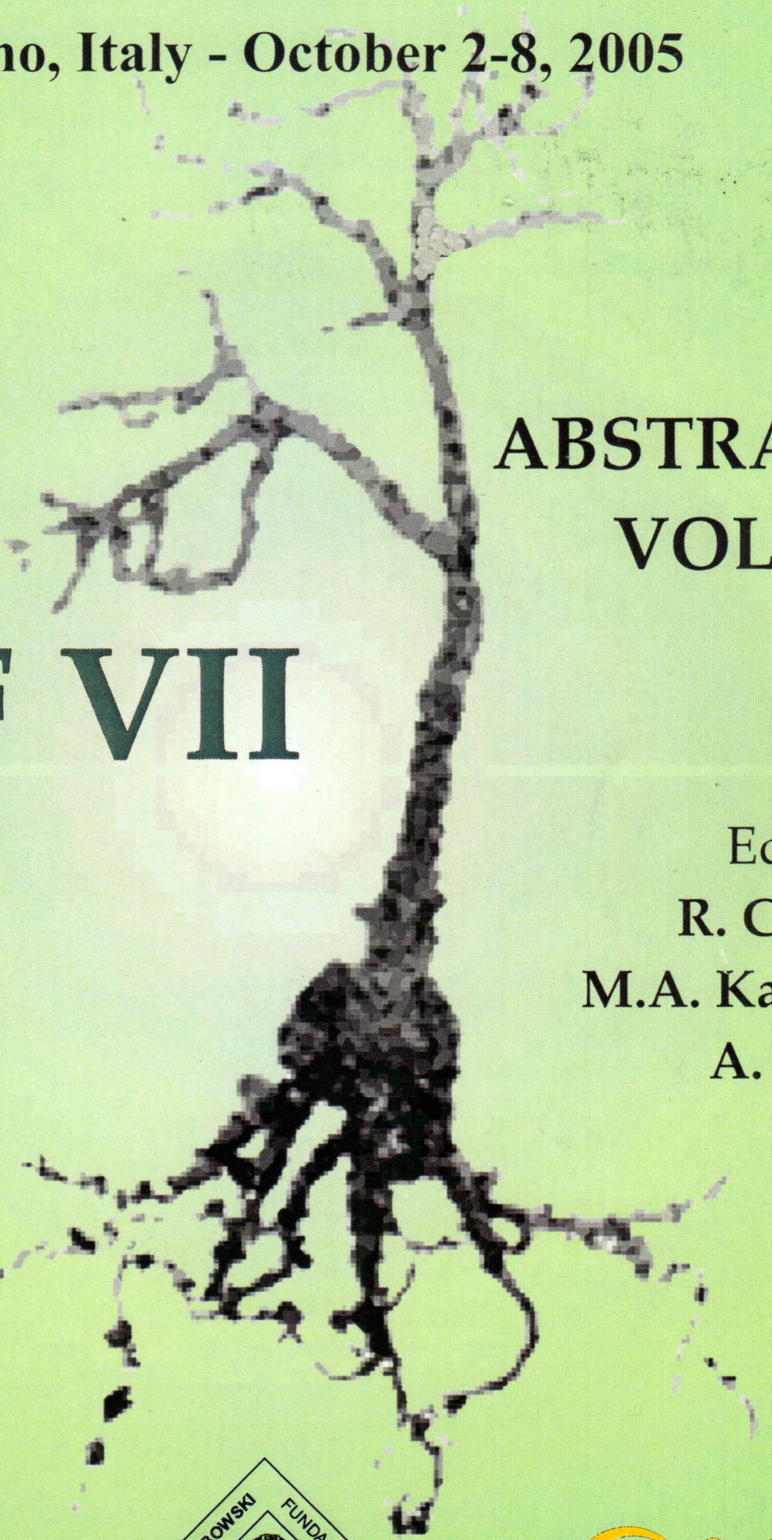
Seventh International Workshop on Agglutinated Foraminifera

Urbino, Italy - October 2-8, 2005



ABSTRACTS VOLUME

IWAF VII

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The Seventh International Workshop on Agglutnated Foraminifera, Urbino Italy, October 2-8, 2005 – A preface

It is our pleasure to welcome you to Urbino to the The Seventh International Workshop on Agglutnated Foraminifera, held at the Institute of Geology of the "Carlo Bo" University of Urbino. We hope that you find Urbino to be a fascinating and hospitable venue for the meeting, and that the scientific content is up to your expectations.

The IWAF-7 meeting is the successor to previous IWAF meetings held in Amsterdam, Vienna, Tübingen, Kraków, Plymouth, and Prague. The purpose of the workshop is to bring together researchers and students who are conducting research on the oldest and largest group of the Foraminifera – the Agglutinated Foraminifera. Recent advances in taxonomy and especially in molecular biology mean that radically new concepts have been recently proposed that affect the systematics of the group. One of the purposes of the meeting is to provide a platform for discussing new concepts and data concerning the rank and classification of the group.

Likewise, the discovery of agglutinated foraminifera at newly investigated localities will serve to improve our knowledge of the distribution of the group, and their usefulness for biostratigraphy and paleoceanography. Many of the presentations at this meeting emphasise the utility of this microfossil group for palaeoenvironmental studies.

The format of the IWAF-7 is similar to that of the previous workshops. Three days of technical sessions are followed by a three-day field excursion to visit some of the classical localities near Gubbio, Monte Conero, and San Marino.

We would like to take this opportunity to thank people who have contributed to the success of this meeting, especially Simone Galeotti, who at the previous workshop suggested the idea of bringing the IWAF-7 to Urbino. We also wish to thank our main sponsor, the Grzybowski Foundation, for providing travel grants that enabled some of the participants to attend the meeting.

We wish you a pleasant stay in Urbino!

Rodolfo Coccioni
Urbino

Mike Kaminski
London

A Shared Information Technology Tool for Foraminifera Taxonomists

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Today's situation of the foraminiferal systematics reminds us of the rain forest with its complexity, mixture of „growing", and „dead" and never ending changes. Even largest „trees" are not lasting forever and fall one day. Young students or those who just enter the „forest" are easily discouraged by the vast amount of systematic literature, huge number of described taxa, and insufficient information support available through modern technologies (e.g., World Wide Web). Existing databases on the Web seem to be built for the experienced Foraminifera worker rather than for the general public. Printed information sources of this discipline seem to reach their limits. There is little chance that somebody will repeat the heroic editorial job of A. Loeblich and H. Tappan - „Foraminiferal genera" that represents the last systematic compendium on foraminiferal systematic and taxonomy at genus level and higher taxonomic groups. Furthermore, it has been over a decade since molecular biology research produced changes of some of our theories regarding the natural classification of Foraminifera. Some substantial changes affected even the high level systematics and the process is expected to continue.

The need of a research and information environment that has to be accessible and friendly to those interested in the study of Foraminifera motivates further endeavors meant to build a capability we can all share. There are two potential approaches for accomplishing such a task: 1) a web based database technology and 2) an ontology (an artificial intelligence technology) also accessible via the World Wide Web. The first approach assumes the creation of a database schema with attributes referring to morphologic and taxonomic elements and a set of queries through which the user retrieves and manipulates the data. The second approach consists of building a Foraminifera ontology that can be queried, augmented, and even modified by users.

As part of the artificial intelligence domain, ontologies can be simply defined as descriptions of the concepts and the relationships that can exist for an entity or a community of entities. An ontology represents a specification of a representation and enables knowledge sharing and reuse. Once built, the ontology describing Foraminifera systematics will reside on a remote server and be accessed via Internet. Given the current high level of interest in the Geoinformatics domain, it is expected that the Cyberinfrastructure for Geosciences (GEON) project and/or its descendant(s) will be hosting the Foraminifera ontology either at San Diego Super Computer Center or at one of GEON's nodes (e.g., University of Utah). This ontology will represent both an educational and a research tool that all of us will share.

Paleocene Deep-water Agglutinated Foraminifera in the Transylvanian Basin

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Recent re-evaluation of the micropaleontological material from deep wells drilled in the Transylvanian Basin offers new insight into the initial interpretation of the basin's evolution.

Since the first gas discoveries almost a century ago, Paleocene deposits were considered to be either continental or missing owing to tectonic events around the Cretaceous/ Paleogene boundary. Among the few wells that recovered pre-Miocene sediments, well Puini-6 contains the first and so far the only proof of deep marine conditions in the Transylvanian basin during the Paleocene.

Diverse and well preserved deep water agglutinated foraminifera, initially interpreted as "Senonian", could be clearly re-assigned to a Danian age, based on accompanying planktonic foraminiferal assemblages (Zone P1c-d). The DWAF assemblage displays moderate diversity, and includes common tubular forms as well as more complex forms such as *Rzehakina minima, Cribrostomoides trinitatensis, Reticulophragmium garcilassoi*, and *Recurvoides* spp. One sample (1860-63 m) from the well contains a mixture of calcareous and agglutinated forms with Danian planktonics, while the overlying sample (1825–28 m) contains only agglutinated forms and is assigned a late Paleocene age, based on the presence of *Reticulophragmium*. The assemblage represents marine conditions, with deposition taking place in a bathyal (probably upper bathyal) environment.

The identification of Paleocene DWAF in the Transylvanian Basin has important paleogeographic and tectonic implications. As a result of our finding, the first tectono-stratigraphic mega-sequence, corresponding to the rifting phase in the basin, can be extended in time from the Late Cretaceous into the Paleocene, at least for the northern part of the basin. Formerly, the Paleocene in this area had been thought to be represented by a hiatus.

Characterization of Paralic Paleoenvironments using Agglutinated Benthic Foraminifera from Lower Cretaceous Deposits (Scotian Shelf)

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Foraminiferal analysis on samples collected from an Early Cretaceous cored interval of Cohasset A-52 well (located on the Scotian Shelf approximately 40 km southwest of Sable Island, Nova Scotia Offshore), reveals the occurrence of "marsh type" fauna.

Forty-one samples from 4 coreholes between (2069 and 2355 m) corresponding to 25 m of interbedded gray-black shale and sandstone with shell fragments have been processed for foraminiferal analysis. The majority of samples results rich of foraminifera allowing a quantitative study: the fraction >63μm has been counted.

The foraminiferal associations recorded from the studied cores are characterized mainly by agglutinated specimens of *Trochammina, Haplophragmoides, Ammobaculites* and *Verneulinoides.* A scattered occurrence of Thecamoebians is also recorded.

The foraminiferal associations and abundances from the examined samples are comparable with modern assemblages of salt marshes and estuaries. Foraminiferal associations characterized by abundant *Ammobaculites* and *Trochammina* are also reported from coeval deposits of the Grand Banks (Hibernia wells). "Marsh-estuary type" faunas similar to the Cohasset ones are reported from sections of similar ages in the western Portugual reported previously.

These foraminifera do not provide biostratigraphic information but the study of their occurrence and distribution has provided paleoenvironmental characterization of marginal marine and paralic environments.

The Eocene Deep Water Agglutinated foraminiferal record of the Contessa section (Gubbio, central Italy): short-term changes and evolutionary turnover

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The upper Turonian to lower Eocene Scaglia Rossa Formation in the Umbria-Marche Basin consists of regularly bedded pink and reddish limestones interbedded with reddish marly layers deposited under well-oxygenated conditions in a lower bathyal depositional environment (Arthur & Fischer, 1977; Kuhnt, 1990). In the Umbria-Marche Basin the P-E transition is present in the pelagic red limestones of the Scaglia Rossa Formation which is suitable for correlating the Paleogene biostratigraphy to the geomagnetic polarity history.

Previous studies of benthic foraminiferal assemblages from the Scaglia Rossa formation (Kuhnt, 1990, Kuhnt & Kaminski, 1996; Kaminski et al., 1999; Galeotti *et al.*, 2004) have shown that DWAF assemblages include elements of mixed calcareous- and organically-cemented bathyal assemblages, purely agglutinated "flysch type" forms, and a number of species known from abyssal sequences deposited below the Carbonate Compensation Depth. The record provided by this unique biofaces (termed the "Scaglia-type" facies by Kuhnt & Kaminski, 1989) can be used for supra-regional correlations and, particularly, for comparison with deeper water settings (below the CCD) where only siliceous microfossils are preserved. Moreover, available magnetostratigraphic, lithostratigraphic, biostratigraphic and geochemical data in the Gubbio area provide a firm chronostratigraphic framework on which the DWAF assemblage record can be placed.

The data set presented here is partly based on data previously published by Galeotti *et al.* (2004) on the Paleocene-Eocene boundary interval, and unpublished M.Sc student projects carried out jointly at UCL and UU. New results on the faunal composition of lower Eocene DWAF assemblages highlight short- to medium-term quantitative changes and evolutionary turnovers in the light of global events such as P/E boundary event, the Early Eocene hyperthermal events (e.g., Elmo), and the Early Eocene Climatic Optimum (EECO).

The P/E boundary, which occurs at 30.30 m above the K/P boundary, is denoted by a ca. 2 ‰ excursion in the $d^{13}C$ record corresponding to the well known Carbon Isotope Excursion (CIE). Across the CIE, which correspond to a 10-cm thick clayey interval, DWAF assemblages show quantitative changes associated with a reduction in abundance and diversity. The most characteristic feature of the basal Eocene at Contessa is the bloom in *G. charoides*, which is most prominent within the CIE interval itself but extends over a 5-m interval corresponding to the calcareous nannofossil Zone CP8. This basal Eocene "*Glomospira* facies" is also recorded in the Carpathian flysch deposits and at ODP sites in the Atlantic. The record of DWAF, however, indicates a gradual initiation of such perturbation beginning some 750 kyr before the BEE with the entrance of shallower water taxa probably in response to warming of bottom waters. This prelude to the P/E boundary event led to the downward bathymetric migration of several (mostly calcareous-cemented) agglutinated taxa and is here ascribed to a re-organisation of intermediate and deep water masses following the onset of deep convection in the western Tethys.

The Lower Eocene part of the uppermost Scaglia Rossa shows faunal changes that are somewhat less well defined. However, we do observe some acme events that may have more than just regional significance. A maximum in *Karrerulina conversa* is found in one sample at 38 m, and the *Paratrochamminoides* group becomes abundant in the interval from 40 to 45 m. *Spiroplectammina spectabilis* appears again at 42 m. Based on their stratigraphic position, the succession of acme events recorded in the lower Eocene Contessa Road section may represent the response of DWAF assemblages to recently discovered hyperthermal events that followed the P/E boundary (Roehl et al., 2004).

The Elmo Event occurs at 44.80 m above the K/P boundary and is marked by a ca. 10-cm thick marly layer that contains elevated proportions of Glomospira and infaunal morphotypes. Based on available magnetostratigraphy (Lowrie *et al.*, 1982), the Elmo event identified in the Contessa Road occurs in the uppermost part of C24r therefore in the same position reported by Lourens et al. (2005) from the Walvis Ridge ODP Sites.

Above this interval, a general decrease in diversity associated with a remarkable decrease in the abundance of shallow infaunal morphotypes is recorded from the base of the cherty member of the Scaglia Rossa, which correspond stratigraphically with the onset of the EECO event. The cherty member of the Scaglia Rossa still contains common *Paratrochamminoides* and *Subreophax* in addition to the ubiquitous tubes, and the abundance of *Haplophragmoides walteri* increases at 70 m. This one sample contains the only occurrence of *Reticulophragmium* observed in the whole of the Contessa section, - several small specimens of *R. intermedium.* The "R. amplectens Zone" which is so ubiquitous in the Eocene sub-CCD sediments in the Atlantic and Western Tethys is not found at Gubbio.

The DWAF assemblage in the basal part of the of the Scaglia Variegata Formation is initially identical to that of the Scaglia Rossa, but a large increase in abundance is observed at 100 m, which is virtually coincident with the base of planktonic foraminiferal Zone P11. *Ammodiscus tenuissimus, Glomospira charoides, Haplophragmoides walteri*, and *Karrerulina* spp. (mostly *K. horrida* and *K. coniformis*) all increase in abundance at this level. The abundance of DWAF again increases at 125 m, where *Saccammina* spp. and *H. walteri* are dominant. At 142.5 m, a massive increase in *Spiroplectammina spectabilis* is observed, and this acme persists to the top of the studied section at 155 m. At 152.5 m, *Glomospira charoides* again becomes common. This interval with common *Spiroplectammina* corresponds to nannofossil Zone CP15a. This event correlates well with the *Spiroplectammina* acme observed in the Labrador Sea (Kaminski & Gradstein, 2005).

The succession of events recognised in the Paleocene-Eocene from the Contessa Road section is used to produce a distribution chart that may be of use for supra-regional DWAF-based biostratigraphic correlations across this interval.

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The new enhanced Bio-Chrono-Sequence Stratigraphy

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A project is underway by the International Commission on Stratigraphy (ICS) to recalibrate the standard Bio-Chrono-Sequence Stratigraphy of Hardenbol et al. (in Graciansky *et al.,* 1998) to the new Geologic Time Scale (GTS2004) by Gradstein, Ogg et al., 2004. To this end, ICS has obtained the copyright release to the master charts from SEPM, and received funding from ExxonMobil and ChevronTexaco.

During Phase 1 of the project, the Triassic, Jurassic, Cretaceous and Cenozoic charts will be recalibrated, and posted on the ICS website. In addition, an interactive, web-based program can generate selected parts of the charts from the master database for personal use. During Phase 2 similar master bio-chrono-sequence charts will be compiled for the Lower and Upper Paleozoic.

All products will be available free of charge on the ICS website under www.stratigraphy.org, and will be enhanced with a master dictionary with synonyms, a zonal search module, and a chronostratigraphic "audit trail".

The record of Deep water Agglutinated Foraminifera (DWAF) is important in building biozonations and well correlation schemes in many petroleum basins, as shown in the linked biostratigraphy columns for North Sea, offshore Norway, Barents Sea, Beaufort Sea and Labrador Shelf. Intra-basin correlation with average stratigraphic ranges of DWAF taxa is common practice, and fascilitated through the use of quantitative biostratigraphic methods.

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GEOLOGIC TIME SCALE 2004 - WHY, HOW, AND WHERE NEXT !

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This lecture reviews *Geologic Time Scale 2004* (*Gradstein, Ogg et al., 2004*; Cambridge University Press), constructed and detailed by 40 geoscience specialists, and indicates how it will be further refined. Since Geologic Time Scale 1989 by *Harland et al*., many developments have taken place:

(1) Stratigraphic standardization through the work of the International Commission on Stratigraphy (ICS) has greatly refined the international chronostratigraphic scale. In some cases, traditional
European-based stages have been replaced with new subdivisions that allow global correlation.
(2) New or enhanced methods of extracting high-precision age assignments with realistic uncertainties from the rock record. These have led to improved age assignments of key geologic stage boundaries and other global correlation horizons.
(3) Orbital tuning has greatly refined the Neogene, and improved parts of Paleogene and Mesozoic.
(4) Statistical techniques of compiling integrated global stratigraphic scales within geologic periods.

Anticipated advances to the Geologic Time Scale during the next 8 years include:
- A geologically realistic Precambrian scale
- Formal definition of all Phanerozoic stage boundaries.
- Orbital tuning of polarity chrons and biostratigraphic events for entire Cenozoic and Cretaceous.
- A detailed database of high-resolution radiometric ages that includes "best practice" procedures, full error analysis, monitor ages and conversions.
- Resolving age dating controversies (e.g., zircon statistics and possible reworking) across Devonian/Carboniferous, Permian/Triassic, and Anisian/Ladinian boundaries.
- Improved and standardized dating of several 'neglected' intervals (e.g., Upper Jurassic – Lower Cretaceous, and Carboniferous through Triassic).
- Detailed integrated stratigraphy for Upper Paleozoic through Lower Mesozoic.

