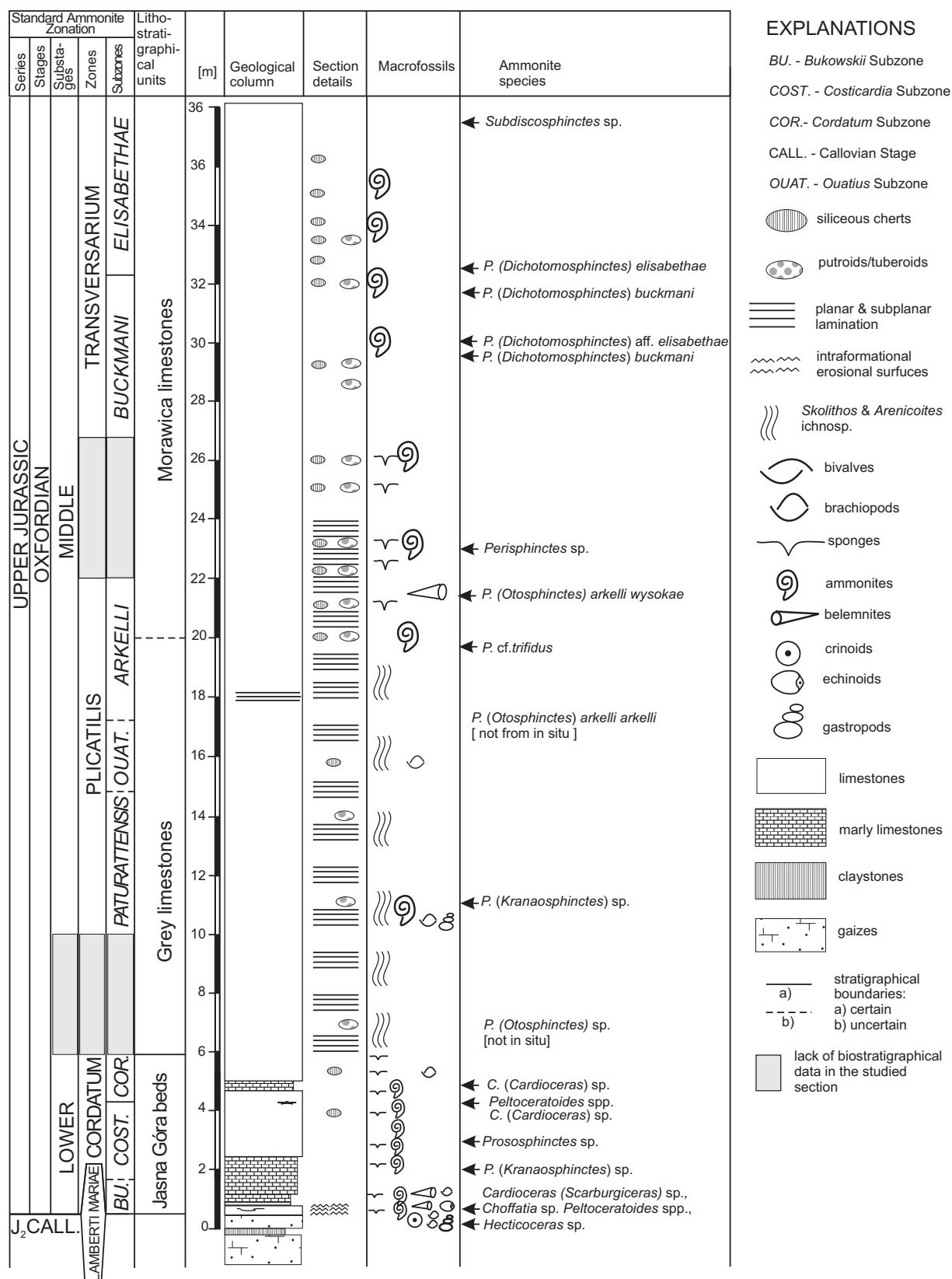


Fig. 1. Geological column of the Oxfordian limestones in the Gnieździska quarry.

thickness of this unit is ca. 14 m in Gnieździska quarry. The boundary with the overlying Morawica limestones is not clear.

