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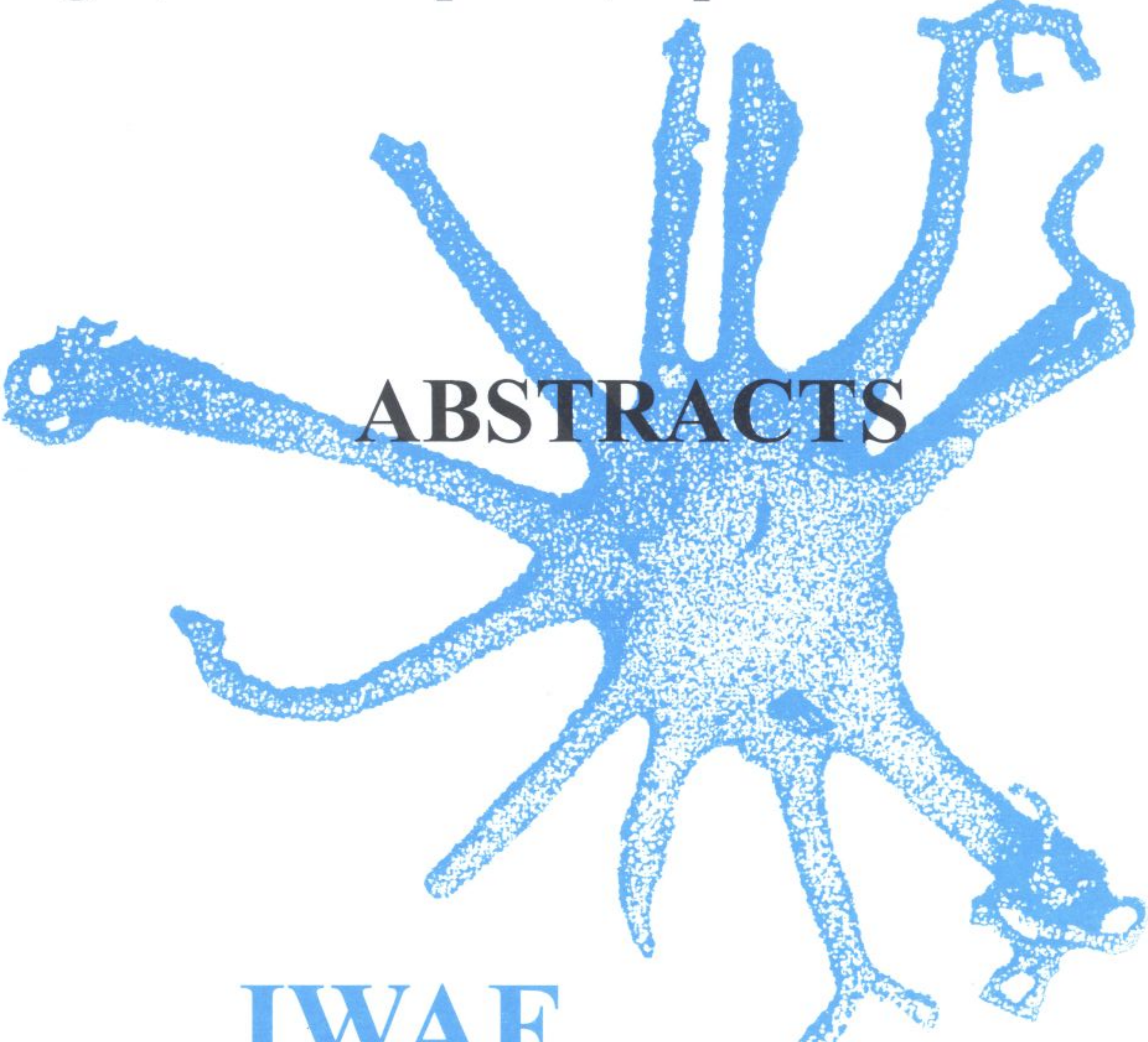

ABSTRACTS

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Edited by: K. Holcová & M. Bubik

Czech Geological Survey

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Czech Geological Survey

Prague 2001

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Lower Eocene deep-water agglutinated foraminifera from variegated shales of the Dukla Nappe, Polish Flysch Carpathians, Bieszczady Mts

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Paleogene variegated shales (mostly non-calcareous) are characteristic facies in the deep-water flysch series in all tectonic-facies zones of the Flysch Carpathians. Their thickness is very diversified: from a dozen centimetres (only one bed) to a 200 m of continuous series. The lower and upper boundaries of the variegated shales are diachronous. The oldest variegated facies represent the uppermost Paleocene (Skole Nappe: Bąk *et al.*, 1997); the youngest variegated facies correspond to the lowermost part of the Middle Eocene (Magura Nappe: Oszczypko *et al.*, 1990; Skole Nappe: Bąk *et al.*, 1997).