The geochronological science community and ICS are focusing on these issues. A modified version of the time scale to accompany the standardization (boundary definitions and stratotypes) of all stages is planned for 2008 (to be presented at the 33th International Geologic Congress in Oslo), with a totally revised version of GTS available in 2012.

The Wootton Bassett mud springs (Wiltshire, UK): an unusual Lagerstätten for Jurassic Foraminifera

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On the 6th January 1997 the mud springs at Templars Firs, Wootton Bassett (Wiltshire) were designated a Site of Special Scientific Interest (SSSI) under Section 28 of the Wildlife and Countryside Act 1981 (as amended). The springs are notified as an SSSI on the basis of their hydrogeological interest, although they are probably best known for their palaeontological interest. Water seeping through the Lower Calcareous Grit and Coral Rag (of Oxfordian age) liquefies the Ampthill Clay Formation (lowermost Kimmeridgian) which then migrates to the surface in a series of mud springs. Many of the fossils brought to the surface still display their aragonitic shells and are quite beautifully preserved. In Autumn 2003 and again in Spring 2004 we collected a series of samples with the permission of English Nature (Wiltshire Team) and these have been washed for foraminifera and ostracoda. The microfauna has been described in a BGS Report, although it is much more extensive and yields all the taxa associated with this stratigraphical interval. Many aragonitic taxa (epistominids) are beautifully preserved, including some of the stratigraphically significant taxa. Large agglutinated foraminifera appear to dominate one of the mud vents and are in an exceptional state of preservation. In the literature, many of these have been referred to modern taxa, although this is almost certainly incorrect. The material from Wootton Basset should allow for a more appropriate determination of these taxa.

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Recent and late Pleistocene agglutinated foraminifera from marine sediment cores, Montserrat, Lesser Antilles, Caribbean Sea

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Marine sediment cores from the Caribbean Sea adjacent to the island of Montserrat have been investigated for foraminifera, pteropods and stable isotopes. The cores were collected in 2002 by the RV *L'Atalante* (CAR-MON Series) and in 2005 by the RRS *James Clark Ross* (JR123 Series). Most of the cores were drilled in water depths of 600-1200 m around the southern half of the island and many contain horizons of volcanic ash or massive volcaniclastic units. Benthic foraminifera are relatively rare, with agglutinated foraminifera making up only a small proportion of the fauna. Many of the taxa include volcanic material in their test wall construction. The ash fall from the 2003 eruption of the Soufrière Hills volcano was intersected at many sites and collected by box-core. Within the surficial sediments of "chocolate brown" mud are large specimens of *Reophax*, but little else except for the occasional pelagic specimens. These elongate species of *Reophax* appear to be the first evidence of benthic colonization following the ash fall and would appear to confirm the work on the Pinatubo ash falls carried out by Silvia Hess, Wolfgang Kuhnt, *et al.*
Our work on the ship was limited and the cores will only arrive in the UK for further analysis at the beginning of June.

The JR123 Cruise was funded by NERC Grant NER/A/S/2002/00963.

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A quantitative record of DWAF from the Cretaceous-Paleogene boundary interval in the Labrador Sea (Indian Harbour M-52 well, Labrador Margin)

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The Micropaleontological collections of the Natural History Museum in London (the so-called British Petroleum Collection) house a detailed micropaleontological record from the BP Indian Harbour M-52 well, which was drilled at a water depth of 198m on the Labrador Margin. Although the foraminiferal assemblages from this well have been studied previously (Gradstein & Berggren, 1981; Kaminski, 1988), the microfaunal slides housed in BP Collection constitute the most complete archive record from this well. Furthermore, the washed residues from this well were also available for study, allowing us to obtain a quantitative record from the well. For the purpose of this study, the interval between 9,900 and 10,750 feet was studied for microfossils.

The assemblage recovered from the studied interval consists almost entirely of DWAF, comprising 131 species. The assemblage is dominated by astrorhizids, lituolids, ammodiscids and saccamminids, and is a typical flysch-type assemblage as described by Gradstein & Berggren (1981). Four stratigraphically important assemblages are recognised in the studied interval:

(1) The Caudammina gigantea Zone is present from 10,750 to 10,510 ft, and is assigned a mid-Campanian to Maastrichtian age. The top of this zone is characterised by the last occurrence of *C. gigantea* and *Remesella varians*. The LO of Cretaceous planktonic foraminifera is observed at 10,510 ft.

(2) An acme of *Spiroplectammina spectabilis* is found in the interval between 10,480 and 10,330 ft. The base of the interval coincides with the LO of *C. gigantea*, the first common occurrence of *S. spectabilis* and a reduction in the abundance of tubular forms. Additionally, this interval contains a higher relative abundance of infaunal taxa such as *Reophax, Subreophax*, and *Ammobaculites*. This assemblage is entirely comparable to the early Danian DWAF assemblages reported from southern Spain, Gubbio, Italy, and from Site 959 in the Eastern Atlantic (Coccioni & Galeotti, 1994; Kuhnt & Kaminski, 1996; Kuhnt *et al.* 1998). This record of the lower Paleocene *S. spectabilis* acme in the Labrador Sea means that the event was geographically widespread.

(3) The interval from 10,300 – 10,210 ft is correlated to the Reticulophragmoides jarvisi Zone (sensu Kuhnt *et al.,* 1998) described from ODP Site 959. The sample collected at 10,300 contains the LCO of *S. spectabilis* and the FO of *R. jarvisi*, suggestion a late Paleocene age.

(4) An assemblage containing abundant *Coscinodiscus* (diatom) steinkerns is observed at 10,180 ft. This sample has a relatively impoverished DWAF assemblage, and it compares well with the Coscinodiscus Zone described by Gradstein *et al.,* (1994) from the Central North Sea. Does this represent a spill-over event from the North Sea which was brackish at the time?

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Thecamoebians from the Upper Vltava River (Sumava Mts., Czech Republic)

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The upper Vltava River is situated in the central part of Sumava Mts. The river springs at 1172 m elevation near the Cerná Hora Mts. and drains 46.5 % of the Sumava National Park. The upper Vltava River flows thought a wide valley containing large peat bogs. Studied sector ends at the Lipno reservoir.

The Sumava Mts. with neighbouring Bavarian Forest represents the largest forest complex in Central Europe with good status of nature preservation. Sumava is influenced by a mixed continental and oceanic climate marked by small annual fluctuation in average temperature of 6.5^{o} C (lowlands) and 3. 5^{o} C (peak areas). Wet and cold weather conditions prevail.

During the studies, one important event occurred: Precipitation during August 2002 reached 296 mm in comparison with an average value of 98 mm. Those enormous precipitations caused two very intensive flood waves in August 2002.

All sampling points were localized by GPS and characteristics of the environment were recorded (Fig.1). Sampling was realized during four field trips: (1) September 1999: benchmark sampling, aim: to test presence/absence of theacamoebian assemblages in main biotopes (lake, streams, peat bogs, wetlands); (2) August 2001: detailed sampling; aim: to test differences in microhabitats. (3) June 2002: main sampling, Besides creeks and river, small peat bogs and wetlands near these streams were also sampled to analyze differences between stream assemblages and assemblages from standing water bodies. (4) October 2002: repeated sampling after flood; aim: to test influence of flood event on the thecamoebian assemblages.

20 cm^3 of sample was used for sieving procedure Fractions 0.5 – 0.036 μm were used for the thecamoebians study. Abundances of species in 20 cm^3 of sample were counted. These abundances represented input data for cluster analysis. Differences in analysed environmnetal factors (fig.1) among clusters were compared and tested by chi^2-test.

Thecamoebian assemblages from one-hundred samples from the Upper Vltava River were analysed and thirty-two species and morhotypes were recognized during years 1999-2002. *Centropyxis ecornis, Pontigulasia compressa* and *Difflugia* div. sp. dominated in the assemblages.

High relative abundance of *Pontigulasia compressa* and *Difflugia* div sp. were recorded from the similar environment characterized by sapropelitic substratum in flowing water. However *Pontigulasia compressa* appeared in more types of assemblages as *Difflugia* div. sp. and therefore may be highly adaptable to any kind of aquatic environment. *Centropyxis ecornis* preferred coarser substratum with low content of sapropel.

Five assemblages were defined by cluster analysis: *Centropyxis ecornis* assemblage, *Pontigulasia compressa* assemblage, *Centropyxis ecornis*-*Pontigulasia compresa* assemblage, *Difflugia viscidula* assemblage and “residual” assemblages. Statistical analysis showed that flow rate and character of substratum significantly influenced the composition of thecamoebian assemblages. Cluster analyses enable distinguishing assemblages with *Difflugia viscidula* and assemblages with other *Difflugia*. Both types of assemblages were recorded from the similar environments (sapropelitic substratum, flowing water) and differences between ecological requirements of *Difflugia viscidula* and other *Difflugia* cannot be distinguished from studied ecological data.

After the flood event of August 2002, higher diversified and more abundant assemblages appeared in stream sediments. Massive appearance of *Centropyxis ecornis* assemblages in streams after flood event confirmed opportunistic character of this species and probable low-nutrient level in streams. Increasing of diversity and abundance of thecamoebians after flood may be explained by accumulation of tests reworked during flood.

Acknowledgment

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Type of freshwater body		Depth	Flow rate		Substratum		Sapropel	Character of vegetation in water body	
1	Spring	measured values [in cm]	1	standing water	1	coarse-grained gravel	estimate relative abundance of sapropel in sediment [in %]	1	moss
2	streamlet (width to 0.5 m)		2	stream pool	2	fine-grained gravel		2	grass
3	small creek (width 0.5 - 2 m)		3	quiet stream	3	sand		3	aquatic plants
4	creek (width 2 - 5 m)		4	speed stream	4	mud		4	algae
5	small river (width above 5 m)				5	coarse organic detritus		5	moss and grass
6	Canal				6	coarse organic detritus and gravel		6	grass and algae
7	Slop				7	coarse organic detritus and mud			
8	peatbog pond				8	grass roots with mud			
9	Peatbog				9	moss			
10	Pond				10	algal growth on stones or wood			
					11	aquatic plants			

Fig.1 Categories for classification of environment in the sampling sites

Complex-walled agglutinated foraminiferal biostratigraphy and palaeoenvironmental significance from the Jurassic supercycle-associated carbonates of Saudi Arabia

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The Jurassic supercycle in Saudi Arabia is represented by at least seven 3rd order sequences, mapped as the Marrat, Dhruma, Tuwaiq Mountain, Hanifa, Jubaila, Arab and Hith formations. With the exception of parts of the Arab, and Hith formations, all other lithostratigraphic units consist of carbonate. The carbonate successions were deposited in response to cyclical marine transgressions over a slowly subsiding, wide platform that formed part of the southern flank of the Tethys Ocean. Foraminiferal biofacies responded with great sensitivity to the variety of palaeoenvironmental conditions, and it is probable that the various species ranges were controlled by niche modification associated with the sequence boundaries.

Age determination has been determined primarily by ammonoid and nautiloid biostratigraphy from the outcrop belt, and has provided a control to investigate benthonic foraminiferal biostratigraphy in the subsurface of eastern Saudi Arabia. The succession ranges from Toarcian to Tithonian age, of which the local age significant foraminiferal species include *Pfenderina trochoidea, P. salernitana, Trochamijiella gollesstanehi, Trocholina elongata, T. palastiniensis, Kurnubia* species, *Pseudocyclammina lituus* and *Alveosepta jacardi*. This approach is used to assign the Marrat Formation to the Lower Jurassic (Toarcian), Dhruma Formation to the Middle Jurassic (Bajocian to Callovian), Tuwaiq Mountain Formation to the Middle Jurassic (Callovian), Hanifa Formation to the Upper Jurassic (Oxfordian), Jubaila and Arab Formations to the Upper Jurassic (Kimmeridgian) and the Hith Formation to the Upper Jurassic (Tithonian). It is hoped that future work may identify additional subspecies of stratigraphic significance. The age significance of such species is especially relevant in correlating subsurface, core and cuttings samples derived from exploration and development wells, with the outcrops to confirm the lithostratigraphy.

Within the applied micropalaeontological application demanded by the hydrocarbon industry, reservoir characterisation downgrades age determination to an academic level, and significantly more importance is assigned to the palaeoenvironmental application of the foraminiferal assemblages. Of significance to the petroleum geologist and reservoir engineer are the lateral extent, and three dimensional distribution of reservoir quality grainstones. Multiwell studies using semi-quantitative micropalaeontological analysis of closely spaced samples is used to provide such control on hydrocarbon field scale, by integration with sedimentology to establish depositional cycles of potential reservoir layer significance. Moderately deep marine assemblages in the Bathonian to Callovian include *Pfenderina trochoidea* and *Trochamijiella gollesstanehi*. Slightly shallower conditions include both of these species in the presence of *Trocholina elongata*. Shallower marine assemblages are typified by the presence of *Redmondoides lugeoni, Pfenderina salernitana, Kurnubia* species and *Nautiloculina oolithica*. *Pseudocyclammina lituus* and *Alveosepta jacardi*, followed by the presence of *Mangashtia viennoti* provide evidence for gradual shallowing conditions. The shallowest conditions are associated with the presence of *Trocholina alpina*.

Based on thin section analysis of randomly oriented sections, the origin of *Kurnubia* species is suggested to be possibly related to *Trochamijiella gollesstanehi*, from which transverse sections are not easily distinguished. *Trocholina elongata* is present throughout the upper Dhruma and Tuwaiq Mountain Formations, and its local extinction at the end of the Callovian provides useful regional evidence for penetration of the upper Callovian and the Hanifa – Tuwaiq Mountain formational contact. The evolution of *Kurnubia* may take place within the Callovian. *Alveosepta jacardi* and *Alveosepta powersi* are difficult to separate using random thin sections within an industrial, time-constrained environment, but the presence of *Alveosepta* cf. *jacardi* in the basal part of the upper member of the Hanifa Formation (Ulayyah member) has been used to mark the lower –upper Oxfordian boundary in Saudi Arabia.

Foraminifera from the Sedili River, west Malaysia, as a proxy for South China Sea Tertiary marginal marine and estuarine palaeoenvironments

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The slow flowing Sedili River drains the east coast of southwest Malaysia and enters the South China Sea through a wide estuary at Sedili Besar. Samples collected for foraminiferal analysis from the estuary upstream yield foraminifera that display clearly defineable provinces. The study was aimed at establishing a detailed environmentally significant biofacies association that could be used to determine Tertiary micropalaeontologically based palaeoenvironments for samples collected from oil wells drilled in the South China Sea. Samples were collected and examined for palynology, but the palynological results are not discussed here. The study provided a useful, pragmatic method of subdividing well sections into environmentally-influenced stratigraphic subunits that assisted regional correlation of reservoir sands.

The lower estuary, mangrove-fringed regime has normal marine tidal influence and salinity (34ppt) and supports a mixed calcareous and agglutinated authochthonous foraminiferal assemblage of which the latter include *Trochammina* species, *Tiphotrocha comprimata, Haplophragmoides* spp and *Ammobaculites* cf. *cylindroides*. It also contains surge-transported inner neritic calcareous benthonic foraminifera including *Lagena gracillima, Reussella simplex, Asterorotalia pulchella, Celanthus craticulatus, Triloculina species* and species of *Ammonia* and *Elphidium* with the planktonic foraminifera *Globigerinoides trilobus* and *Globorotalia* cf. *angustiumbilicata*. A modified lower estuarine, mangrove-fringed regime, located upstream of the lower estuarine, contains a diverse, rich but exclusively agglutinated foraminiferal assemblage dominated by *Trochammina* species, but accompanied by species of *Tiphotrocha*, *Cribrostomoides* and *Ammobaculites*. An upper estuarine, freshwater to slightly brackish, *Pandanus* and grass-fringed tidal regime supports a rare, low diversity agglutinated foraminiferal assemblage that is dominated by *Miliammina fusca*, *Spirolocammina* and *Psamminopelta* species. Upstream of this regime, the freshwater conditions support *Nipa* palm and grass-fringed river banks but do not contain foraminifera. Specimens of a sponge spicule designated *Silicosphaera asteroderma* were present in most samples collected from the lower estuary.

Biostratigraphic value of *Rzehakina epigona* in the Paleocene – Lower Eocene of Northern South America

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The Paleocene – Early Eocene history of marine sequences from Northern South America remains poorly known. Several events such as Paleocene – Eocene Thermal Maximum, the beginning of the Andes uplift or the initial closure of the Tethys Sea are poorly understood within northern South America because of a poor calibration to the time scale of local biostratigraphic zonations. Local biostratigraphy needs to be correlated to the geological time scale if the geological information from Neotropics is to be integrated with the rest of World. The Paleocene described in the marine Tertiary of Northern South America is based on the presence of *Rzehakina epigone* (Duque – Caro, 1971). This benthic foraminifer's occurs in the Paleocene Lizard Spring Formation in Trinidad. However, it is now considered of limited bioestratigraphic value (Bolli et al, 1994)
In equatorial regions the *R. epigona* has been reported in the Early Campanian (Moullade et al, 1998), through the early Eocene (Zone P9); with doubtful occurrences in Middle Eocene (Zones P10 through P13) (Morkhoven *et al* 1986). Recently, this species has been reported in Miocene deep waters from the Vioska Knoll, offshore of Louisiana (Green et al, 2003).

Here we report *Rzehakina epigona* in the Salto Outcrop, Serrania de San Jacinto, Colombia, occurring together with a Middle Eocene assemblage of planktonic foraminifera (*Hastigerina bolivariana, Turborotalia bolivariana, Acarinina wilcoxensis, A. pentacamerata y Globigerina aff eocaena*). Therefore, *Rzehakina epigona* should not be used as a Paleocene marker in northern South America

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The ACEX Arctic Drilling Expedition (Summer 2004) – Preliminary Results based on Agglutinated Foraminifera

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The IODP Arctic Drilling Expedition (IODP Leg 302) was the first scientific drilling expedition to drill in the permanent Arctic ice. This IODP cruise was first "Alternate Platform" leg – using ships other than the JOIDES RESOLUTION. The ACEX Arctic Drilling Expedition consisted of a purpose built drill ship accompanied by two Arctic-class ice-breakers. During the ACEX Expedition, four holes were drilled at a locality on the Lomonosov Ridge in the Central Arctic, providing a composite stratigraphic record extending back to the Campanian. For the first time, we now have a more or less complete record of Polar marine environments in the High Arctic. This presentation will review the background to the ACEX Expedition, show some highlights from the cruise, and discuss the most significant shipboard scientific results.

The Campanian and Paleocene to Eocene record of the "Arctic Gulf" is of interest for studies of Boreal Paleogeography, as many of the foraminifera species are endemic. The foraminiferal assemblage recovered from the base of Hole 4A consists wholly of a low-diversity agglutinated foraminiferal assemblage (mostly *Trochamminoides* and *Recurvoides*), that is assigned an early Campanian age based on dinoflagellates.