In the grey limestones planar and low angle cross-lamination accompanied at the tops of beds by *Skolithos* and *Arenicolites* (characteristic members of *Skolithos* ichnofacies) appear (Pieńkowski *et*

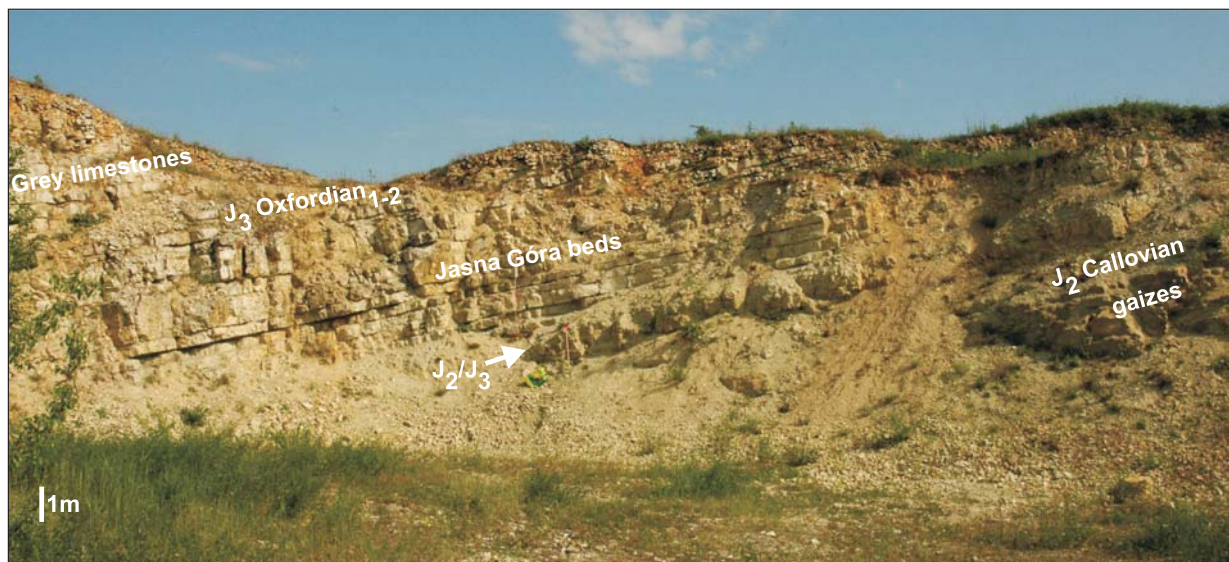


Fig. 2. General view on the Callovian–Oxfordian gaizes and limestone succession in the Gnieździska quarry (NW side). Arrow indicates a massive layer which contains the J2/J3 boundary.

al., 2008). The repetitive character of beds (erosional bottoms, subplanar lamination and bioturbated tops) conducted Pieńkowski *et al.* (2008) to the assumption of the tempestite origin of the grey limestones. This interpretation requires however some further studies as the environment of the latter unit has been commonly interpreted as a low energy open-shelf (e.g. Hoffmann & Uchman, 1992).

Morawica limestones (Fig. 1)

These are tuberculitic and putroidal bedded limestones with cherts. They contain abundant benthic and pelagic macro- and microfossils: ammonites, belemnites, foraminifers, brachipods, bivalvs, echinoderms, crustaceans, bryzoans and serpulids. Only the lower part of this unit, ca. 18 m thick, is exposed in the Gnieździska quarry.

The Oxfordian limestones in Gnieździska quarry range from the Lower Oxfordian *Cordatum* Zone through the Middle Oxfordian *Plicatilis* Zone and the *Transversarium* Zone (Główniak, 2008) (Fig. 1). The standard perisphinctid Oxfordian zonation for the Submediterranean Province can be applied (Główniak, 2002; 2006). Ammonites of the genera *Cardioceras* and *Peltoceratoides* appear in the *Jasna Góra* beds which thus assigned to the *Cordatum* Zone (Fig. 1) (for species register see Drewniak & Matyja, 1992; 1996). The boundary between the *Cordatum* Zone and the Middle Oxfordian *Plicatilis* Zone lies somewhere in the lower part of the overlying grey limestones. Its precise location has not been found because ammonites there are very rare (Fig. 1). Grey limestones belong mostly to the *Plicatilis* Zone as they yielded some undoubtful perisphinctid ammonites of the subgenera *Otosphinctes* and *Kranaosphinctes* accompanied by *Perisphinctes* cf. *trifidus* (Fig. 1). Lower part of the overlying Morawica limestones still belong to the *Plicatilis* Zone because of *Perisphinctes* (*Otosphinctes*) *arkelli* *wysokae* and *Perisphinctes* (*Otosphinctes*) *arkelli* *arkelli* occurrences (Fig. 1). The taxa are diagnostic for the *Arkelli* Subzone in the upper *Plicatilis* Zone. The upper part of the Morawica limestones in Gnieździska quarry belongs to the *Transversarium* Zone. They yielded *Perisphinctes* s. str. and of the subgenus *Dichotomosphinctes* (e.g. *P. (D.) buckmani* and *P. (D.) elisabethae*, Fig. 1) – ammonites diagnostic for the *Buckmani* and *Elisabethae* subzones of the *Transversarium* Zone.