The present studies concern the foraminiferal assemblages from the variegated shales in the Dukla Nappe, one of the inner tectonic-facies zones of the Flysch Carpathians. The variegated shales occur in this tectonic unit within thin-rythmic flysch series of the Hieroglyphic Beds, which consists mainly of green shales and thin-bedded turbidite sandstones and siltstones, highly bioturnated (Upper Paleocene-Eocene; Olszewska, 1980). The thickness of the variegated facies in the all known sections do not exceed 10 m; representing the lowermost values in the whole Flysch Carpathians.

The studied sections of variegated shales in the Bieszczady Mts (Lutowy stream, Solinka stream, Szypowaty stream and Pod Rawka stream) create only a 3-m thick series, with a few layers of red shales (up to 12 cm thick), a few layers of variegated shales and claystones (up to 5 cm thick), numerous layers of green shales (up to 35 cm thick) and intercalations of thin-bedded fine-grained muscovite sandstones and siltstones.

Glomospira biofacies with abundant small specimens of *Glomospira charoides* (Jones & Parker) is the most characteristic component of the foraminiferal assemblages, which occur in these sediments. The dimensions of foraminifers are significantly lower then in the assemblages from neighbouring sediments. The tubular taxa are practically absent. Besides of glomospirids, forms belonging to *Trochamminoides* sp., *Paratrochamminoides* sp., *Trochammina* sp. and *Karrerulina* sp. are abundant. Taxonomic diversity of foraminiferal assemblage is low (10-12 species per sample), with high dominance of glomospirids. Other characteristic feature is an occurrence of poorly preserved radiolarians (indeterminable). Their number is not such numerous if compared with assemblages from other tectonic-facies zones of the Flysch Carpathians (Subsilesian or Skole nappes). Moreover, fish teeth occur as significant component of the microfaunal assemblages in fraction 0.063-0.15 mm.

The foraminiferal assemblages from the neighbouring Hieroglyphic Beds (mainly green shales) are similar to those, described from variegated facies. *Glomospira* biofacies also dominate in these sediments; however, the number of glomospirids is lower. Agglutinated assemblages are very scarce, dominated by tubular taxa and opportunistic small forms from genera *Recurvoides* in the lowermost part of the green facies (Hieroglyphic Beds). Higher up in the section, the assemblages are more diversified, including numerous specimens of *Trochamminoides*.

The studied assemblages from the green and variegated facies within the Dukla Nappe represent the so-called "Glomospira Event", which was referred in lower-middle Eocene of several localities also from the Alps and the North Atlantic (see, Grün *et al.*, 1964; Kaminski *et al.*, 1990). Its occurrence was associated with oxygen facies, low sedimentation rate and the 'radiolaria flood'. These features have been base for interpretation, that the "event" may reflect a change of paleocirculation patterns of the surface water which induced change in bottom water masses (oxic and cool), and was associated with low surface productivity.

The changes within the "Glomospira Event" in the Dukla Series, from the *Recurvoides-Glomospira*, through the *Trochamminoides-Glomospira* up to the *Karrerulina-Glomospira* biofacies is here interpreted as the progressive changes of oxygenation of bottom water, which maximum took place during the sedimentation of the variegated facies. The oxygenation of bottom water was probably induced by paleogeographic changes within the northern margin of the

Western Tethys near the Paleocene/Eocene boundary. It was connected with surface circulation, with water flowing from east via Gibraltar Gate to the Atlantic Ocean (Kaminski *et al.*, 1996). Low sedimentation rate in the Dukla Basin and inflow of cool oxygen water caused the oligotrophic conditions at the sea floor.

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Agglutinated foraminifera from the Spiroplectammina carinata zone (Middle Badenian) of the NW part of Vienna basin (Slovak part)

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The Middle Miocene benthonic foraminiferal assamblages have been studied from a mudstone and a siltstone samples collected from the NW side of Vienna basin (Slovakia) and statistically processed to reveal relationships of the agglutinated forms to the calcareous foraminifera. Two type of assamblages has been distinguished within the studied material, with the emphasis to the agglutinated forms:

1. *Spirorutilus carinatus - Uvigerina semiornata - Heterolepa dutemplei* assamblage, which represent typical assamblage of the Spiroplectammina carinata Zone (sensu Grill 1941), Middle Badenian.