The upper Paleocene agglutinated foraminiferal assemblage is more diverse with tubular forms, ammodiscids, *Haplophragmoides, Verneuilinoides*, and species of primitive *Reticulophragmium* first described from the Beaufort Sea. Paleocene-Eocene Boundary strata contain a peak in the dinoflagellate cyst *Apectodynium*, and the benthic foraminiferal record exhibits a major turnover, indicating a change in oxygenation associated with a peak in global temperatures. Lower Eocene sediments overlying the *Apectodynium* peak contain a low-diversity agglutinated assemblage with *Lagenammina*. Middle Eocene sediments are largely biosiliceous with indicators of brackish and fresh-water conditions, and are barren of Foraminifera.

The opening of the Fram Strait and the onset of the current fully-marine conditions took place in the early Miocene. The oldest fully marine sediments with cosmopolitan DWAF present on the Lomonosov Ridge are dated to the earliest middle Miocene (approx 15 Ma). Since the mid-Miocene, the Arctic experienced open connections with the Norwegian-Greenland Sea to the south. The foraminiferal record from the mid Miocene to Pliocene marine sediments consists entirely of agglutinated benthic species, largely sparse assemblages containing *Cyclammina pusilla* and *Alveolophragmium polarensis.* Nevertheless, by comparing the foraminiferal record of the new Arctic Drilling holes with the record from ODP Hole 909C in the Fram Strait, we now have better constraints on the timing of the opening of the Fram Strait, and the establishment of the Arctic – Atlantic faunal connections.

A Database of Agglutinated Foraminiferal Genera

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The descriptions of Genera of Agglutinated Foraminifera are in need of revision and updating. The compilation of Loeblich & Tappan (1987), though an invaluable contribution that brought stability to field of foraminiferal systematics, is now 20 years out of date. At latest count, over 120 new genera of agglutinated foraminifera have been described since 1987 (Kaminski, 2000, 2004); and many others have been emended based on subsequent study.

In 2002, an international working group was convened to address the problem of updating the systematics of the Foraminifera. New advances in molecular biology and new ideas for the suprageneric classification of the Foraminifera (including changes in rank of the group as a whole), have now made the Loeblich & Tappan classification obsolete.

As a first step towards the eventual task of reclassifying the Foraminifera, we have prepared a compendium of all the agglutinated genera considered valid. The original file (Agglut-2004), consisted of the generic descriptions scanned from Loeblich & Tappan (1987), with updated comments added as remarks. An appendix at the end of the Word file listed all the newly described genera, presented in the same format as in Loeblich & Tappan (1987). Another appendix listed those genera that are considered to be invalid or junior synonyms. This Agglut-2004 file was very much a working document.

This year, as a further step toward making a proper database of agglutined foraminiferal genera, each genus has been copied into a separate file. The file format follows the general format of the Ellis & Messina Catalog of Foraminifera, and contains the name of the genus, the type species, type reference, synonymy (if needed), the description and remarks, stratigraphic range, and the illustrations scanned from Loeblich & Tappan (1987), with their explanations. At a later stage, we will add additional illustrations and re-scan the original figures to provide better quality. The database of genera can then be used for systematic purposes – to fit into a newly revised classification.

In the short term, our goal is to produce a revised compendium of the general of agglutinated foraminifera, which can be accessed in electronic form. It is envisaged that this will be the first stage in the revision of the group as a whole.

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An Atlas of Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera

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As a step towards the documentation of the global deep water agglutinated foraminiferal faunas through geologic time, we have prepared an extensively illustrated Atlas of Paleogene Deep-Water Agglutinated taxa. These faunas started to flourish in deeper water basins as early as Middle Jurassic, with major phases of evolutionary expansion in the Aptian-Turonian, Campanian, late Paleocene, Early Eocene and Middle Miocene.

The Atlas, which we began as a taxonomic project in 1979 at the Bedford Institute of Oceanography in Dartmouth, N.S., Canada, is intended to serve as a reference guide for micropalaeontologists working with agglutinated benthic foraminifers in deep marine, siliciclastic strata of Paleogene age around the world, and is intended to be a companion volume to the "Van Morkhoven *et al.* Atlas" of deep-water calcareous benthic foraminifera. Some of the agglutinated taxa covered in the Atlas are stratigraphically long ranging, while others either appeared in Late Cretaceous time or extend into Neogene.

The 130 Agglutinated Taxa are grouped in Linnean taxonomic units using fossil shell morphology, which represent the majority of species to be expected in deep-marine clastic sediments. For each of these valid species we provide illustrations – mostly based on type material – with one or more plates of SEM and optical photographs, and/or hand drawings. There is concise description for each species, followed by a discussion of its paleogeography and stratigraphic occurrence. Three species (*Glomospira glomerata, Paratrochamminoides deflexiformis*, and *Reticulophragmium intermedium*) are formally emended, and one species (*Eratidus gerochi*) is described as new. Lectotypes are designated for several species (*Psammosiphonella discreta* (Brady), *Rhabdammina linearis* Brady, *Ammodiscus cretaceus* (Reuss), *Hormosinella distans* (Brady), *Hormosinelloides guttifer* (Brady), *Reophax pilulifer* Brady, *Reophax subfusiformis* Earland, *Trochamminoides subcoronatus* (Grzybowski), *Recurvoides retroseptus* (Grzybowski), *Recurvoides setosus* (Grzybowski)).

The Atlas begins with an introduction outlining the history of investigations, and discusses the most important collections. The second chapter summarises the Paleoecology and its spin-off Paleobathymetry, a subject that is in demand for the study of deep-water basins. Chapter three deals with biostratigraphical record of DWAF in over 26 basins, including offshore eastern Canada, North Sea, offshore Norway, Norwegian Sea, Barents Sea, Beaufort Sea, Carpathian Basins, southern European Tethyan basins, India, and Trinidad/Venezuela. Each main area of investigation has a stratigraphic range chart for key taxa. The following section contains the main course of this Atlas: Systematic Taxonomy. This is followed by the master reference listing and the species index.

The "Atlas of Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera" is available from the Grzybowski Foundation.

Kaminski, M.A. & Gradstein, F.M. 2005. *Atlas of Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera.* Grzybowski Foundation Special Publication, 10, 547 pp.

Shocked Diamonds in agglutinated foraminifera from the Cretaceous/Paleogene Boundary interval at Monte Conero, Italy

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Agglutinated foraminifera were examined from washed acid residues of samples collected at measured intervals across the Cretaceous/Paleogene boundary section in Monte Conero, Italy to assess their ability to select heavy mineral phases. Examination by scanning electron microscopy and electron microprobe has enabled us to identify minerals comprising the outer walls of various agglutinated foraminiferal species, including *Psammosphaera fusca*, and *Reophax* cf. *parvulus*. Modern representatives of these genera are known to preferentially to agglutinate heavy minerals. Because of this behaviour, we postulated that heavy detrital minerals, including possible impact ejecta, would have been scavenged by the agglutinated foraminifera and incorporated into their tests.

We report here the discovery of impact derived minerals, including microdiamonds and Ni-Co bearing fractionated siderophile element residues, in specimens from the K/P boundary clay, and also from specimens sampled both above and below the boundary clay. The dimensions of the microdiamonds (4-5 microns) are in agreement with the predicted size range of ejecta particles from the Chicxulub impact site in Mexico. We conclude that scavenging of ejecta grains by agglutinated foraminifera is an important process for the subsequent bioturbation and redistribution of the ejecta material. This is the first reported occurrence of impact microdiamonds associated with the K/P boundary interval discovered outside North America.

Milankovitch control of terminal Maastrichtian productivity in the Bottaccione section, Italy: Evidence from deep-water agglutinated foraminifera and trace fossils

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The impact of an extraterrestrial body at the Cretaceous/Paleogene (K/P) boundary triggered a series of abrupt biological, oceanic and climatic changes.

Based on the record of agglutinated benthic foraminiferal species and their morphogroups, five periods of higher productivity may be recognised within the uppermost two metres of the Maastrichtian at Bottaccione. Carbonate flux, variations in the trophic structure of benthic foraminifera, and macrofaunal burrowing activity show a five-peak, cyclical response that may be related to Milankovitch- frequency productivity variations. The duration of each high productivity period was ~17 k.y., and the last one was suddenly interrupted by the K/P boundary event.

During periods of high productivity, which we suggest are correlated to the %$CaCO_3$ peaks, food would have been transported to deeper layers of the sediment, thus promoting an increase in the relative abundance of deep infaunal species such as *Gerochamina* spp., *Reophax* spp. and *Subreophax* spp. Shallow infaunal species such as *Saccammina sphaerica* also proliferated during periods of increased productivity, although their abundance would have been limited due to competition with deep infaunal species. An increase in the relative abundance of the epifaunal *Paratrochaminoides olszewskii*, *Ammodiscus* spp. and *Glomospira* spp. also correlates with levels of high carbonate content.

Ammodiscus spp. and *Glomospira* spp. may have proliferated during periods of environmental instability or during changes in productivity related to the main peaks in %$CaCO_3$. On the contrary, the infaunal species *Spiroplectinella israelskyi* seems to be associated with oligotrophic environments, and its relative abundance remained low during periods of higher productivity.

The decrease in the overall abundance of the infaunal morphogroup, as well as a decrease in the total number of benthic foraminifera from the base towards the top of the studied interval is interpreted as reflecting an overall decrease in primary productivity during the latest Maastrichtian. This general trend is also supported by the occurrence of *Planolites* burrows in our samples.

We suggest that these peaks in productivity during the Maastrichtian were determined by Milankovitch-frequency orbital parameters. The general trend towards a decrease in primary productivity during the latest Maastrichtian was apparently modulated by Milankovitch cyclicity, thus conferring the five-peak signal to the studied benthic foraminiferal and trace fossil assemblages. Prior to the K/P boundary, variations in primary productivity were mainly controlled by Milankovitch cyclicity in the Umbria-Marche Basin.

Micropalaeontological characterisation of Miocene deep-sea fan deposits, Congo (Zaire) Fan, offshore Angola

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The documentation of microfauna from a well drilled through the distal section of the Congo (Zaire) deep-sea fan has been carried out. The Congo fan is largely built of Miocene sands, mudstones, clays and shales organized into sedimentological facies. These include canyon, upper fan valley, upper and lower channel-levees leading to distal lobe deposits. The progradation of this system throughout the Neogene, together with the unique active meandering turbidite channel and salt diapir formation, has lead to accumulations of hydrocarbons in high-quality sands that have already yielded oil in sufficient quantities for extraction.

The well in this study began being sampled at 2775m, with samples processed at 10m intervals down to 4452m. Abundant calcareous and agglutinated benthic and planktonic foraminifera are present. Agglutinated foraminifera constitute the most persistently occurring forms, and show wide diversity and good preservation. Foraminiferal abundance and composition vary downhole, which is believed to result from a combination of both environmental and sedimentological factors.

Planktonic foraminifera have been used to date the upper section of the well to Zones M6 – M5/M4b (15-16.6 Ma), using the occurrences of the *Globigerinoides – Praeorbulina – Orbulina* lineage, and *Globorotalia peripheroronda*. The well then penetrated barren sands that re-emerged into nearly pure agglutinated foraminiferal assemblages suggestive of the lower Miocene or upper Oligocene.

Agglutinated foraminifera consist a large proportion of typical Palaeogene forms, such as *Glomospira gordialis*, *Glomospira charoides*, *Glomospira irregularis*, *Glomospira glomerata*, *Cribrostomoides subglobosus*, *Paratrochamminoides olszewskii*, and *Haplophragmoides excavatus*. Typical Miocene forms are also present, including *Reticulophragmium rotundidorsatum*, *Haplophragmoides carinatus*, enlarged *Reticulophragmium* sp. comparable to *R. amplectens*, and various cyclamminids. The cyclamminids undoubtedly consist of various species previously put under the *Cyclammina acutidorsata* and the *Cyclammina cancellata* groups. There are also many specimens of *Trochamminoides* and *Paratrochamminoides* that appear to be indicative of the Neogene. Below the sand, the DWAF point to a paleoenvironment that is well-oxygenated and deep (below the CCD). The fauna is of a cosmopolitan nature.

Stratigraphical significance of the Foraminiferal assemblages from the Eocene Red Clays near Barwinek described by Rudolf Noth in 1912 (Magura Unit, Outer Carpathians).

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Foraminifera have been studied from one of the type localities studied by Rudolf Noth (1912) in his monograph on the "Foraminifera of the Red Clays from Barwinek and Komarnok". The main goal of our study is to undertake the documentation of the foraminiferal assemblages from this famous Carpathian locality, and to place the unit within a regional stratigraphical context. Noth (1912) described several new species of foraminifera from the localities near Barwinek. As Noth's original collection no longer exists, a revision of this fauna serves in the interest of the stability of taxonomical nomenclature.

Samples have been collected from an outcrop in a stream bank located ca. 100 m above the Youth Hostel in Zyndranowa. The locality consists of red and variegates claystones of the Magura Unit of the Outer Carpathians. The samples have been processed for foraminifera, calcareous nannofossils, and dinoflagellate cysts.

The Foraminiferal assemblages consist entirely of deep-water agglutinated taxa, and are rich and well-preserved, with over 50 species present. The dominant genera present in the samples consist of tubular forms such as *Nothia*, *Rhizammina*, *Rhabdammina*, and *Bathysiphon*. Among the non-tubular genera, the various species of *Trochamminoides* and *Paratrochamminoides* are well-represented. The samples also contain an early morphotype of *Reticulophragmium amplectens* (Grzybowski) which closely resembles the species *Reticulophragmium intermedium* (Mjatliuk) described from the Lower Eocene of the Ukrainian Carpathians. Our study of the DWAF points to an early Eocene age for the locality.

The Lower Eocene Red Clays are known from numerous localities in the Western Tethys and North Atlantic. The stratigraphical and paleoceanographical significance of the microfauna from Barwinek are discussed within context of the Tethyan foraminiferal events.

Recent (Rose Bengal stained) benthic foraminifera from Portuguese margin canyons

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From an ecological point of view submarine canyons are not well studied, although they form essential elements in our global system. Through them vast quantities of erosional products, including nutrients and carbon, are transported to the deep sea, either directly from the riverine point source or indirectly after temporary deposition on the shelf. In Nazaré canyon excess 210Pb values in sediments are found to be an order of magnitude higher than in the adjacent shelf and slope environment, reflecting increased particle settlement fluxes (van Weering et al., 2002). In addition, the same study indicates that the canyon sediments are rich in C-org. As such, canyons are important loci where organic matter from shelf sediments and the settling flux is concentrated and oxidized and its nutrients are re-mineralized. Consequently, the oxygen consumption in canyons is high. This was demonstrated by Epping et al. (2002), who measured enhanced anaerobic oxidation, denitrification and burial of C-org in Nazaré canyon in comparison to the surrounding shelf, where aerobic oxidation dominates. The combination of these parameters together with the physical disturbance due to functioning of the canyon will result in an extraordinary and adapted ecosystem.

Preliminary results will be presented from a detailed quantitative analysis of living (Rose Bengal stained) benthic foraminiferal assemblages from Nazaré and Lisbon-Setúbal canyons, which are located on the Portuguese continental margin. These canyons have a comparable oceanographic setting, including narrow shelf, summer upwelling regime and exposure to southwesterly storms in winter. However, while the Lisbon-Setúbal canyons are fed by the rivers Sado and Tagus, the Nazaré canyon has no direct river influence.

Highest abundances of living foraminifera are found at the head of each canyon declining with depth. However, the axis of the Nazaré canyon appears to be nearly barren in contrast to Lisbon-Setúbal canyons. This may be related to recent disturbance inside the canyon. Nevertheless, in a previous study carried out at Royal NIOZ, van den Berg and de Stigter (data not published) found abundant foraminifera populations close to the axis of the Nazaré canyon. Generally low abundances of living foraminifera were also found in Jersey canyon, and this has been related to periodic mass wasting and disturbance in the canyon (Jorissen et al., 1994). Agglutinated taxa, such as *Cribrostomoides ssp*., *Trochammina ssp*., *Buzasina ringens*, *Bigeneria cylindrica* and *Nouria ssp*., are present in great numbers at many locations and sometimes dominate the assemblages of the Portuguese margin canyons. This is in contrast with previous canyon studies by Jorissen et al. (1994) and Schmiedl et al. (2000), which revealed that the foraminifera assemblages in canyons off New Jersey and Gulf of Lions are dominated by calcareous foraminifera species such as *Uvigerina* spp. and *Bulimina* spp..

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Thecamoebians (Rhizopoda, Testacea) in the youngest sediments of the Lipno Water Reservoir – response to anomalous precipitation in 2002 and 2003

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Thecamoebians are one of few numerous groups of freshwater microorganisms with shells and thus they are able to fossilize. It is necessary to know their recent requirements concerning environment to use this group for interpretation of paleoenvironments. The aim of our research granted by GAAV CR denominate "Actuoecology of the freshwater thecamoebians of the Sumava Mts." is to find out ecological demands of thecamoebians that can be used in paleontology.

The environments of thecamoebians are very heterogeneous, however they are always characterized by sufficient moisture. We specialize in thecamoebians living just in water environments. The area of the Sumava Mts. is very suitable for such research because of its diversity. From the Sumava Mts., only one contribution is addicted to lake thecamoebians (Frič & Vávra, 1903). Within our study assemblages from lakes, the Lipno Water Reservoir, water streams of various dimensions and peat bogs were investigated. The investigation applying variability of assemblages on a small area was published (Holcová & Lorencová, 2004).

Two years of anomalous precipitations in 2002 (1549 mm) and 2003 (921 mm) in comparison with average 1082 mm (data from meteorologic station Kvilda at Jezerní slat) represent a "natural experiment" and its reflection in the assemblages of thecamoebians was examined. It was possible to dig several holes in the bottom of Lipno thanks to water level decrease in summer 2003. The thecamoebians assemblages were studied in individual layers. This contribution discusses the results from the youngest beds that represent dry year 2003 and extreme precipitation in summer 2002 most probably.

The holes were dug in two stages. The first one was performed at the end of August 2003 when water level was starting to decline. The holes were situated near the shore. Other holes were located furthermost from the shore towards to the centre of the reservoir in October 2003 after next decrease of water level. Sediments caught in holes were described and all layers were sampled. 20 ml of every sample were washed, the fraction 0,036 - 2 mm was then separated and analyzed using optical stereomicroscope. Detailed morphological characters were studied using SEM. The measurements were performed using a system of microvideo camera. The longest diameter of the tests of the species *Centropyxis aculeata* was evaluated.

It is possible to distinguish three types of thecamoebian assemblages in the investigated material:

1) diversified associations with more than 8 thecamoebian species; these assemblages contain mainly genus *Difflugia* (10–50%), *Centropyxis* (30–70%) a *Bullinularia* (5–30%); *C. aculeata* reaches dimensions 70–160 µm, average 85–120 µm;
2) assemblages with a distinct dominance of genus *Centropyxis* (90–100%) represented especially by species *C. aculeata* and *C. platystoma*; *C. aculeata* reaches sizes between 38–75 µm, average 50–60 µm;
3) assemblages with dominating species *Bullinularia* (60–100%).

At the same time the distribution of these assemblages in profiles were studied. The profiles were correlated on lithological basis. It is possible to compare slight layer of organic mud (2–5 mm) on surface. It represents the dry year 2003 when the input of clastic material to the reservoir was very small. This layer is characterized by diversified assemblages (type 1). The genus *Bullinularia* (assemblage of type 3) is very abundant in the bays in this layer.