Final remarks

In the Late Jurassic, the studied area was a part of the European epicontinental marine basins extended along the northern margin of the Tethys Ocean (e.g. Ziegler, 1990). The Holy Cross Mountains belonged to the southern margin of the Central European Basin located in the peri-Carpathian area (e.g. Kutek, 2001).

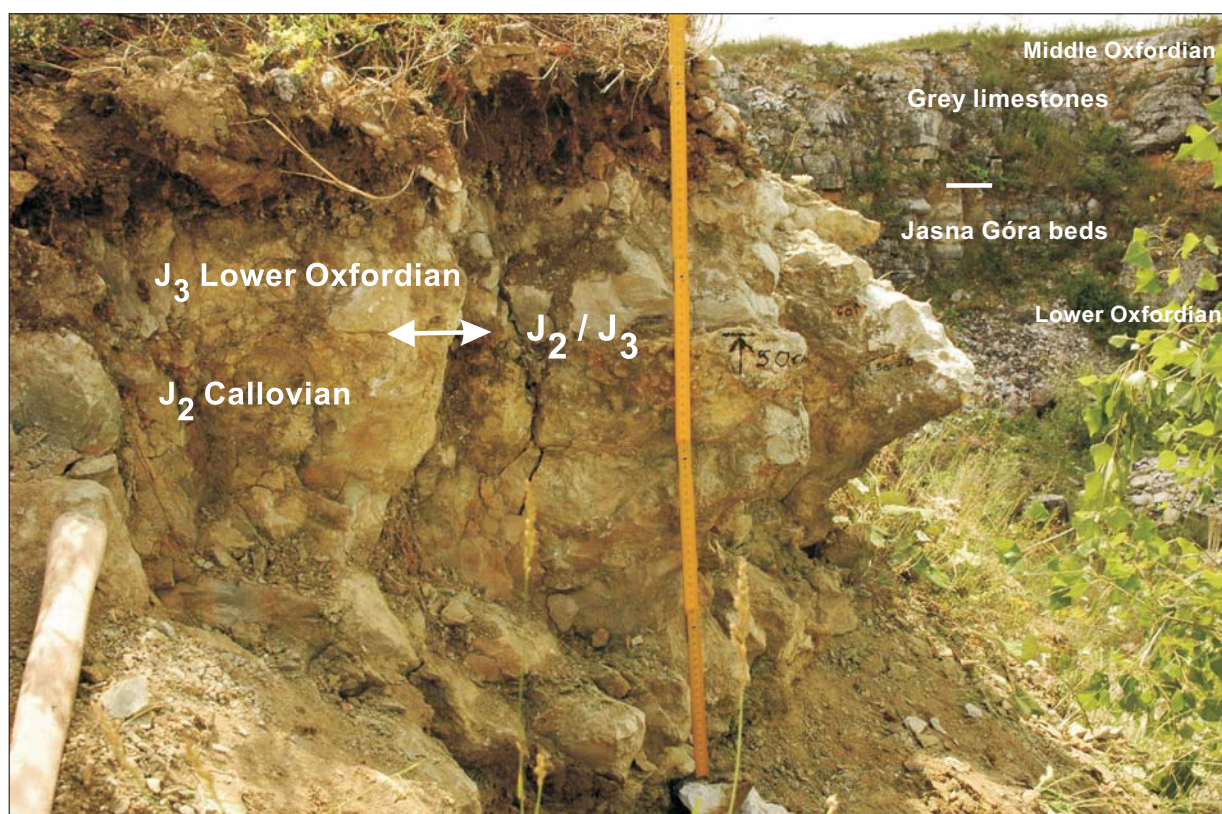


Fig. 3. The Callovian–Lower Oxfordian massive layer with the erosional surface (arrow) at the Middle/Upper Jurassic boundary. The overlying sponge-bearing limestones (Jasna Góra beds and grey limestones) are Early to Middle Oxfordian in age. Picture taken in the SE part of the Gnieździska quarry.