2. *Budashevaella wilsoni - Uvigerina semiornata - Cassidulina laevigata* assablage, which represent Spiroplectammina carinata Zone too.

The different species composition within the same stratigraphic zone (Spiroplectammina carinata Zone), is probably caused by granularity of the sediments and by the measure of the O_2 contain.

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Foraminiferal stratigraphy and facies of Jurassic and Cretaceous strata, North Greenland

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The main basis of the study are foraminiferal assemblages of the Upper Jurassic Drumledome and the Lower Cretaceous Splitbaek formations of North Greenland. Foraminifera are of particular biostratigraphic importance in these deposits, because organic-walled microfossils are destroyed by diagenetic processes (high thermal impact). Aspects of depositional conditions are elucidated by foraminiferal distribution data combined with sedimentological features apparent from field logs and organic carbon and calcium carbonate content.

The analysed part of the Drumledome Formation consists of black shales with high organic content. The foraminiferal assemblages of these sediments are entirely agglutinated, and show low species diversities, suggesting hypoxic depositional conditions. The dominant species is *Evolutinella* aff. *anabarensis*, followed by *Trochammina taboriensis, T. omskensis* and *Cribrostomoides subretusus*. The assemblages show close similarities with Callovian to Lower Kimmeridgian faunas of the Barents Sea and Svalbard (Nagy et al. 1988; Nagy & Basov 1996).

The studied interval of the Splitbaek Formation consists of grey shales containing mixed calcareous-agglutinated assemblages with rather high species diversities in the lowermost and middle parts. The dominant species are *Rhizammina* sp. and *Pseudopolymorphina*? aff. *gurievensis*. Locally common species include *Ammobaculites* aff. *gerkei*, *Verneuilinoides* aff. *neocomensis*, and *Cribrostomoides* sp. Deep water conditions are suggested by several species (including *Rhizammina* sp. *Repmanina charoides* and *Glomospirella arctica*), although presence of calcareous taxa indicates deposition above the CCD. Faunal comparisons with Svalbard suggest a Ryazanian to Hauterivian age (Nagy et al. 1988; Nagy & Basov 1996).

According to current paleogeographic reconstructions, Svalbard had a more distal (basinal) position than North Greenland in the Upper Jurassic and early Lower Cretaceous (Dypvik et al., *in press*). In accordance with this, the Upper Jurassic succession of Svalbard is dominated by dark shales deposited in hypoxic waters, while the North Greenland succession shows a more sandy development, although it also includes hypoxic black shales. Low diversity agglutinated assemblages are typical for both areas. The lowermost Cretaceous in both areas contains deep water indicators. The occurrence of calcareous foraminifera in North Greenland suggests, however, deposition above CCD while the usually agglutinated nature of the Svalbard assemblages indicates deposition below this level.

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Foraminiferal stratigraphy at the Jurassic-Cretaceous transition reflecting the Mjølnir meteor impact (Barents Sea)

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Foraminiferal assemblages have been studied in core samples from two IKU deep boreholes (7430/10-U-01 and 7329/03-U-01) drilled on the southern Barents Shelf. 7329/03-U-01 is from the central high of the Mjølnir impact crater, while 7430/10-U-01 is located about 30 km northeast of the crater. Earlier publications (Gudlaugsson 1993; Dypvik et al. 1996; Tsikalas et al. 1998; Smelror et al. in press), identified the crater as a bolide impact close to the Jurassic-Cretaceous boundary.

The core from 7329/03-U-01 is divided into several depositional intervals of which the lower, and major, one is comprised of strongly deformed sandstones and shales. This deformation has been attributed to the impact. The succeeding and much thinner interval has been interpreted as impact suspension deposits. The impoverished foraminiferal assemblages and the lithologies of both these intervals show similarities with the Wilhelmøya Subgroup (Norian to Toarcian) in Spitsbergen. The upper, unaffected part of the core contains almost exclusively calcareous foraminifera, typical for the Ryazanian to Valanginian interval. These faunas are dominated by epifaunal and partly epiphytic morphotypes.