There are different coarse-grained clasts (10–50 cm): sand to gravel, or clayey-sand sediments under this slight layer. Certainly at least some part of these clasts sedimented from the big amount of clastic material transported to Lipno in consequence of the high precipitation in August 2002. Either thecamoebians do not occur there or only small individuals of the genus *Centropyxis* (assemblages of the type 2) are presented in this horizon.

There is a monotonous layer of clay with sandy admixture under these clastics. There are almost no thecamoebians. Sporadic finds are originated from the higher parts of this horizon.

The knowledge about ecology of the lake thecamoebians is quite insufficient. According to Dalby (Dalby *et al.,* 2000) their distribution in lakes is effected by vegetation nearby the lake, climatic conditions and amount of food. The greatest number of data is about the species *Centropyxis aculeata* in literature. It is a typical r-selection organism, colonizer that tolerates worse environment, especially lack of food (Collins et al., 1990, McCarthy et al., 1995). It is possible to interpret the assemblage of type 2 with dominating genus *Centropyxis* very similarly. It also corresponds with small dimensions of their tests. The size of tests could be caused by the amount of nutrients (Bobrov *et al.,* 1999).

Diversified assemblages (type 1) indicate more stable and more optimal environments. Concerning species dominating in this type of assemblages the most number of data is about *Difflugia oblonga*. Generally requirement of high content of sapropel (Patterson & Kumar, 2000) is determined for genus *Difflugia* that is why high content of nutrients is assumable for assemblage of type 2.

In reference to environments of assemblage of type 3 the only datum about life demands of the dominating genus *Bullinularia* is a relation to genus *Sphagnum* (Medioli & Scott, 1988). That does not correspond with our observations of distribution of this type of assemblages.

The evolution of the bottom environment of Lipno was interpreted basing on distribution of thecamoebian assemblages in the youngest sediments as follows: homogenous clayey sediments with practically no thecamoebians could represent a constant stage of the aquatic environment before 2002. Stable conditions were unfavourable for thecamoebian expansion. This first stage was suddenly interrupted by high precipitation, rise of water level and extensive input of clastic material probably in August 2002. Thecamoebian assemblages colonized low-nutrient environments in different coarse-grained sediments. More diversified assemblages appear occasionally. Colonization of the bottom continued in 2003 where abundant and varied assemblages indicate environment with sufficient nutrients. We are not able to interpret the presence of the genus *Bullinularia* mainly in the bays. It will be very interesting to observe consecutive evolution of the thecamoebian assemblage further, though great decrease of water level in Lipno in 2003 interrupted the colonization of the bottom again.

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Gas Chimneys? Agglutinated Foraminifera? – Another Example of Diagenetic Effects Preserved in Agglutinated Foraminifera from the Beaufort-Mackenzie Basin of Arctic Canada

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Agglutinated foraminifera have proven to be sensitive to two main types of burial-related, thermally controlled diagenetic change that are easily recognized – colouration and silicification. Colouration becomes progressively darker with increasing thermal maturity, particularly in the early stages of petroleum generation, in trends that closely parallel thermal maturity data from more traditional methods such as vitrinite reflectance. Silicification is also thermally controlled, and occurs by the precipitation of diagenetic quartz overgrowths on the primary grains of agglutinated foraminifera.

A more specific, hydrocarbon-related, type of diagenetic alteration has been recognized in agglutinated foraminifera in an exploration well in the Beaufort-Mackenzie Basin of Arctic Canada. The Immiugak A-06 well was drilled in an offshore fold belt and penetrated 3800 m of marine to terrestrial strata of Early Eocene to late Cenozoic age. The well, classified as dry and abandoned, is situated on a shale-cored anticline that was breached by vertically migrating hydrocarbons. An apparent gas chimney occurs in Oligocene-Miocene strata at the crest of the anticline, and seismic data indicates that the chimney extends in a narrower zone through upper Cenozoic strata to the seafloor.

Agglutinated foraminifera from cuttings of the A-06 well at approximately 1000 to 1700 metres (i.e., within the main gas chimney) show clear evidence of hydrocarbons preserved as conspicuous bitumen trapped within silicified tests. The silicified tests also show effects from other migrating fluids and current preservation indicates that both precipitation and dissolution have occurred. Specimens show a wide range of siliceous alteration, with quartz being added and taken away.

Thermal maturity indices, determined by Rock-Eval, vitrinite reflectance (%Ro), and FCI (foraminiferal colouration index), indicate that Eocene strata near the base of the A-06 well are within the early oil generation window (e.g., ~0.60%Ro; Tmax up to 436^{o}C, and FCI up to 5.9). Hydrocarbon-related diagenetic alteration of foraminifera in the A-06 well occurs only within the Oligocene and Miocene section of the A-06 well and does not conform to normal, burial-related, thermal maturity trends.

Shell Wall Ultrustructure in Some Genera of Verneuilinoidea Cushman, 1911 (Foraminifera)

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In their generally accepted foraminiferal classification Loeblich and Tappan (1987, 1989) devided all the multichambered agglutinated Foraminifera into noncanaliculate and canaliculate groups regarding wall microstructure "as primary in importance" for classification of this group. According to this division the agglutinated forms with the initial trochoid and later rectilinear part are divided into the two superfamilies: Verneuilinoidea (=Verneuilinacea in Loeblich & Tappan, 1987) Cushman, 1911 and Textularioidea (=Textulariacea in Loeblich & Tappan, 1987) Ejhrenberg, 1938. In the classification of Mikhalevich (2000, 2004) which stresses the primary significance of the shell morphology in the taxonomy of the Foraminifera, the forms with the trochospiral initial part isomorphic to verneuilinids were removed from Textularioidea into the special superfamily Valvulinoidea Berthelin, 1880 and placed within the order Verneuilinida Mikhalevich et Kaminski, 2004. The main taxonomic feature distinguishing these two superfamilies following the Loeblich & Tappan, 1987 classification is canaliculate or noncanaliculate character of their wall. Nevertheless in the majority of the genera and species of the both superfamilies this character of the wall was not verified and the data of a few studied forms were extrapolated on the wider material. Thus only three genera of the Prolixoplectidae out of the nine composing the family were studied from this point of view and the noncanaliculate charcter of their shell wall was verified.

In the present study the wall ultrastructure of the fourteen recent and Cretaceous species of the six genera of the superfamilies Verneuilinoidea and Valvulinoidea were studied in EM: seven species of the superfamily Verneuilinoidea, family Verneuilinidae, subfamily Verneuilininae – 1.*Gaudryina laevigata* Franke, 1914 (Cr), 2.*G. pyramidata* Cushman (Cr), 3.*G. triangularis* Cushman, 1911, 4.*G. quadrangularis* Bagg, 1908, 5. *G. exilis* Cushman et Bronnimann, 1948, 6. *G. atlantica* (Bailey), 1851, 7. *G. siciliana* Cushman, 1936, and seven recent species of the different families of the superfamily Valvulinoidea – 8. *Eggerella scabra* (Williamson), 1858, 9. *Plotnikovina compressa* (Cushman), 1935, 10. *Karreriella bradyi* (Cushman), 1911, 11. *Clavulina communis* d'Orbigny, 1826, 12. *C. crustata* Cushman, 1937, 13. *Goesella flintii* Cushman, 1936, 14. *Rudigaudryina inepta* Cushman et McCulloch, 1939. (1, 2 – from the Cretaceous of Poland, 3 – 14 – Recent: 10, 11 – from Antarctic; 3 – from Tonkinskij Bay; 4, 5, 6, 9, 14 – from the tropical part of the Atlantic coast of the South America; 7, 12, 13 – from the North African Atlantic Coast; 8 – from the Black Sea).

In the two species of the Cretaceous gaudryinids canaliculi were absent.

In the recent gaudryinids the well expressed distinct canaliculi were clearly seen in *G. triangularis* and *G. siciliana*: rather wide cylindrical canaliculi going in parallel and divided by very narrow spaces of the wall in *G. triangularis* and by more wide spaces of the wall in *G. siciliana*. In the same species the pseudopores have more stable character than in the rest ones and more regular in their form. In the first of them the pseudopores on the inner surface of the wall are circular and regular resembling that ones of secreted bilamellar Rotaliata, though their external pseudopores may be either circular in outline or of irregular form as well, in the second one even the external pseudopores have regular character, circular in outline and displaced close to each other giving the whole test somewhat sieve appearance. In *G. quadrangularis* and *G. atlantica* spaces between the sand particles on the transverse fractures (breakings, breaks) of the chamber wall looks going in radial direction to the surface but are of irregular form as if they are transitional from noncanaliculate to canaliculate wall. The surface of their external wall shows multiple and distinct pseudopore character under magnification of x600 and x1000 but their openings are scattered irregularly and have mostly irregular outline. The similar irregular openings are seen in the thin smooth wall of *G. exilis* where sand particles are packed parallel to the surface. The apertural faces in the rugous species of *Gaudryina* are more smooth than their lateral walls and only with a few rare small subcircular pseudopores. Distinct canaliculi were also observed in the both species of *Clavulina* (in *C. crustata* canaliculi are very narrow, curved and branching, being divided by the rather wide spaces of the wall, though in some places they may be unbranching), *Plotnikovina compressa* and *Karreriella bradyi*. In *Rudigaudryina inepta* and *Eggerella bradyi* the wall was not fractured because of the lack of material. But in all of these last species the pseudopore openings also present. At the outer surface of the wall they are of irregular form in all of them (under the magnification x700 and x1500). In *Clavulina communis* the openings of the inner chamber wall are circular and rather regular in their disposition. The microgranular calcareous wall of *Karerriella bradyi* looks from the outside like the etched wall of the higher calcareous Rotaliata when the surfaces of irregular form closely adherent each other by their outstanding parts leaving some spaces of irregular form along their indented borders. The circular pseudopores of the smaller size may be scattered over the surface of these indented "plates". Thus its wall character could be considered as transitional between the agglutinated forms of this group having the microgranular cement and the higher calcareous Rotaliata with their special wall ultrustructure.

Among the species studied only *Gaudryina* is stated as having noncanaliculate wall as the study of Loeblich & Tappan (1987) of its Cretaceous type species *G. rugosa* d'Orbigny, 1840 taken from the Maastrichtian of England had shown. At the same time Cushman, Todd & Low (1954) considered *Gaudryina* from Rongerik Lagoon in the Marshall Islands as distinctly perforate. The two Cretaceous species of *Gaudryina* in our material turned to be noncanaliculate …. *(but having pseudopores) ?.*

The question arises if the absence of canaliculi in the ancient forms is of primary character or the subject of preservation. The fact that even in some recent species ((e.g. *Dorothia* – Loeblich & Tappan (1985)) the canaliculi may be masked stresses the necessity of the additional studies. Thus *Bigenerina* was shown as noncanaliculate by Lacroix (1931) and as canaliculate by Schroeder *et al.,* (1975), Wood (1949) marked canaliculi in *Tritaxia,* which is considered recently as noncanaliculate. *Gaudryina atlantica* (Bailey) taken as type species for the genus *Pseudogaudryina* does not show distinct canaliculi in our material.

The second question is of the taxonomic significance of the presence or absence of canaliculi. Banner & Desai (1985), Desai & Banner (1987) and Banner *et al.,* (1991) had shown that canaliculi appeared in agglutinated-microgranular forms since Mesozoic and Paleogene in different groups in parallel and that the transition from noncanaliculate to canaliculate forms was iterative. We agree with the opinion of these authors supported by Kaminski (2004) that such feature used as a criterion of suprageneric classification would lead to the artificial uniting of the polyphyletic forms. And vise versa – closely related genera such as *Dorothia – Praedorothia, Marssonella – Protomarssonella* and many others are considered under the opposite point of view to be convergent and are placed in different rather remote taxa of higher level. We even doubt if the presence of canaliculi may serve as a valid taxonomic base of a generic level resulting in the enlarging of the number of genera by the creating of parallel pairs of noncanaliculate and canaliculate forms (*Gaudryina – Pseudogaudryina, Dorothia – Praedorothia, Marssonella – Protomarssonella, Verneuilina – Hemlebenia, Eggerelloides – Eggerella, Karrerulina - Karreriella*) at least at the recent state of their coverage of studies. The conclusion goes that the classification of the Verneuilinoidea and Valvulinoidea ought to be revised along with the further additional studies of the ultrastructure of the shell wall of their more multiple representatives.

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Orbitolina hensoni sp. nov., a new orbitolinids from the Upper Albian of Iraq

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A new species of the family Orbitolindae, *Orbitolina gracillis* sp.nov., is observed and described from the Late Albian rocks of Iraq. Its description depend on the morphology and internal structural features.

This new species differs from the other species of the genus *Orbitolina* (subfamily Orbitoliniane) by the presence of a depression near the embryonic area, and by the presence of a perfect, well-developed periembryonic area.

Sediment distribution and Foraminifera in the eastern South Atlantic

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The "DIVA"-project is the German contribution to an international biodiversity programme called "Census of Marine Life - CoML". The DIVA II expedition took place in February and March this year in the south Atlantic. During "Meteor cruise 63/2" leading from Capetown, South Africa to Mindelo, Cabo Verde, samples from the three deep sea basins of the southeast Atlantic (Cape basin, Angola basin and Guinea basin) were collected. Samples were achieved with a "Multicorer" to receive virtually undisturbed soft sediment cores down to a sediment depth of about 35 cm. The water depth of the sampled areas range between 5100 and 5600m.

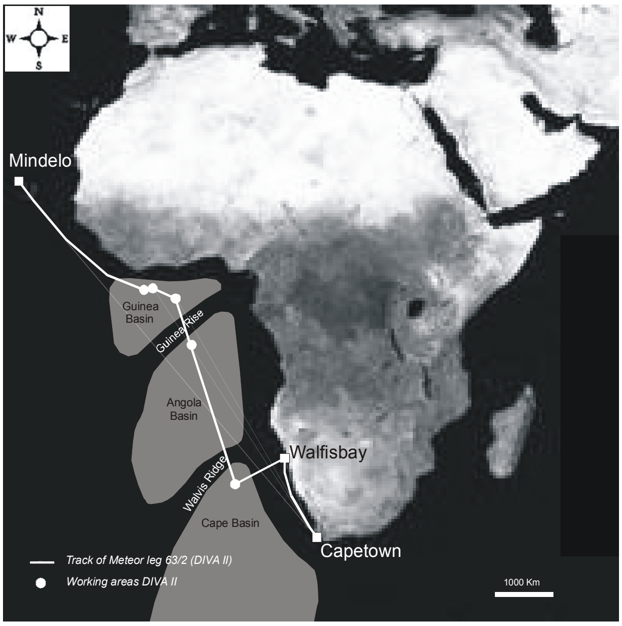

Fig. A: Working areas of Meteor leg 63/2

Samples were taken at 31 stations in 5 working areas. 11 cores were sampled in the Cape basin, 9 cores originate from the Angola basin and in sum 41 cores were sampled at three working areas in the Guinea basin. The working areas are arranged to form a latitudinal transect. For the planned investigations a selection of 10 cores will be examined.

On board of the research vessel Meteor subsamples were taken in surface-parallel slices and were stained with Bengal-rose to facilitate distinction between dead and living Foraminifera. First observations showed that both benthic and planktic Foraminifera tests occur in all samples even at water depths >5500m. The tests are well preserved and dissolution does not seem to be very obvious. This indicates that the CCD (Calcite compensation depth) lies deeper than the sampled areas.

Sediments consist mainly of clay size particles but contain various portions of silt and sand, most built by the tests of Foraminifera. Initial observations showed that sediments from the Guinea basin, situated close to the equator, carry large quantities of planktic Foraminifera while samples from higher latitudes show an increase in benthic species. Strong bioturbation was observed in all samples. This is due to crustaceans like amphipods which were found alive down to a sediment depth of about 10 cm.

Sessile agglutinating Foraminifera were found on the surface of dropstones, shark teeth, ossicles and the tests of other foraminiferans all of which build secondary hardgrounds.

General questions of the presented project are diversity patterns of benthic Foraminifera in the deep sea basins and its correlation with biotic and abiotic variables. For this reason it is intended to describe the change in species composition along a latitudinal transect ranging in respect of DIVA II from 0° to S 28°. This will help to draw biogeographical conclusions as if the "Walvis-ridge" and the "Guinea-ridge" can be considered as biogeographical barriers.

Foraminiferal Stratigraphy and Facies of Middle Jurassic to Lowermost Cretaceous Deposits of the Mid-Norwegian Shelf

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Foraminiferal assemblages are analysed in ditch cutting samples taken from the Melke and Spekk formations in commercial wells drilled on the Mid-Norwegian Shelf. The Melke Formation, of Bajocian to Oxfordian age, is an up to 620 m thick succession of shales with subordinate siltstones and sandstones. The overlying Spekk Formation, ranging in age from Oxfordian to Ryazanian, is an up to 65 m thick package of dark shales with high organic content. The succession contains major hiatuses formed during periods of tectonic activity. Both formations are characterized by low diversity foraminiferal assemblages strongly dominated by agglutinated taxa. Calcareous forms are subordinate or absent.

Seven foraminiferal assemblages (informal zones) of stratigraphic significance are distinguished in the analyzed sediment package; five in the Melke and two in the Spekk formation. The standard stratigraphic stages recognized in this succession are listed below together with their age-diagnostic foraminiferal taxa. 1) Bathonian: *Recurvoides anabarensis, Ammobaculites lapidosus, Riyadhella shapkinaensis.* 2) Callovian: *Ammobaculites borealis, A. igrimensis, Kutsevella memorabilis.* 3) Oxfordian: *Recurvoides scherkalyensis Ammobaculoides primoris, Ammodiscus pseudoinfimus.* 4) Kimmeridgian: *Recurvoides disputabilis, Ammoglobigerina canningensis, Bojarkaella firma.* 5) Volgian: *Evolutinella schleiferi, Trochammina annae.* 6) Ryazanian: *Recurvoides obskiensis, R. praeobskiensis, Evolutinella emeljancvei.*

The foramminiferal assemblages occurring in the Melke Formation reveal close similarities with fauns recorded from Spitsbergen, Western Siberia and the Canadian Arctic Archipelago, while those of the Spekk are particularly related to Spitsbergen assemblages. These similarities indicate a direct marine communication between basins of the Boreal Realm and the Mid-Norwegian Shelf following a relatively narrow seaway between the Baltic and Laurentian shields. It implies that the land bridge connecting Northern Norway and East Greenland became opened up in the early Middle Jurassic, establishing an open marine (shelfal) connection between North Western Europe and the Boreal Realm from Bathonian to Ryazanian time.

The low diversity (alpha < 5) and agglutinated nature of the foraminiferal assemblages occurring in the Melke and Spekk formations indicate restricted environmental conditions. For a closer interpretation of environments, foraminiferal distribution data are integrated with sedimentary parameters (as grain size and gamma-ray activity), and organic geochemical parameters (as organic carbon content, kerogen type, hydrogen index and pristane/phytane ratio. This ratio shows increasing values with increasing degree of oxygenation, and its combination with foraminiferal distribution data appears to be a useful approach to biofacies assessments.