The Callovian sediments were accumulated during a period of sea-level rise (e.g. Hallam, 2001). The gaizes of Gnieździska originate from a highly porous spiculite, which was accumulated in low energy depressions. Basinal spiculites of Gnieździska underwent considerable compaction during diagenesis, the estimated original porosity having been 2–3 times bigger at the early stage of compaction (Drewniak, 1966). The early diagenetic processes led to appearance of cherts. *Thalassinoides* burrows were privileged paths of migration and precipitation of siliceous solutions.

The limit between the Callovian siliceous complex and the Oxfordian limestones in Gnieździska is discontinuous. The Callovian/Oxfordian discontinuity is a global phenomenon which occurred during the sea-level high stand conditions. This led to a widespread condensations and/or non deposition in the Middle/Upper Jurassic known e.g. from carbonate platforms of central and SW Europe.

During Oxfordian, an extensive development of the Late Jurassic sponge lithofacies took place in central and southern Poland, attaining a thickness of some hundred metres, documented as well in the SW margin of the Holy Cross Mountains (Matyja, 1977; Kutek, 2001). The lithofacies was dominated by siliceous sponges (“lithistida”, *Hexactinosa* and *Lychniscosa*) and it was deposited in a neritic environment along the northern margins of the Tethys (Trammer, 1982, 1989). It extended from Lusitania through of central Europe, and further to the east as far as Tadzhikistan and the Pamirs. It also includes cyanobacteria-sponge bioherms and it was replaced in the deeper interbioherm depressions by layered limestones. Gnieździska quarry with its bedded limestones exposes just the deeper, interbiohermal facies.

The bathymetry of sponge megafacies has been estimated e.g. against the ecological limitations of siliceous sponges (according to Krautter, 1997) and independently calculated against the evaluation of the sea-bottom palaeorelief in the Late Oxfordian and Kimmeridgian by Matyja & Wierzbowski (1996, 2004). The latter authors (op. cit.) mention the depths of more than 100–300 m in the Early–Middle Oxfordian whereas over 400 m in the Late Oxfordian to Early Kimmeridgian.

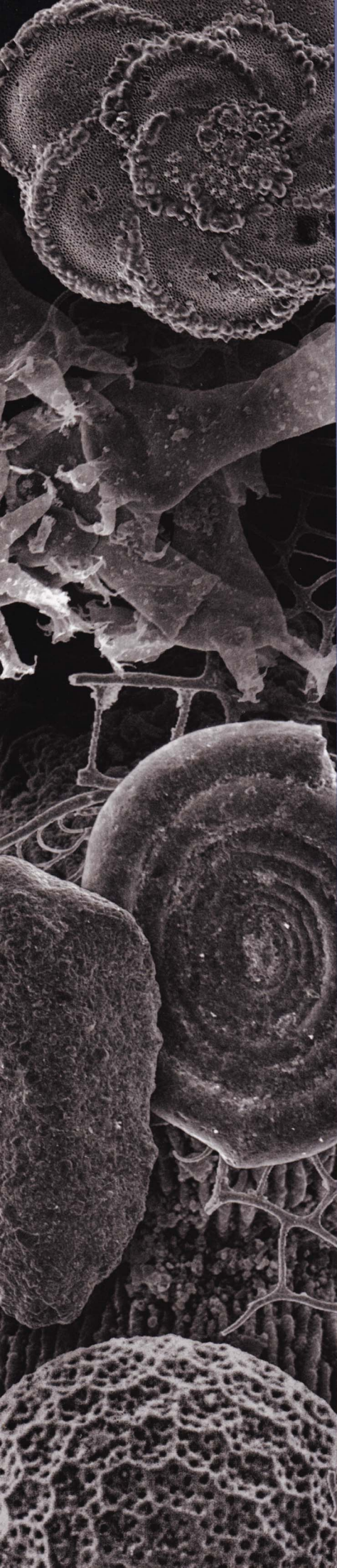
The Oxfordian carbonate deposits of Poland became exceptionally useful for various stratigraphic research, due to its continuous sedimentation without gaps and condensations, homogeneous facies, and easy access to the outcrops. Being rich in ammonites, they have become well known for numerous relevant ammonite works (e.g. Bukowski, 1887; Głowniak & Wierzbowski, 2007; Kutek, 1968; Siemiątkowska-Giżejewska, 1974). Due to the convenient location at the cross roads of incursions of Boreal and Mediterranean ammonites, this region increased in significance in the last two decades as reference area for inter-regional biostratigraphic correlations (e.g. Głowniak, 2006; Matyja *et al.*, 2006) and also palaeomagnetic studies (e.g. Przybylski *et al.*, 2009).

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