In the 7430/10-U-01 core, the impact is marked by a mudflake conglomerate associated with other indicators such as shocked quartz and Ir-anomaly. The interval (ca. 1 m) immediately above these indicators is barren of foraminifera or contains only very few, probably redeposited specimens. Rich Ryazanian to Valanginian calcareous faunas occur above this interval.

The foraminiferal succession in the 7430/10-U-01 core is subdivided into 5 zones in ascending order: 1) Trochammina omskensis Zone - Late Kimmeridgian to Middle Volgian; 2) Calyptammina praegyroidiniformis/Recurvoides obskiensis Zone - Late Volgian to Earliest Ryazanian; 3) Gaudryina rostellata Zone – Early Ryazanian; 4) Lenticulina sossipatrovae Zone – Late Ryanzanian; 5) Reinholdella tatarica Zone – Latest Ryazanian to Earliest Valanginian. In the 7329/03U-01 core the assemblages are divided into 3 zones: 1) Ammodiscus aff. yonsnabensis Zone – Norian to Toarcian; 2) Evolutinella vallata Zone – Latest Ryazanian; 3) Dorothia hauteriviana Zone - Valanginian. Zone assignment is based on correlations with previously published subdivisions of the Spitbergen succession (Nagy et al. 1990; Nagy & Basov 1998).

In both cores the unaffected intervals consist mainly of organic rich shales with low diversity foraminiferal assemblages strongly dominated by agglutinants. This is typical for oxygen depleted conditions associated with a high organic influx. In the uppermost part of the cores the proportion of calcareous forms strongly increases and faunal change is correlative with a major faunal turnover, also developed in the Ryazanian in Spitsbergen.

The sediment packages in both Spitsbergen and the Barents Sea are dominated by organic rich shales deposited in hypoxic and, more seldom, anoxic environments as demonstrated by Nagy et al. (1988) and the present study. The agglutinated faunas of the Middle Jurassic to basal Cretaceous parts of the cores closely resemble those of the middle part of the Janusfjellet Subgroup (Kimmeridgian to Valanginian) in Spitsbergen. The faunas are also correlative with Western Siberia and the Eastern Barents Sea.

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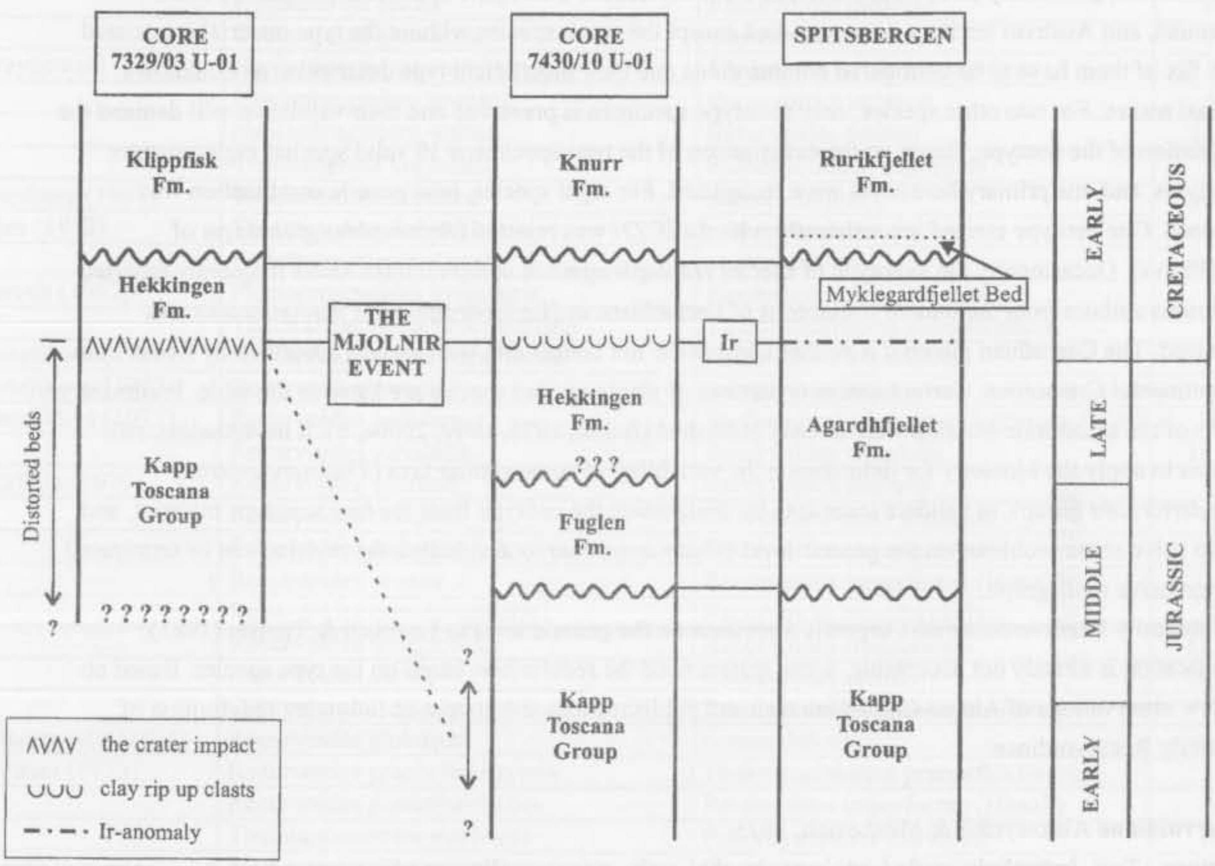