The Melke Formation mudstones were deposited in prodelta shelf environments. The foraminiferal alpha diversity in these sediments varies from 1.0 to 2.5, and the dominant genera are *Trochammina* and *Riyadhella,* followed by *Recurvoides*, *Kutsevella,* and *Ammobaculites.* The organic carbon content of the mudstones is moderate, and the kerogen component consists mainly of material originating from terrestrial sources, indicating high fresh water influx to a prodelta area. It is supposed that the main restricting factor in this depositional setting was low salinity through the whole water column. Relatively high pristane/phytane ratio and low oxygen index suggest that the basin floor was well-oxygenated.

At the Middle to Late Jurassic transition, increased tectonic activity lead to subsidence of deeper shelf subbasins between tectonic highs. The subbasins had a pronounced tendency to develop stagnant benthic conditions, creating the black shale depositional environment of the Spekk Formation. In this unit the species diversities are extremely low (with alpha values around 1.0) and the dominant genius is *Trochammina,* while *Recurvoides* snd *Verneuilinoides* are strongly subordinate. The sediments reveal strongly increased gamma values and significantly decreased pristane/phytane ratios; features indicating that low oxygen content acted as the main factor restricting the foraminiferal facies. The high organic content (with TOC up to 10%) and high hydrogen indexes accord well with hypoxic conditions. Relatively large numbers of radiolarian and increased proportions of marine kerogene suggest increased influence of open marine water masses. In spite of this, the upper part of the water column might have been hyposaline, as suggested by relatively high proportion of terrestrial organic matter.

New Opinions for a more Natural Systematic of the Agglutinated Foraminifera

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The author proposes a taxonomic reorganisation of the group of agglutinated foraminifera, Recent and fossil. The essential idea around which revolve this new taxonomic opinion is the wall structure of the test, which is the only one avaiable for the fossils. The studies on the living specimens showed that the wall structure is a result of the metabiolic activity. With other words, the character of the test and inclusively the wall structure are hereditary transmited, consequently useful for fossils: hence the wall structure become an axial character useful in the taxonomy of this group.

In ths conception there are separated 5 subclasses, considering the Foraminifera as a Class. There are proposed new taxa: subclass Orbitilinana n.scl., with Biokovinida n.ord and Orbitolinina n.subord, and Pfenderinana n.scl., with Pfenderinida n.ord.

Subclass **LAGYNANA** Mikhalev, 1980
Groups together all the recent foraminifera with a membranaceous (proteinaceous) wall. The wall could present ferruginous incrustations or a few foreign particles attached on the membranaceous wall.

Order **ALLOGROMIIDA** Hastog, 1906

Subclass **ASTRORHIZIANA** Saidova, 1981
Groups together genera with a compact, simple wall structure; the agglutinated material cemented as ordinary by calcite, aragonite or rarely ferruginous siliceous or organic cement.

Order **ASTRORHIZIDA** Haeckel, 1894
Order **SACCAMINIDA** Lankester, 1885
Order **HYPPOCREPINIDA** Saidova, 1981
Order **LITUOLIDA** Lankester, 1885

Subclass **ORBITOLINANA** Neagu, n. scl.
Wall with variable structure from a bistratificated till three stratified one with an external-epidermal thin compact layer and an inner-hypodermal-one with a large variability in structure: alveolar, perforated, canaliculated or reticulated.

Order **BIOKOVINIDA** Neagu, n. ord.
Wall bistratificated with a compact epidermal layer and a hypodermal one, alveolar or with a large perforated aspect.

Suborder **BIOKOVININA** Guzic, 1977
Suborder **CYCLOLININA** Loeblich & Tappan, 1964
Suborder **LOFTUSIINA** Brady, 1884
Suborder **ORBITOLININA** Neagu, n. ord.
Wall with a complex structure; an epidermal finely agglutinated compact layer and an inner layer with secondary elements with a complex to wery complex structure. Embrionary apparatus with trochospiral chambers disposition is followed by a conical test with numerous chambers with secondary, very sophisticated structures.

Subclass **TEXTULARIANA** Mikhalevich, 1980
All of the test, thick to very thick is typically canaliculated with strait and simple tubules.
Order **EGGERELLIDA** Neagu, n. ord.
Test trochospirally enrolled or triserial in the early stages. Latter might be reduced to triserial to uniserial: wall canaliculated, agglutinated.
Order **TEXTULARIIDA** Delage & Herouard, 1896

Subclass **PFENDERIINANA** Neagu, n. scl.
Wall of imperforate microgranular calcite with some agglutinated material, without exo or endoskeletal structures.
Order **PFENDENIDIDA** Neagu, n. ord.
Families: Nezzazztinidae, Barkerinidae, Nautiloculinidae, Pfenderinidae.

Diversity and taxonomic composition of the Agglutinated Foraminifera assemblages from the Ross Sea, Antarctica: preliminary observations

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Foraminifera are a major component of benthic communities in cold oceans as well as in the deep-sea. In these low-temperature environments, this group plays an important role in the initial breakdown of organic material at the sediment surface and in the cycling of organic carbon within the benthic community.

Recent sediment samples collected during the austral summer 1997-98 and 2000-01, in the Ross Sea (63¡-75¡ S, Antarctica) were analysed for the benthic foraminiferal content to study the microfaunal distribution patterns and ecological preferences.

Analyses of living (Rose Bengal stained) and dead foraminifera were carried out in twelve surface sediment samples. The benthic foraminiferal assemblage has been evaluated using standard meiofaunal techniques and size fraction >150 micron was analysed; all the species were counted and identified. Faunal composition and standing stock were analysed for living (Rose Bengal stained) and dead foraminifera.

Agglutinated foraminifera, mainly multilocular forms in addition to the less commonly studied soft-shelled monothalamous foraminifera, dominate the living assemblage. Unilocular forms include spherical or flask-shaped agglutinated specimen, which are assigned provisionally to the family Saccamminidae and subfamily Psammosphaeridae. Unilocular species with agglutinated shells (Family Astrorhizidae) are particularly abundant in the central part of the studied area. The biocoenosis's standing stock is higher in the southern area from a minimum of 6.75 n/ml (bc 19; 593 m water depth) to a maximum of 48.2 n/ml (bc DI; 1213 water depth). Diversity is low (4 - 55 species per samples) whereas dominance is usually high in many samples where several species are represented by few specimens.

In the southern area multilocular agglutinated foraminifera dominate the dead assemblage, whereas in the northern area there is a prevalence of calcareous foraminifera.

Our analyses allow distinguishing two areas characterised by different microfauna (living and dead): the northern area where the calcareous benthic microfauna prevails (*Trifarina angulosa* and *Ehrenbergina glabra*) and a southern area dominated by agglutinated taxa. We interpret this two-fold distribution as corresponding to different hydrographic settings: in the southern area the prevalence of agglutinated foraminifera in the tanatocoenosis could indicate the presence of corrosive bottom water whereas in the northern area the dominance of calcareous taxa reflects the presence of strong bottom current.

UNILOCULAR AGGLUTINATED TAXA (order Allogromiina)
Saccamminid sp3 (40x) *Saccamminid* sp17 (40x) *Saccamminid* sp1 (40x)
MULTILOCULAR AGGLUTINATED TAXA (order Textulariina)
Reophax spiculifer (7.5x) *Reophax ovicula* (7.5x) *Labrospira jeffreysii* (6.5x)

The Early Miocene agglutinated foraminifera from the Zbudza P-6 well (East Slovakian Basin)

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The study presents new results of micropaleontological and biostratigraphical investigation of basement sediments of the evaporite series and of the evaporite series alone from the Zbudza P-6 well. It is located in the Trebisov Depression belonging to the East-Slovakian Neogene Basin which is the autonomous part of the Transcarpathian Basin (Vass *et al.,* 2000).

Previous researches on foraminiferal assemblages, performed near the village of Zbudza (Gašpariková, 1963), showed the presence of only foraminiferal assemblages typical of the Middle Miocene (Badenian). The present investigations allowed for documenting basement sediments of the evaporite series (at depths of 600.0m and 596.0m) by an Early Miocene foraminiferal assemblage assigned to the Eggenburgian. This assemblage is represented by fairly abundant agglutinated forms, calcareous benthos and small specimens of planktonic taxa. The most important representatives of the agglutinated association are the following: *Reticulopragmium acutidorsatum* (Hantken), *R. rotundidorsatum* (Hantken), *Haplophragmoides cf. vasiceki pentacamerata* Cicha & Zapletalova, *H. vasiceki vasiceki* Cicha & Zapletalova, *Cyclammi praecanceolata* Voloshinova, *Cribrostomoides subglobosus* (Brady), *Budashevaella* sp., *Bathysiphon* sp..The large size of this forms indicating optimal living conditions. For biostratigraphic interpretation, the most important is the presence of index taxa and characteristic taxa such as: *Reticulopragmium acutidorsatum* (Hantken), *R. rotundidorsatum* (Hantken*), Cyclammi praecanceolata* Voloshinova, *Elphidium felsense* Papp, *Pappina primiformis* (Papp et Turnovsky), *Uvigerina multistriata* Hantken, *Glogorotalia semivera* Hornibrock, *Globigerinoides primodius* Blow & Banner, *Globoquadrina langhiana* Cita & Gelati.

The Eggenburgian marine deposits of the East-Slovakian Neogene Basin are of transgressive character corresponding to the global eustatic sea level. During the Eggenburgian there was a communication between that basin and the Outer Flysch Carpathians units, West Carpathians and the Carpathian Foredeep in SW Moravia.The basin was also opened to the SW where a sea communication with the Fil'akovo/Pétervására Basin and/or a bay (Halásová et al. 1996; Vass et al., 200) existed. All these communications favoured the mixing of microfaunal associations containing taxa originating from various areas of the Eggenburgian Basin.

Palaeontological and biostratigraphical characteristics of this foraminiferal assemblage indicates the closest relationships with the Eggenburgian sedimentation developed as the Presov Fm, corresponding to outer shelf neritic conditions of the East-Slovakian Neogene Basin (Zlnská, 1992).

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Molecular Phylogeny and Higher-Level Classification of Agglutinated Foraminifera

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Phylogenetic analyses of DNA sequences suggest multiple origins and reversions of agglutination in Foraminifera. Contrary to the traditional mprphological view, molecular studies show that agglutinated tests were formed several times during the evolution of the early Foraminifera. Many monothalamous lineages contain both thecate and agglutinated species, and there is no evidence for progressive transformation from one type to the other. Furthermore, the molecular data do not confirm the division of polythalamous textulariids according to the biochemical and structural differences in the formation of the agglutinated test. The representatives of three polythalamous agglutinated orders intermingle and form a series of independent lineages. Most probably they represent a paraphyletic group from which the calcareous Rotaliida and robertinids evolved. There is strong molecular evidence that at least one species assigned to the Textulariida is in fact related to Miliolida. Based on the available molecular data, a new higher-level classification of foraminifera has been proposed.

Agglutinated Foraminifera Changes across the Cenomanian/Turonian Boundary in SE Poland

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The Cenomanian/Turonian boundary bioevent is a relatively minor Phanerozoic mass extinction (Raup & Sepkoski 1984), recognised as a stepped mass extinction (Koch, 1980; Kauffman, 1988) and is related to a 2nd-order sequence boundary (Kauffman 1985). Generally, the Cenomanian/Turonian boundary interval is widely recognised as one of the all-time sea level high-stands (e.g., Haq et al. 1987). The C-T extinction is closely associated in time with Oceanic Anoxic Event (OAE) 2 that was probably triggered by areal expansion of oxygen-poor waters (e.g., Schlanger & Jenkyns, 1976).

In order to estimate the response of agglutinated foraminifera to the C/T boundary event in SE Poland, a 35-m-thick section, comprising the uppermost Cenomanian and Lower Turonian strata, from the S-19 borehole has been studied. The S-19 borehole is located on the periphery of the East European platform, within the Podlasie-Lublin Horst. The studied section originated in an epicontinental sea.

A section through depths 466-433 m has been studied in detail. It encompasses the upper part of the *Rotalipora cushmani* Zone, *Whiteinella archaeocretacea* and *Helevetoglobotruncana helvetica* Zones (Fig. 1). The studied interval consists of dense pelitic limestone of lenticular-nodular texture with more marly part in the topmost part of the Cenomanian.

Agglutinated foraminifers and stable isotopes (^{13}C, ^{18}O) have been investigated in 50 samples. $\delta^{13}C$ values show a major two-phased positive excursion through the upper *Rotalipora cushmani* and *Whiteinella archaeocretacea* Zones.

Samples from the *Rotalipora cushmani* Zone yield foraminiferal assemblages of which 10-30% are planktic taxa (Fig.1A, see also Peryt & Wyrwicka, 1991, 1993). The benthic fauna is relatively high diverse and is typical of the late Cenomanian; calcareous forms dominated assemblages (Fig. 1B, C). Upward the *Rotalipora cushmani* Zone agglutinated component gradually increases. *Tritaxia* spp. form up to 40% of benthic foraminiferal assemblages in the upper part of the zone and in that interval rare species such as *Arenobulimina sabulosa*, *A. conoidea*, *A. frankei*, *A. advena*, *Pseudotextulariella cretosa*, *Ataxophragmium depressum*, *Gaudryinopsis gradata*, *Verneuilinoides gorzoviensis*, *Plectina cenomana* underwent stepwise extinction.

However, the most dramatic change in the benthic foraminiferal assemblage, with the majority of the typical Cenomanian groups becoming extinct, is connected with the boundary between *Rotalipora cushmani* and *Whiteinella archaeocretacea* Zones. At the boundary, dominant *Tritaxia* spp. completely disappear. *Tritaxia pyramidata*, *T. macfadyeni* and *T. plummerae* become extinct. *Tritaxia tricarinata*, *Eggerellina mariae*, *Marssonella oxycona*, *Gaudryina angustata* temporarily disappear; they re-appear again in the Lower Turonian. About 1-m-thick interval corresponding to the first shift of the $\delta^{13}C$ values is almost completely devoid of benthic foraminifera (Fig. 1D).

At the base of the *Whiteinella archaeocretacea* Zone, a rapid increase in the percentage of planktic foraminifera is recorded, and a high P/B ratio continues upwards. Low species diversity and domination by two to four species are recorded in the assemblages of benthic foraminifera in the lower part of *Whiteinella archaeocretacea* Zone. Immigrant *Arenobulimina preslii* is the main contributor to the assemblages in the very basal part of the zone. Higher up, *Marssonella oxycona* and *Tritaxia tricarinata* reappear and a slow upward increase in diversity of agglutinated foraminiferal assemblages is recorded (Fig. 1).

It seems that encroaching oxygen-minimum zone to that part of the Danish-Polish Trough, had lowered significantly the oxygenation level within most part of the water column. The response of benthic foraminiferal biota was: extinction of several species, temporary absence of other species and almost complete absence of epifaunal forms within agglutinated foraminiferal assemblages. The recolonisation of the vacated niches during the early Turonian was slow (in contrast to the micro-plankton) and is most likely a result of the low migration rates of the micro-benthos (cf. Leary & Peryt, 1991).

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A Change in Composition and Microstructure of the Campanian-Maastrichtian Agglutinated Foraminiferal Wall in Western Siberia

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The authors have mainly investigated the Campanian-Maastrichtian foraminifers within the south part of the West Siberian Plate (southward of Ob latitudinal stream), where there have been numerous wells drilled and sufficient core sample information obtained. Data on foraminiferal assemblages in the Campanian-Maastrichtian section were published in many works (Kseneva, 1999; Podobina, 2000; Foraminifers …, 1964; et al.).

Agglutinated foraminifers in these assemblages differ in chemical and taxonomic composition. Quartz-siliceous forms mainly correspond to the lower Campanian deposits, being part of the upper layers of the Slavgorodskaya Suite, where both calcareous secreted and agglutinated forms were discovered in most of the sections of the central area. The most representative early campanian foraminiferal assemblage with Bathysiphon vitta, Recurvoides magnificus was encountered within the boundaries of the borehole 1-r Ambar area (Podobina, 1975, 2000).

Agglutinate sizes vary in the wall of the shells from fine to coarse grains. The former, with fine grained size walls, comprise *Bathysiphon, Ammodiscus* and *Glomospira* genera. These are generally the forms with sugary white shell, remaining their microstructure in other hydrological conditions of the late Campanian-Maastrichtian basins. The latter are distinguished as *Labrospira, Haplophragmoides, Cribrostomoides, Alveophragmium, Recurvoides, Cyclammina, Verneuilinoides*, *Gaudryinopsis* and others. Agglutinate sizes in the shells of these genera are highly diverse, i.e. morphologically more formed genera are those of approximately the same size, commonly with fine and rarely medium grained microstructure (these are *Cribrostomoides, Alveophragmium* and *Cyclammina*). The agglutinate size variability of the rest of the foregoing genera is within a considerable range (from 0,01 to 0,2 μк). This can be even observed on a single shell, for example, that of *Labrospira* and *Haplophragmoides* genera (Podobina, 1978, 1998).

The late Campanian-Maastrichtian assemblages mainly comprise calcareous forms. In the same assemblage there occur both calcareous secreted-agglutinated and agglutinated shells with various content and sizes of agglutinate in the wall composition. They comprise *Siphogaudryina*, *Dorothia*, *Verneuilina, Ataxophragmium,* and other genera. The amount of agglutinate and cement of these genera varies within a considerable range. Agglutinate in the wall composition being less than 25%, it is the secreted-agglutinated wall type. But commonly agglutinate is more than 25% - the agglutinated wall type. Agglutinate and cement combination of the wall of these genera is represented as calcium carbonate. The late Campanian-Maastrichtian foraminifers correspond to the Gankinskaya Suite – grey clays and siltstones, which unlike lower deposits are calcareous. This denotes higher temperature of water masses caused by mainly the expansion of transgression from the south across Turgai Strait resulting in an absolutely different taxonomic composition of the late Campanian-Maastrichtian assemblages.

Agglutinate may be both mono and polymineral, but mainly comprised of quartz or other silica combinations. Agglutinated wall was studied in detail by V.P. Petelin (1970) on modern shells. As provided by mineralogical composition and dimension of agglutinated matter there can be to a certain extent made an evaluation both on habitation conditions of foraminifers (in a littoral, shelf or relatively abyssal part of a basin) and sedimentation conditions of maritime basins, which is very important in terms of paleographic reconstruction. The findings, mainly those concerned with the variation of agglutinate sizes in the wall composition corresponding to lithological rock characteristics, were proved to be true during paleographic investigations of the author (Podobina, 1966). Based on the study of some modern Haplophragmoididae and those at the Cretaceous–Paleogene deposits in western Siberia, the author points out the inventive ability of various genera shells. Therefore agglutinate composition, proportion and quantity provide an important basis for the foraminifer classification. In terms of particular genera, in the author's opinion, a specific range of its variability is observed. Thus one can give some examples as to the considered Haplophragmoididae. More primitive genus Labrospira is characterized by a wide range of agglutinate grain size variability (0,025 – 0,25 μк), yet coarse grained quartz (0,1 – 0,2 μк) of heteroclastic structure predominates. For more advanced genus Haplophragmoides, the grain size variability is somewhat different. There dominate shells with agglutinate ranging from fine to medium grained sizes (0,025 – 0,05 μк). Sometimes the agglutinated wall of this genus is entirely composed of quartz fine grains therefore the shell looks smooth. Homoclastic structure

(Cribrostomoides genus) is distinguished by even more uniformity of fine and medium grains, i.e. the wall seems smooth. Such a uniformity of agglutinate determines more advanced genera. Cyclammina are composed of approximately fine grained and more rarely uniform-sized medium grained quartz (homoclastic structure), packed with each other so tight that sometimes cement happens to be almost imperceptible. J.Hofker (1953) considered that mineral material, sizes and the form of agglutinated particles were generic and species characteristics for foraminifers, as were chamber arrangement and shell form. This opinion is completely confirmed by our investigations as well. On the basis of peculiarity in agglutinated wall composition and microstructure there has been made a conclusion on autonomy of many genera, species and subspecies (Podobina, 1975, 1978, 1998, 2000).

It is the author's opinion that for further classification of primitive foraminifers having comparatively uniform morphological structure, it is the wall composition and microstructure that take on primary taxonomic significance. In terms of more complicated Ammodiscida, especially Haplophragmiidea, morphological characteristics of shells are of great importance along with the wall composition and microstructure.

Therefore sugary white quartz-siliceous agglutinated shells correspond to particular taxons such as Bathysiphon, Ammodiscus, Glomospira, Asanospira, Cyclammina and others. They dominated on certain stratigraphic levels, for example, in the lower Campan of some regions in the West Siberian Plate presenting particular hydrological conditions of the basin. It was likely to be a relatively coldwater, shallow basin where the living conditions happened to be adverse for other taxons.

Anisomerous quartz-siliceous agglutinated shells of other taxons – Trochamminoides, Labrospira, Haplophragmoides et al. turned to be more mobile and could exist under various conditions changing their wall microstructure due to the multivariate agglutinate.

Another chemical composition agglutinated forms occur in the late Campanian-Maastrichtian more warmwater basins provided that there is an increase in solute calcium carbonate content. There are two wall types to distinguish depending on the percentage of calcareous agglutinate and the cement among shells: secreted-agglutinated (agglutinate being less than 25%) and agglutinated ones (agglutinate being more than 25%) (Podobina, 1978, 1992, 1998). It is necessary to introduce such a term as diversity of microstructures in terms of the previously emphasized by the author agglutinated shell microstructure types, i.e. scarce, average and full-agglutinated microstructures. This term is to denote agglutinate dimension in the wall composition. There are the following wall dimensions of agglutinated shells to differentiate: fine or close grained (0,01 – 0,05 μк), medium grained (0,05 – 0,2 μк) and coarse grained (more than 0,2 μк). Relatively highly-organized taxons are one-dimensional and more often have fine or medium grained microstructures.

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Agglutinated Foraminiferal Assemblages of the Paleocene in Western Siberia

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The Paleocene foraminiferal assemblages of western Siberia are mainly represented by agglutinated quartz-siliceous shells. They have been studied almost on the whole survey territory but most of the boreholes were drilled southward of Ob latitudinal stream. The Paleocene foraminiferal assemblages differ in their systematic composition both laterally and in section. The correspondence of foraminiferal assemblages with two Suites that of different lithology, i.e the Talitskaya Suite and the lwer part of the Lower Lulinvorskaya Subsuite, determined the difference in their systematic composition. However, the eastern part is characterized by systematic composition similarity of foraminiferal assemblages from the Talitskaya Suite and the overlying Lower Lulinvorskaya Subsuite. In particular, medium and coarse grained quartz-siliceous forms of *Reophax, Labrospira, Haplophragmoides, Ammoscalaria*, *Trochammina* and *Verneuilinoides* genera correlated with the central and western areas of the Talitskaya Suite are distinguished and referred to the Zealandian Ammoscalaria friabilis assemblage (Podobina, 1998). Sometimes fine grained sugary white forms of such genera as Ammodiscus, Glomospira, Asanospira, and Cyclammina are singularly encountered in this assemblage. Although to the east in the mentioned assemblage one may encounter much more fine grained sugary white forms, medium and coarse grained shells of the foregoing genera being singular in presence.

Another Zealandian assemblage with *Cyclammina coksuvorovae* (fig.) is encountered in the eastern part of western Siberia (Tym, Chuzik, Parbig, Kenga river basins). Psammosphaera, Glomospira, Asanospira and Cyclammina genera predominate here in terms of the amount. As to the section of the borehole 70, located in the basin of the river Kenga (a left tributary of Ob), eastern assemblage systematic composition in grey dense clays from the interval of 236,0 - 224,0 m comprises *Bathysiphon nodosarieformis* Subbotina, *Psammosphaera laevigata* White, *Glomospira gordialiformis* Podobina, *Asanospira grzybowski* (Mjatliuk) and *Cyclammina coksuvorovae* Ushakova species. There occurs about the same foraminiferal assemblage eastwards in the sections of the river Tym basin boreholes (a left tributary of Ob). Foraminifers of such a species composition and form denote peculiar habitation conditions in a comparatively shallow-water basin, waters of which were desalinated but imbued with silica. The layers with all foraminiferal assemblages of the Talitskaya Suite and its analogues have been distinguished as the Ammoscalaria friabilis Zone of the Paleocene (Zelandian). Systematic composition and form of agglutinated shells change in the upper layers of the Talitskaya Subsuite and the lower layers of the Lower Lulinvorskaya Suite and are represented in the same way as in the eastern assemblage of the underlying Ammoscalaria friabilis Zone. In this part of the section there has been established the Upper Paleocene (Thanet) Glomospira gordialiformis, Cibicidoides favorabilis Zone. Sugary white fine grained forms of *Glomospira*, *Asanospira* and *Cyclammina* genera provide the basis for the assemblages of this zone.

In eastern region the uppermost layers of the Talitskaya Suite comprise clays of more than light color, possibly being transitional between the Talitskaya and the Lulinvorskaya Suites. Clays of the upper part of the Talitskaya Suite and the overlaying layers of the Lower Lulinvorskaya Subsuite are known to comprise the foraminiferal assemblage with *Glomosrira gordialiformis* and *Cyclammina coksuvorovae*. Thickness of rocks comprising the given assemblage ranges from 15 to 25 m within the investigated zone. The assemblage is dominated by sugary white fine grained shells that of *Bathysiphon, Ammodiscus, Glomospira, Asanospira*, and *Cyclammina* genera. At the same time, secreted calcareous forms of Eponides, Cibicidoides genera are singularly encountered or do not occur at all. This assemblage, as well as the western one with *Glomosrira gordialiformis* and *Cibicidoides favorabilis*, is reffered to the upper layers of the Talitskaya Suite and the lower layers of the Lower Lulinvorskaya Subsuite. In terms of the quantity (up to 15 specimens) and species the given assemblage is dominated by the representatives of more primitive forms (Glomospira, Ammodiscus genera), one can find abundant (10-15 specimens) shells of *Asanospira grzybowskii* (Mjatliuk) species. But more representative species is *Cyclammina coksuvorovae* Ushakova, unit specimens of which have been encountered in the underlying Ammoscalaria friabilis assemblage. Discoveries of calcareous forms and their correlations with even-aged ones found near the city Rudni (Sarbai section) to the north-west of Turgai associated by representative planktonic forms (Acarinina acarinata Subbotina, A. mckannai (white), give enough ground to recognize the mentioned zone and all of its assemblages as the Thanet-dated (Podobina, Amon, 1992). It is obvious that typical sugary white forms with fine grained quartz-siliceous agglutinate in the wall composition used to occur in a rather desalinated but imbued with silica basin. Similar conditions predetermined the appearance of sugary white forms both in the Zealand of eastern region and in the Thanetian shallowed basin almost on the whole territory of western Siberia.

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Jurassic Transgressive-Regressive Cycles in Carbonate and Siliciclastic Shelf Facies: Comparison of Foraminiferal Assemblages

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The study compares distribution trends of foraminiferal assemblages in two Jurassic transgressive-regressive sequences of contrasting facies. The Navalperal section (Prebetic, SE Spain) of carbonate facies is dated as Upper Oxfordian, whereas the Brora section (Inner Moray Firth Basin, northeast Scotland) of siliciclastic facies is dated as Middle to Upper Callovian. The aim of the study is to demonstrate that transgressive-regressive developments can be delineated and compared by means of foraminiferal distribution data, in spite of contrasting lithofacies, palaeoenvironment and biogeography. The assemblage distribution parameters used for the comparisons include generic composition, diversity, shell type groups, and mode of life.

The Navalperal section (NV) is located in the Prebetic Zone (Betic Cordillera), where Oxfordian deposits represent the first phase of pelagic-hemipelagic sedimentation in outer shelf environment. The studied succession (8.7m thick) consists mainly of two lithofacies: 1) The lumpy-oncolitic limestone has a nodular appearance with a packstone-wackestones of peloids, bioclasts, lumps and oncoids. 2) The condensed lumpy-oncolitic limestone have a marked nodular appearance with numerous ammonoid remains, and is microscopically dominated by packstone with lumps, oncoids and bioclasts. The condensed lumpy-oncolitic limestone represents a transgressive phase with the maximum flooding surface developed at its top (Olóriz et al., 2002). The lumpy-oncolitic limestone represents the regressive phase.

The Brora section (BR) is located on the northeastern margin of the Inner Moray Firth Basin. The section (27m thick) comprises the Brora Brick Clay and Fascally Siltstone members (Brora Argillaceous Fm.). The two members form a coarsening upward succession from shales to siltstones. The Brora Brick Clay was referred to offshore shelf and Fascally Siltstone to offshore shelf to shoreface (Nagy et al., 2001). Thus, the BR section represents an environmental setting comparatively more proximal than the NV section. The lower part of the Brick Clay of dark silty mudstones has been interpreted as a transgressive phase. Within this organic rich interval a regional maximum flooding surface is formed. It is marked by a horizon with large carbonate concretions corresponding to a peek in the organic carbon content. The upper part of the Brick Clay shows upwards increasing silt content and reduced amount of organic carbon. The Fascally Siltstone Member, of numerous coarsening upwards mudstone to siltstone parasequences, shows an overall coarsening upward development and decreasing organic carbon content. The interval including the upper Brick Clay, and the Fascally Siltstone has been interpreted to represent the regressive phase of the sequence.

The foraminiferal assemblage of NV section comprises planktic and benthic components, giving a total of 31 genera. Textulariina is mainly represented by *Reophax* (Hormosinidae) and *Ammobaculites* (Lituolidae). The calcareous group comprises forms with calcitic perforated wall (Lagenina, Spirillinina, Involutinina and Globigerinina), porcelaneous wall (Milionina) and aragonitic wall (Robertinina). Dominant calcareous genera include *Vinelloidea*, *Globuligerina*, *Spirillina*, *Lenticulina*, *Dentalina*, *Nodosaria*, *Ophthalmidium* and *Bullopora*. The general composition of the assemblages is dominated by vagile benthic forms (54%), followed by planktic taxa (31%) and sessile benthic taxa (15%). The vagile component includes mainly agglutinated forms (46%) and spirillinids (18%). Lagenina and Miliolina are in minority. The sessile benthic forms are nubeculariids, siliceous agglutinated forms and *Bullopora*.

Foraminiferal assemblages of the BR section are composed exclusively of benthics, with a general dominance of agglutinated taxa in the Brick Clay and calcareous perforated taxa in the Fascally Siltstone. The assemblages contain 34 genera representing the suborders Textulariina, Lagenina, Robertinina, and Spirillinina. The suborder Textulariina is represented essentially by: Verneuilinidae (*Gaudryina*, *Verneuilinoides*), Trochamminidae (*Trochammina*, *Ammoglobigerina*), Hormosinidae (*Reophax*) and Lituolidae (*Ammobaculites, Haplophragmoides*). The calcitic taxa belonging to Lagenina (mostly *Lenticulina* and *Astacolus*). The aragonitic forms are represented by Robertinina (*Pseudolamarckina* and *Epistomina*). The Brora Brick Clay assemblages consist exclusively of vagile forms, mainly Textulariina (71%) and Lagenina (24%). The Fascally Siltstone assemblages are mainly composed of Lagenina (63%), Robertinina (25%) and Textulariina (12%).

Foraminiferal stratigraphy of T-R cycles

During the transgressive phase of the NV sequence, the foraminiferal assemblages show an upward increasing proportion of planktic forms and benthic epifaunal taxa with calcitic and aragonitic shells (mostly *Vinelloidea*, *Spirillina* and *Epistomina*). The assemblages of the same phase of the BR sequence reveal a progressively higher proportion of agglutinated forms with infaunal habitat. At the concretionary horizon, the proportion of the epifaunal component (mainly calcitic forms) decreases, while the infaunal component (mainly shallow digging forms) increases.

The regressive phase of the NV section is characterised by a trend opposite, to that of the underlying transgressive phase. The amount of planktic forms decreases, Spirillinina and Lagenina keep their values constants, Milionina and Robertinina diminish, while the proportion of Textulariina expands. Benthic forms with infaunal life habit (mostly *Ammobaculites*, *Reophax* and *Lenticulina*) show higher values. The regressive development of the BR sequence reveals expanding proportions of both the calcitic (mainly *Lenticulina*, *Astacolus* and *Eoguttulina*) and aragonitic (*Epistomina* and *Pseudolamarckina*) components. The opposite trends are shown by *Ammobaculites*, *Trochammina*, *Haplophragmoides* and *Reophax*. The general trend reveals an increase in epifaunal versus shallow infaunal taxa.

The different response of the foraminiferal assemblages to relative sea level changes is related to the overall sedimentary environment of the two sections. The BR section represents a siliciclastic environment comparatively more proximal (inner offshore shelf to shoreface) and with higher sedimentation rates than the carbonate facies of the NV section (outer shelf). These settings also controlled the nutrient resources, which were dominated by primary production in the BR section, while the NV section was dominated by nutrient influx from more proximal areas with higher primary production.

During the transgressive phase, the NV sequence received progressively diminishing amounts of allochtonous sediments and nutrients, owing to increasing distance to the coastal source area. It resulted in an organic-poor firmground development, having a strongly reduction agglutinated infaunal component. The greater water depth and distance to shore of the BR sequence, in a trasgressive setting implies high organic production and a reduced sedimentation rate. It resulted in organic-rich substrate and hypoxic bottom water favourable to low diversity agglutinated infaunal assemblages.

The regression shows the opposite faunal trend in the two domains. In the NV sequence, it increased the nutrient influx and sedimentation rate, creating conditions more favourable to agglutinated infaunal forms preferring softground with good nutrient availability. In the BR sequence, regression reduced the organic matter enrichment in the substrate owing to increase in sedimentation rate, and established normal marine oxygenation. Thus the conditions turned unfavourable to agglutinated infaunal foraminifera and benefited the calcitic and aragonitic epifaunal forms.

The analyses demonstrate that the composition of the assemblages was controlled by nutrient availability, oxygenation and sedimentation rate, showing fluctuations according to transgressive-regressive cycles. Major assemblage differences between the two sections are attributed to the contrasting facies.

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Vanhoeffenella (Suborder Textulariina, Family Astrorhizidae): a chameleontic genus between monothalamous agglutinated Foraminifera

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The genus *Vanhoeffenella* (Suborder Textulariina, Family Astrorhizidae) has long been known to occur in deep-water settings at both high and low latitudes. As presently defined, this very distinctive monothalamous taxon is characterised by a flattened, polygonal to fusiform morphology. The test consists of an agglutinated rim produced into several tubular apertural extensions and flat, transparent upper and lower sides composed of thin, organic material. Our studies of benthic foraminifera from deep-water Antarctic habitats reveal the presence of several *Vanhoeffenella* morphotypes (Plate 1 and 2). Specimens were recovered from core, epibenthic sledge and trawl samples collected during cruises aboard R/V Italica in the Ross Sea (ANTA98-05 box core: 75° 54'.08S; 177° 36'.72W; 646 m water depth; ANTA01-09 box core: 76° 42'.84S; 168° 48'.55E; 835 m water depth) and R/V Polarstern in the Weddell Sea (62-70°S, 1600-4800 m water depth). Many of the Antarctic morphotypes differ from those found at lower latitudes in having a distinctly wider agglutinated test rim with short apertural extensions. However, eye-shaped morphotypes with thinner rims are also represented among our Weddell Sea material. The range of morphologies is similar to those illustrated by Wiesner (1931, Deutsche Südpolar Expedition, v. 20, 49-165) and Earland 1933, Discovery Rept, v. 7, 29-138) for a species that they identify as *V. gaussi*. In addition, one Weddell Sea site (Stn 132: 1580 m) yielded a distinctive new species of *Vanhoeffenella* with up to 6 or 7 well-developed tubular extensions arising from a central region of the test that is usually more three-dimensional and box-like than typical forms of this genus. The agglutinated part of the test is variably developed; in some specimens it forms a thin strip but usually it occupies a larger proportion of the test. In extreme cases, the transparent, organic part of the test wall is reduced to a small window. Interestingly, specimens of both morphotypes from the Ross and Weddell Sea occasionally contain the developing eggs of nematodes or small juvenile nematodes. This phenomenon was not observed in any other foraminifera. The nematoda were probably parasites or predators, rather than inquilines.

Early Cretaceous agglutinated foraminifera from the carbonate sediments of the Carpathian Foredeep (SE Poland)

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The paper presents assemblages of agglutinated foraminifera from the Early Cretaceous (Berriasian and Valanginian) carbonate sediments of the Carpathian Foredeep (SE Poland). They have been collected from the Zagorzyce 6, Zagorzyce 7, Ropczyce 7 and Wiewiórka 4 wells located in southeastern Poland.

The Early Cretaceous sedimentary basin in the Polish Lowlands has developed along the margin of the East European Platform in area known as Mid-Polish Trough. In the Early Cretaceous the southeastern part of that basin was dominated by carbonate facies, which show feature halfway between facies from the central part of the basin (Central Poland) and facies from the Tethys Ocean. The analysed deposits consist of two lithological members: The Ropczyce Series (Upper Tithonian and Berriasian) includes carbonate rocks deposited in lagoons, barriers and shoals environment, periodically in the extremely shallow water conditions. The carbonate rocks with siliciclastic material characteristic for the Debica Series (uppermost Berriasian and Valanginian) were deposited on the platform margin in the shallow open marine shelf (Zdanowski *et al*., 2001; Dziadzio *et al*, 2004). The biostratigraphy of the analysed succession using microfauna was established by Olszewska (2001) and Smoleń (in Dziadzio *et al*., 2004).

The higher abundance of the agglutinated foraminifers was found in the Upper Berriasian lagoonal limestones composed of algal mats (the upper part of Ropczyce Series). The foraminiferal association is dominated by the representatives of the following agglutinated genera: *Ammobaculites*, *Everticyclammina*, *Pfenderina*, *Charentia*, *Haplophragmium, Rectocyclammina, Stomatoecha* and *Melathrokerion*. Apart from the frequent agglutinated forms rare calcareous foraminifers from genera *Trocholina* are also observed. These association with many lituolids correspond to those of carbonate platform areas situated on the northern European margins of the Tethys described by many authors from the Berriasian deposits as characteristic for the low-energy, shallow water marine environment (Ivanova & Koleva-Rekalova, 2001; Hart *et al*., 2001).

In the Valanginian diverse group of stenohaline fauna indicate normal marine conditions. The benthic foraminifera assemblage consists of high diversity and number of calcareous species from the genera: *Trotline*, *Lenticulina, Astacolus*, *Discorbis, Epistomina, Citharina, Planularia* and others. The agglutinated foraminifers are scarce and are represented by such genera as: *Dorothia*, *Melathrokerin*, *Marsonella* and *Verneuilinoides*. The majority of the species noted from the Valanginian sediments in southeastern Poland are characteristic for the carbonate facies of the northern Tethys shelf (Kuznetzova & Gorbatchik, 1985) but the cosmopolitan forms are also present in the Valanginian associations and they are reflecting the global Valanginian transgression in Europe in that time.

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Agglutinated foraminiferal changes related to sedimentation episodes in the Early/Late Cretaceous Silesian Basin, Polish Outer Carpathians.

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The distribution of agglutinated foraminifers in the mid-Cretaceous of the Silesian Basin is discussed. Changes in their number, morphological and taphonomic variability are distinctly determined by deep-water siliciclastic and biosiliciclastic sedimentation, which took place in this area. The contemporary deposition is controlled by geotectonic (tectonic subsidence, volcanism, eustasy) and biogenic (biocoenosis) factors, which can be correlated with global paleogeographical and paleoceanographical events. Changes in activity, frequency and a range of these controlling factors resulted in lateral and vertical distribution of lithofacies changes in the Silesian Basin. There are represented by Albian-Cenomanian turbidities including conglomerates with exotics, silicified sandstones, hornstones (Lgota beds) and gaizes (Gaize beds), Cenomanian-Turonian variegated hemipelagic (Veriegated shales) and green pelagic (Radiolarian shales) deposits, and also by Turonian thick-bedded sandstones series (Godula beds). This lithofacial arrangement is closely related to the sedimentary regime, which had an effect on paleoecological conditions. All of these factors were essential for the evolution of biotopes and then the fossilization of microorganisms in the Albian-Turonian sediments. Among the microfossils present in the studied deposits, agglutinated foraminifers are only autochthonous ones. Bathyal and abyssal environments were colonized by these microorganisms. Their number and variability distinctly decreased during oxygen deficient periods and increased after anoxic events. As a consequence of the paleoecological setting the almost monogenic agglutinated assemblages including mainly shallow infauna (*Recurvoides*) and sometimes rare deep water infauna (*Gaudryina, Pseudobolivina*) or scarce semi-infauna (*Jaculella*) in dark organic-rich deposits. The studied series are represented by Albian black and dark grey shales intercalated in coarse-grained turbidities (Lgota beds, mainly in the lower part). These shales were deposited in more distal environment dominated by suspension currents and where sedimentation was quieter. Impoverished foraminiferal assemblages also existed during the deposition of arenaceous Variegated shales in the Cenomanian. At the time epifaunal active deposit feeders (*Ammmodiscus*, *Glomospira*) and deep water infaunal bacteria feeders (*Caudammina*, *Pseudonodosinella*, *Reophax*) lived in bathyal environments. However, this process took place gradually. Consequently foraminifers are absent in hemipelagic shales (Gaize beds, Variegated shales), which were immediately deposited after a change in a sedimentary regime. The disappearance of agglutinated foraminifers is also noted in manganiferous Radiolarian shales.

In the studied lithological series, a second type of microfauna was also observed. Albian-Cenomanian deposits (Lgota beds, mainly upper part) contain a foraminiferal association dominated by shallow (*Plectorecurvoides*, *Thalmannammina*, *Haplophragmoides*) and deep (*Gaudryina*, *Bulbobaculites*, *Arenobulimina*) infauna accompanied by epifaunal suspension feeders (*Jaculella*). Changes in numbers and variability of foraminifers are noted in light-grey and green shales, which were supplied after the intensive deposition of sandstones series in the Silesian Basin. Consequently, hemipelagic deposits interbedded in sandstones series (Lgota beds) contain oligotrophic deep water foraminifers. Taxonomical changes in the Late Cretaceous microfauna are correlated with sedimentation fluctuations, as well as, with the disappearance of Early Cretaceous forms. Cenomanian variegated shales comprise new forms, which belong to shallow (*Recurvoides*) and deep water infauna (*Falsogaudryinella*, *Uvigerinammina*). In the Turonian, deep dwelling forms (*Uvigerinammina*, *Gerochammina*, *Caudammina*) were more numerous and coexisted with epifauna including suspension feeders (*Nothia*) and active deposit feeders (*Ammodiscus*). These numerous and high variability assemblages appeared in variegated shales interbedded in sandstones series and also these ones, which constitute an independent lithological unit (Variegated shales).

Generally many of studied foraminifers are characteristic for Cretaceous cosmopolitan deep-water agglutinated assemblages. Changes in their numbers, morphological variability, and ecological affiliation were closely related to sedimentation cycles, which could be correlated with periods of increase geotectonic activity and a redeposition of coarse-grained turbidite series or with intervals of low geodynamic activity and hemipelagic and pelagic sedimentation. The lack of foraminifers could be caused by the establishment of dysaerobic bottom conditions related to increase of volcanogenic activity and a maximal deepening of the basin during pelagic sedimentation. The impoverished assemblages could also reflect short sedimentation periods following just after sudden supplies of coarse-grained substrates into the basin. In long perspective the same supplies of sandstones series contributed to the increase in water circulation and oxygenation of the bottom of the basin. In consequence, these sedimentation episodes favored numerous and variable, deep water morphotypes, which comprises the second ecological type of microfauna.

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Morphospace of foraminiferal shells

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Theoretical morphology covers two different conceptual areas focused on morphology of organisms, including (1) the simulation of organic morphogenesis and (2) the analysis of the possible spectrum of organic forms via hypothetical morphospace construction (Raup & Michelson, 1965; McGhee, 1999). The first area "models the actual process of biological morphogenesis itself." The second area explores the possible range of morphologic variability produced by constructing *n*-dimensional geometric hyperspaces called "theoretical morphospaces". These hyperspaces are created by systematically varying parameter values of a modelled form. The ultimate goal is to understand why real form exists and why nonexistent does not (McGhee, 1999). This research focuses on a theoretical morphospace of multilocular foraminifera with single apertures simulated based on the moving reference model described separately (Topa & Tyszka, 2002; Labaj *et al.*, 2003; Tyszka & Topa, 2005).

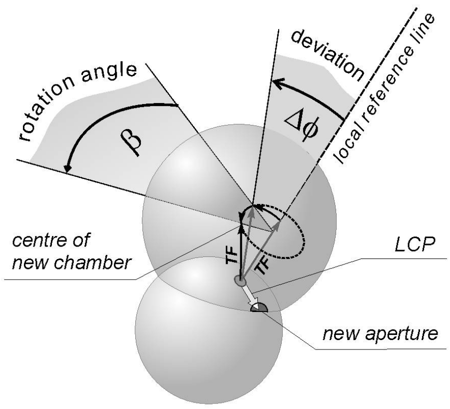

Figure 1. Basic terminology and parameters used in simulation foraminiferal test morphogenesis based on the moving reference model; LCP – Local Communication Path.

Methods. This morphospace analysis is based on the model presented by Łabaj *et al*. (2003), simulating theoretical foraminiferal shells in 3-dimensional space. The model includes 6 parameters, representing morphospace dimensions: (1–3) **Chamber scaling ratios** defined in 3-dimensional space by 3 parameters: k_x - chamber width ratio, k_y - chamber height ratio, k_z - chamber depth ratio. If all chamber scaling ratios equal each other, i.e., $k_x = k_y = k_z$, a new chamber is isometric to the previous one. Any differences in chamber scaling ratios cause allometric growth of successive chambers; (4) ***TF*** (translation factor) controls an **overlap** of successive chambers (Fig. 1). The "0" *TF* value places the centre of a new chamber directly at the aperture of the last chamber. This parameter ranges from "–1" to "+1" values. Higher values detach a new chamber from the existing shell that represents a "forbidden zone" *sensu* Berger (1969); (5) $\Delta\phi$ as a **deviation angle** (deflection angle) is an angle between the local reference line and the line defining the centre of a new chamber (Fig. 1). It ranges from –180° to 180°. Higher or lower out of range values can be recalculated to the values from the given range; (6) β represents a **rotation angle** along the local growth line (Fig. 1). This parameter is necessary in 3-dimensional space. It ranges from –180° to 180°. Higher or lower values can also be recalculated.

Morphospace. A classical option of morphospace visualisation applies 2-dimensional morphospaces already presented elsewhere (see Łabaj *et al*., 2003; Tyszka *et al*., 2005). Unfortunately, it is difficult to explore 4- or 5-dimensional morphospaces based on one- or two-dimensional cross-sections through the morphospace. We therefore apply a "**theoretical morphospace tree"** (so-called "morphotree") that gives a better overview of multidimensional morphospaces. We can start from a test (shell) form defined by any combination of selected parameters. This form is placed in the centre from where all presented dimensions spread out. Then this original form can be modified along any dimension, presenting the succeeding morphologies on the same line depicting changing, i.e. increasing or decreasing, parameters. The same procedure can be applied to other parameters/dimensions represented by additional lines radially spreading out from the centre. An example of such a morphospace tree is shown on Figure 2. The central form simulates a simple biserial morphotype, well known from calcareous and agglutinated foraminifera (Fig. 2). Then, the parameters are changed step by step, either ascendingly or descendingly. Changes of the parameter TF modify test arrangements from streptospiral-biserial forms, through triserial-biserial forms to highly trochospiral in the most positive values (e.g., 0.9). The values higher than 1.0 would cause separation of chambers that represents the "forbidden zone" (*sensu* Berger, 1969). Lower or negative TF-values create uniserial or biserial rectilinear forms with strongly overlapping chambers at most negative values. Relatively strong changes in foraminiferal patterns, from biserial, through streptospiral-biserial, streptospiral, streptospiral-to-4-serial, highly trochospiral, low trochospiral, planispiral, curved uniserial, rectilinerar uniserial to zigzac-like uniserial forms, can be observed along the $\Delta\phi$ dimension, going from 5° to 180° $\Delta\phi$–values. Parameter β (rotation angle) gradually modifies morphotypes via spiral twisting of biserial forms.

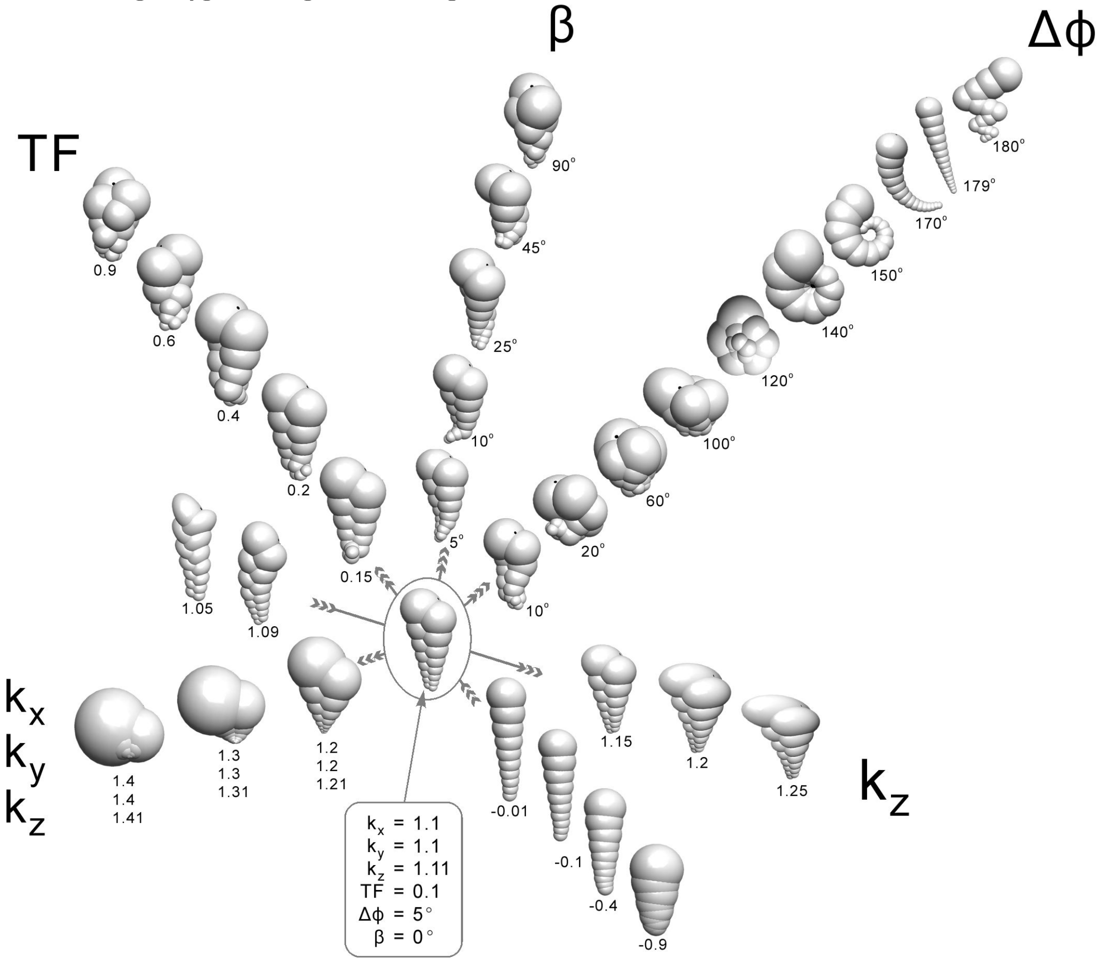

Figure 2. An example of the theoretical morphospace tree (morphotree) constructed along 5 dimensions (see text).

Changes of isometric or allometric scaling ratios influence the overall chamber and test proportions. There are possible unlimited combinations of parameters giving different results.

Discussion and conclusions. Overall comparison of the theoretical morphospace and empirical foraminiferal morphotypes suggests that evolution of small polythalamous foraminifers probably have "discovered" nearly the whole theoretical morphospace that means most of the simulated morphotypes are known from reality. It seems that most of theoretical morphotypes are functional as protective envelopes. An opposite interpretation assumes that most chamber arrangements are not essential for evolutionary success, even if we consider some morphotypes as more suitable for particular modes of life, such as planktonic or deep infaunal habitats. It is likely that evolution of small foraminifera can choose from a huge variety of shell shapes that may often have neutral adaptive values.

There are also some simulated forms (see Tyszka *et al*., 2005 – fig. 2) that almost certainly never existed in reality but resemble some abnormal shells switching or swinging from the biserial growth mode to spiral one. Some of them show every-2-chamber rhythms from left to right coiling, resembling a pseudo-biserial arrangement. Such arrangements are theoretically possible, but probably not functional. We can suppose that this presented geometric model does not integrate all factors controlling foraminiferal morphogenesis. The model does not include the morphogenetic role of apertures in shaping chambers. Real foraminal paths often tend to follow linear streaming of cytoplasm supported by cytoskeleton. This may be observed during ontogenesis of various morphotypes, which avoid strong bending as soon they reach rectilinear foraminal paths. It means that uncoiling forms are relatively common and they do not switch to the coiling mode during ontogenesis (e.g., *Ammobaculites*, *Astacolus*, *Marginulinopsis* etc.). A similar pattern is well known from complex foraminifers which show intercameral foramina situated along straight lines facilitating protoplasmic streaming between successive chambers and/or their chamberlets (see Hottinger, 2000; Tyszka & Topa, 2005). This phenomenon should be further investigated based on empirical examples and then built-in the future model.

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Deep Water Agglutinated Foraminifera as Proxy of the Post-Cretaceous/Tertiary Cooling Event: Evidence from the Elles Section (Tunisia)

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The first high resolution, quantitative analysis of benthic foraminiferal assemblages across the extraordinarily continuous and expanded Cretaceous/Tertiary Boundary (KTB) transition of the Elles section, allow me to recognize the following paleoenvironmental changes: a) sudden and incisive faunal turnover across the KTB in terms of diversity, abundance, and community structure; b) extinction of the species *Bolivinoides draco* and *Sliteria varsoviensis*; c) drastic decrease in the abundance of infaunal forms; d) two successive marked peaks in abundance of agglutinating taxa.

Besides these changes in faunal parameters, benthic foraminiferal assemblages record the invasion of two new boreal agglutinating taxa (*Ammomarginulina aubertae* and *Arenoturrispirillina* sp.) in the lowermost Danian.

The incoming of these species, which also occur in the lowermost Danian of El Kef, may reflect a short-term cooling following the KTB (Gradstein & Kaminski, 1989; Speijer and Van der Zwaan, 1994; Galeotti et al., 2004). These forms, in fact, are absent or very rare in the upper Maastrichtian of the southern Tethys but are common constituents of benthic foraminiferal assemblages in the same interval in Boreal settings. Accordingly, a negative shift of $\delta^{18}O$ values (Stüben, 1998) indicates a short-term cooling in the lowermost P0 Zone at Elles. Moreover, the development of sinistrally coiled dominated *Cibicidoides pseudoacutus* populations in the El Kef section (Galeotti & Coccioni, 2002; Galeotti et al., 2004) and Elles (Venturati, 2000; Galeotti & Coccioni, 2002) might also be related to such a decrease in temperature. Furthermore, at El Kef an invasion of cool-water, Boreal forms in dynocyst assemblages are recorded in the same interval where the shift in the coiling preference of C. pseudoacutus occurs (Brinkhuis et al., 1998).

Besides its paleoclimatic significance, the development of sinistrally coiled populations in *C. pseudoacutus* and the occurrence of the agglutinated Boreal forms are potential biostratigraphic proxies, representing the powerful markers to assess the completeness of stratigraphical sequences in Tethyan shallow water settings just above the KTB. Similarily, the two discrete increases in abundance of agglutinating foraminifera within lowermost Danian can be regarded as a potential tool for, at least, regional biostratigraphic correlation across the KTB.

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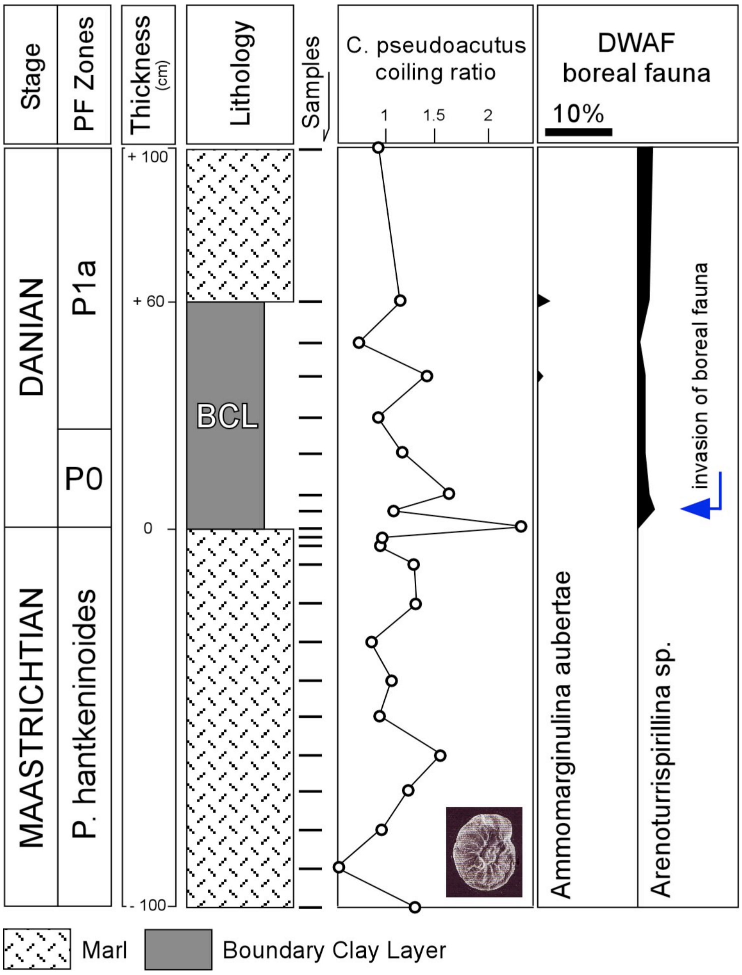

Fig. 1. Changes in *Cibicidoides pseudoacutus* coiling ratio and relative abundance of *Ammomarginulina aubertae* and *Arenoturrispirillina sp*. across the Cretaceous/Tertiary boundary at the Elles section.

Planktonic and Agglutinated Benthic Foraminiferal Response to the mid-Maastrichtian Extinction Event: Evidence from the Bottaccione Section (Gubbio, Central Italy)

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The mid-Maastrichtian was characterized by remarkable worldwide unfavourable biotic events resulting from large-scale paleoceanographic changes. The biotic crisis included: global extinction of the cosmopolitan, long-ranging epifaunal inoceramid bivalves (e.g., Chauris *et al*., 1998), extinction of tropical rudists reef faunas (e.g., Johnson & Kauffman, 1990), and changes in the latitudinal distribution of planktonic foraminifera and calcareous nannoplankton (e.g., Huber & Watkins, 1992). Enhanced production of cold, oxygen-rich deep waters from low to high latitudes as well as the subsequent decreased influence of warm saline bottom waters, could have triggered the extinction related to the mid-Maastrichtian Event.

In order to explore the effects of the mid-Maastrichtian Event on the deep-water agglutinated foraminifera, their abundance and distribution was analyzed in detail across the inoceramid extinction event from the pelagic limestones of the Bottaccione section (Gubbio, central Italy). In this locality the decline and extinction of inoceramids occurs some 4 Ma before the Cretaceous-Tertiary boundary, in the uppermost part of the planktonic foraminiferal *Contusotruncana contusa – Racemiguembelina fructicosa* Zone and magnetic interval C31R (Chauris *et al.,* 1998).

The mid-Maastrichtian Event did not lead to extinction of any species. However, a major faunal change in agglutinated foraminiferal communities consist of a remarkable increase in abundance of specimens belonging to the opportunist, infaunal genus *Spiroplectammina*. Close to inoceramid extinction event, Chauris *et al*. (1998) reported also, a drastic decline bi-keeled planktonic foraminifera, suggesting changes in the structure of oceanic waters.

Moreover, the mid-Maastrichtian biological crisis could be correlated to the Faunal Event 2 at DSDP Site 525A. This origination event is characterized by the appearance of 16 new species of planktonic foraminifera, most of them deeper dwellers, living at or below thermoclinal depths. Faunal Event 2 is associated also with climatic cooling, that appears to have resulted in a major increase in upwelling and nutrient supply which in turn lead to major evolutionary diversification in planktonic foraminifera (Li & Keller, 1998).

This study testifies that the mid-Maastrichtian Event was a period of high paleoenvironmental perturbations, and agglutinated benthic and planktonic foraminifera may be used as biological proxy for instability of worldwide marine paleoenvironments.

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Agglutinated foraminifera and palaeoenvironmental applications to the Pliocene of Piedmont (Northwestern Italy).

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Biostratigraphical and palaeoenvironmental analyses carried out on planktonic and benthic foraminifera from the "Argille Azzurre" (Blue Clays) and Sabbie di Asti (Asti Sands) Formations of Piedmont (Northwestern Italy), outcropping in North-Eastern Monferrato, Astigiano, Langhe and Monregalese, document a marine sedimentation ranging from the Lower Pliocene MPl1 biozone to the Middle Pliocene MPl5 biozone (Violanti, 2005). Foraminiferal assemblages, as well the lithologies, show clear differences in species composition and abundances, related to different palaeobathymetrical conditions (Dela Pierre *et al*., 2003). Agglutinated taxa represent only a minor component of total microfossils, but are of great significance for palaeoenvironmental interpretations.

Typical "Argille Azzurre" sediments yield rich and diversified assemblages referable to the MPl1 biozone (*Sphaeroidinellopsis* acme zone), MPl2 biozone (with *Globorotalia margaritae*) and MPl3 biozone (with *G. margaritae* and *G. puncticulata*) and are indicative of the upper epibathyal zone. Agglutinated foraminifera show a rather high diversity but very low total percentages (<3-5%). *Bigenerina nodosaria, Cylindroclavulina rudis, Karreriella bradyi, Martinottiella communis, Textularia* spp. are the most common species.

Already along biozone MPl3, and mainly in deposits referable to the MPl4 biozone (with *G. puncticulata*), less diversified assemblages become widespread, indicating shelf palaeoenvironments, subject to heavy transport from the inner neritic zone. Diversity of agglutinated assemblages is very low; *Dorothia gibbosa* and *Spiroplectinella wrighti,* reported as a mud-dweller with preference for a low clay input (Jorissen, 1987) are the dominant species, reaching more than 10% of the total benthic foraminifera in silty-sandy outcrops. Very rare *Bulimina basispinosa* and *Globobulimina ovula* document the deposition of sediments with similar composition up to the MPl5 biozone.

Most of the silty sands and sands, pertaining to the "Sabbie di Asti", yield inner neritic and shallow outer neritic microfaunas, devoid of biostratigraphic markers and very poor in agglutinated foraminifera.

A common characteristic of the entire succession is that stout, thick-shelled calcareous-cemented forms constitue the agglutinated assemblage, whereas thin-shelled taxa (trochamminids, etc.) are absent. The loss of fragile thin-walled, organic cemented specimens, and the consequent reduction of taxonomic diversity, could be caused by taphonomic and diagenetical processes (Kuhnt *et al*., 2000), rather than by palaeoecological preferences.

Rare, large tests of *Ammobaculites* sp., *Cyclammina cancellata, Recurvoides* sp., *Reophax scorpiurus, R. papillosus*, and fragments of *Rhabdammina* sp. have been collected from epibathyal and outer neritic assemblages referable to the MPl3/lowerMPl4a biozones. In the same samples siliceous microfossils (diatoms, radiolarians, sponge spicules) are common to abundant and suggest changes in the water mass circulation, increased supply of nutrients and seasonality. Enhanced erosion and deposition of turbidic layers are documented in the same time interval. Agglutinated foraminifera appear very sensitive to changing water mass conditions and, even if in very low abundances, can be successfully applied to detailed palaeoenvironment interpretations.

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The Influence of the Pyroclastic Sediments Deposition on the Deep Water Agglutinated Foraminifera in the Early Eocene

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Recently conducted geological-cartographic research, in the area of the Subsilesian Unit (Polish Outer Carpathians), revealed the numerous occurrence of bentonite intercalations within shaly sediments of the Early Palaeogene. They are white or cream in the colour and form from several to a dozen or so thin layers that thickness usually amounts from 0.5 to 5 cm (sporadically to 17 cm). The petrographic studies of the bentonitic sediments proved that they had developed as a result of underwater weathering of pyroclastic material (Cieszkowski *et al.* – in print), in that case they can be treated as bentonitized tuffites. The biostratigraphic analyses associate the deposition of tuffites with the Early Eocene age (foraminiferal assemblage *Glomospira* div. sp. and *Saccamminoides carphaticus* zones – zones after Olszewska, 1997).

The micropalaentological analyses have been made on the strength of foraminiferal assemblages representing sediments collected from twelve outcrops. Preliminary research results concerning changeability of foraminiferal associations from the exposure in the Żywiec tectonic window, were presented during the last IWAF meeting (Waskowska-Oliwa, 2001).

The comparison DWAF assemblages coming from tuffites and surrounding shales: The comparative analysis of the foraminiferal associations occurring in the bentonitized tuffites and surrounding them shales proved significant discrepancies concerning qualitative and quantitative changes of DWAF. That shows that cyclic deposition of pyroclastic material on the bottom of the deep Carpathian basin had an influence on the population of deep-water benthonic foraminifera and considerably disturbed their life environment. The Early Eocene deposition of tuffites is an example of the catastrophic event on a local scale.

The bentonitized tuffites are fine-grained sediment consisted of mainly clayish minerals and accompanying them sparse, fine and white grains of terygenic quartz. Most agglutinated foraminiferal from studied tuffites (60%-90%) own tests built of such material. The taxa, which tests are typical developed as coarse-grained e.g. *Rhabdammina* or *Gerochammina*, occur as white tests composed of medium-grained material. However, the taxa that are always fine-grained e.g. *Haplophragmoides kirki* Wickenden, *Glomospira charoides* (Jones et Patrker) and were found within tuffites posses very smooth tests similar to porcelain. The remaining foraminifera coming from the tuffites (40%-10%) have typical developed tests, which are made up of grey quartz, looking likewise all foraminifera from the shaly sediments surrounding tuffites. There is a relationship between a type of material that build a test and a life strategy of foraminifera. The grey tests taxa represent mainly the infauna group, while the taxa that tests consist of white and finer grained material belong to the epifauna group. Presumably, the infauna forms (the grey test foraminifera) survived a period of ash deposition inside sediment, whereas the epifauna (white tests foraminifera) adapted to environmental conditions, after the character of supplied sediment had changed, and settled sediment of volcanic ash.

The differences between DWAF associations found in tuffites as well as in the surrounding sediments concern also the composition of foraminiferal genera and species. Foraminiferal associations coming from tuffites show definitely less taxonomical diversity, the number of species amounts from 2 to 23 and genera from 2 to 16 in single samples. Deposits surrounding tuffites include more diverse quantities of foraminiferal genera and species, which are higher in comparison with those representing tuffites in the single sample and amount from 12 to 43 (mostly 20-28 genera) and from a dozen or so to 60 and above (30-40 species on average). The taxonomical diversity decline amounts 30-60% on average in samples representing tuffites and concerns genera mainly belonging to the epifauna group, which experienced the result of volcanic ash settling down the most intensely. The foraminifera occurring in the tuffites are represented by genera recognised as cosmopolitan in general.

The most spectacular discrepancy concerns foraminifera that are numbered among *Glomospira* genus. The quantity of *Glomospira* found in the tuffites fluctuates from 40% to 70%, whereas it is lower about 50% at an average among foraminifera representing surrounding shales and oscillates between 20% and 40%. It should be mentioned that *Glomospira* genus has been classified to opportunistic taxa that characterise an extremely high ecological tolerance. The double quantity of *Glomospira* within tuffites, which sedimentation was a local catastrophic event, confirms that view additionally. The foraminifera representing *Glomospira* genus occupied niches left by lower ecological tolerance organisms in a short time. There have been recognised some white specimens of *Glomospira charoides* (Jones et Parker) and *Glomospira gordialis* (Jones et Parker) that revealed an anomalous coiling of the last part of tubular chamber, what can be a result of a tough environmental conditions. The foraminiferal tests developed in this way have not been found among those representing surrounding sediments.

The significant reduction of the quantity among foraminiferal species as well as a sudden and short-lived development of *Glomospira* genus within tuffites influenced a decomposition of morphogroups. In connection with this the increase of participation of mobile epifauna containing *Glomospira* genus ensued as well as the insignificant decline of the other morphogroups types was noticed. Within tuffit layers the less number of suspension feeders foraminifera e.g., *Rhabdammina* or *Rhizammina* was observed, what can be connected with a reduction of nourishment delivery in suspension. The changes within the infauna forms depend on the thickness of tuffit layers. The amount of deep-water infauna foraminifera was considerably limited in thicker layers, however only a small decline or even an increase of infauna general number can be observed within thin tuffit layers. Some of the species representing contemporary infauna such as *Ammobaculites* or *Reophax* have been considered as organisms, which can survive disadvantageous periods e.g. volcanic ash deposition, and they have been recognised as pioneer forms (Hess & Kuhnt, 1996). The same relationship is observed within foraminifera associations found in the analysed thin tuffit layers coming from the Subsilesian Unit (Polish Outer Carpathians).

Moreover, there are discrepancies that are evident in sizes of foraminiferal tests. It is revealed in a clear reduction of sizes of white tests epifauna from bentonits (so-called ‘liliputian effect’). The measurement of *Glomospira charoides* (Jones et Parker) tests diameter let to estimate the scale of diminishing within this species that amounts to 10% on average.

The infauna, found in the thick layers of bentonitized tuffites, includes sparse specimens of *Gerochammina* and *Karrerulina*, which tests are built with white, fine-grained quartz. It indicates their affinity with the infauna group recolonizing tuffite sediment. They are smaller and more delicate then typical samples like the epifauna forms. An adult specimen test of *Gerochammina conversa* (Grzybowski) should be made up of 9-10 whorls, a trochospiral part, triserial as well as biserial part. White foraminifera of the mentioned species are found in a juvenile stage, their tests show only trochospiral part or trochospiral-biserial part with 4-5 whorls developed. The similar situation is within *Ammodiscus* genus, where relatively numerous white specimens have been discovered, but they stopped growing up at the juvenile stadium or megalosphaeric forms, which are formed as a result of an asexual reproduction, have been found. Populations of dwarfish specimens that are poorly species diverse and settled sediments of volcanic ash, are typical examples of r-strategists.

In the bentonitized tuffites there have been recognised from 95% to 65% less foraminifera specimens with reference to foraminiferal composition of shaly sediments surrounding tuffites. The similar phenomenon has been observed in analogous present environments. It is a result of a mass dying out of foraminifera and remaining only spare opportunistic forms, which are able to survive such crisis (Hess & Kuhnt, 1996). Comparisons with contemporary environments can imply the same reason of quantity changes, however the analysis of such data for conditions existing during the Early Palaeogene cannot have crucial importance because the quantity of fossils depends on many different factors that total influence cannot be estimated.

Conclusions: The deposition of pyroclastic material on the bottom of the Subsilesian basin brought about discrepancies in the structure of agglutinated foraminifera assemblages. The reorganisation of foraminifera associations occurred on the smaller scale within forms representing thin tuffites layers than in thick ones. The more diverse and numerous foraminifera association has been recognised as well as bigger tests specimens and lower number of white tests forms have been revealed in the thin layers. The infauna group, which ratio changes only a little in relation to the surrounding sediments, is relatively numerous. It should be taken into consideration that the infauna group could have sensed the changes, caused by volcanic ash during its deposition, to a small extent because of not large thickness of analysed bentonites layers. Concerning the quantity and composition of the foraminifera association the changes are much more visible in thicker tuffit layers.

There are usually between a few and a dozen or so layers of bentonitized tuffites within individual profiles, what proves that a volcanic ash deposition was not a single event but cyclical. Changes noticed in foraminifera associations show that each settling of volcanic ash on the basin bottom was a catastrophic event and caused changes of environment near the bottom, and thus disorganised the structure of foraminifera assemblages. The quick rebuild of full structure of foraminifera assemblages followed each pyroclastic deposition, what proves the great recolonising and reproduction abilities of these organisms.

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"Tiny Giants Of The Great Seas"—Foraminifera, their scientific and aesthetic values

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Foraminifera are widely used in many scientific disciplines such as biostratigraphy, paleoecology, paleogeography, paleoclimatology, oceanography, as indicators in oil exploration etc., of which agglutinated foraminifera by virtue of their ubiquitous distribution, occurring in almost all kinds of environment, including extreme habitats, have great advantages over other types of foraminifera. In allusion to the very important role they play as past and present environmental bioindicators, foraminifera have been dubbed "Tiny Giants of the Great Seas".

The aesthetic value of foraminifera lies in their extremely diversified modes of growth manifested by their exquisite, sometimes unimaginably elegant artistry of shell morphology endowed on a one-celled organism by Mother Nature that perhaps very few other organisms in the microscopic world can surpass. Some spirally coiled foraminifera can vie in beauty with the multicellular chambered nautilus whose shell had long been praised for the beauty of its logarithmic spiral. They are in reality "Art Forms in Nature, "Abstract Art in Reality" especially manifested by the agglutinated foraminifera which use visible material such as various kinds of sand grains, mica flakes, sponge spicules, empty foram tests, etc. present on the sea bed instead of invisible inorganic calcium carbonate in the water to construct their shells. The beauty of foraminiferal shells reflecting on the diversity and artful creativity of Mother Nature had long been admired and illustrated by scientists specializing research on them. Because of their microscopic size, it is a pity that the layman scarcely has any chance of seeing their shells in their 3-dimensional splendor.

With my almost half a century of research on the taxonomy and ecology of foraminifera, I, a member of the Chinese Academy of Sciences, Senior Scientist of the Institute of Oceanology, CAS, having their morphology at my finger tips, personally sculpted out foraminiferal models proportionately enlarged tens to hundreds of times their original size. In collaboration with an arts and crafts artist, an entirely new vista of the foraminiferal microcosm in the form of enlarged, seeable, touchable and purchaseable 3-dimensional models of porcelaneous, hyaline and arenaceous foraminifera is unfolded for use as scientific educational tools and as tourist souvenirs, for the public to share the magnificent artistry of Mother Nature, and for the cause of popular science. Along with these, some 40 stone sculptures of foraminifera, 11 of which are arenaceous foraminifera, are rarely seen excellent city attractions reflecting marine culture, probably the first of their kind in the world. It is hoped that the morphological beauty of foraminifera can inspire and motivate students to conduct research on this very important group of protozoa, as in my case it was "love at first sight" having a first glance of them under the binocular microscope when I was at university, and that it can inspire artistic creations and open up endless possibilities for their use in the design fields – especially in the New Organic Architecture, in interior decoration, furniture, textile, pastries, jewelry, etc. to impart a sense of the harmonious integration of science, art, and nature.

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1. "The Origins of Applied Micropalaeontology: The School of Józef Grzybowski", edited by M.A. Kaminski, S. Geroch, & D.G. Kaminski (1993). Translations of the original micropaleontological monographs of J. Grzybowski, W. Friedberg, and M. Dylążanka; with a revision of foraminiferal species in the Grzybowski Collection. Format: B5, 336 pp. hardback. ISBN: 83-901164-0-5. *Sale Price:* £15.00 ($28.00)

4. "Lower Cretaceous deep-water benthic foraminifera of the Indian Ocean" by A.E.L. Holbourn & M.A. Kaminski (1997). A monograph detailing 260 species from 12 DSDP-ODP sites in the Indian Ocean. Format: A4, 172 pp. hardback. ISBN: 83-901164-4-8. Price: £22.00 or $40.00.

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8. "Proceedings of the Sixth International Workshop on Agglutinated Foraminifera" edited by M. Bubík & M.A. Kaminski (2004). Twenty-seven research articles on agglutinated foraminifera presented at the IWAF-6 in Prague, September 2001. Format: A4, 485 pp. ISBN: 83-912385-4-7. Price: £40.00 or $75.00 (individuals); £49.00 or $89.00 (Libraries).

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10 "Atlas of Paleogene Cosmopolitan Deep-Water Agglutinated Foraminifera", by M.A. Kaminski, F.M. Gradstein, and collaborators (2005). The Taxonomy, Biogeography, and Biostratigraphy of 130 DWAF species. A companion volume to the "Van Morkhoven Atlas" of calcareous benthic foraminifera, Format: A4, 547 pp. ISBN: 83-912385-8-X, Price £49.00 or $89.00 (Individuals); £59.00 or $109.00 (Libraries).

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