Fig. 1. Schematic correlation of the Mjølnir Impact (not to scale).

Iconography to the taxonomic revision of the Cretaceous to Paleogene Recurvoidinae (Foraminiferida) of the Alpine-Carpathian realm

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Agglutinated foraminifers of subfamily Recurvoidinae are frequent in various deep-sea facies but difficult to classify and determine due their uniform "sand aggregate" external appearance and variable internal arrangement (coiling mode). Permanent confusion of insufficiently defined species by various authors still has not enabled to exploit the biostratigraphical potential of this group except few taxa. For removing a part of the taxonomic chaos the taxonomic revision of Cretaceous to Paleogene Recurvoidinae of the Alpine-Carpathian deep-sea facies was

done during years 1997-99 in a framework of the project No. 205/97/0495 supported by the Grant Agency of the Czech Republic.

Various authors described from the Alpine-Carpathian region 44 species of Recurvoidinae as new. Revision was based on examination of the preserved type material of 34 species in the collections in Prague, Krakow, Vienna, Bucharest and Moscow.

Revision of Recurvoidinae started by examination of the type specimens. The specimens were observed and drawn using the "camera lucida" in a transparency (in glycerine) to learn the features of coiling mode. The six standard views related to a position of an aperture were documented (see Bubik, 2000b). Schemes of coiling mode ("rollograms") following Geroch (1962) and modified by Bubik (2000b) were constructed for each test.

Until now, practically all species described from Cretaceous-Paleogene sediments of Czech, Polish, Ukrainian, and Austrian territory were restudied except the seven species without the type material (presumed lost). Six of them have to be considered nomina dubia due their insufficient type description and unknown original nature. For two other species, only metatype specimen is preserved and their validation will demand the designation of the neotype. Based on the examination of the type specimens 19 valid species, eight younger synonyms, and one primary homonym were recognised. For eight species, new generic combination was proposed. One neotype erected inconsistently with the ICZN was rejected (*Recurvoides globulosus* of Hanzlikova). Occasionally the lectotype of species *Haplophragmium nonioninoides* Reuss frequently reported by various authors from the middle Cretaceous of Carpathians as *Haplophragmoides nonioninoides* was examined. The Carpathian material is neither conspecific nor congeneric with species described by Reuss from epicontinental Cretaceous. Current names or statuses of single revised species are listed in the table. Preliminary results of the taxonomic revision were already published (Bubik, 1998, 1999, 2000a, b). It nevertheless, still remains to apply the biometry for delimitation the variability of some similar taxa (*Thalmannammina meandertornata* group), to validate some taxa by designation the neotype from the new topotype material, and also to solve some problems on the generic level (*Thalmannorecurvoides*) before the revision can be terminated by conclusive monograph.

Subfamily Recurvoidinae asks urgently a revision on the generic level as Loeblich & Tappan (1987) classification is already not acceptable. Some genera need the redefinition based on the type species. Based on the new observations of Alpine-Carpathian taxa and published data it is proposed following redefinition of subfamily Recurvoidinae:

Recurvoidinae Alekseychik & Mitskevich, 1973.

Diagnose: Test irregularly coiled at least in the early stage; coiling mode streptospiral s. s., recurvoidiform, thalmannamminiform, plectorecurvoidiform, pseudotrochospiral, pseudoplanispiral, or combined of more different modes; aperture always areal (respectively interioareal, multiple etc.).

Stratigraphic range: ?Permian, Lias - Holocene.

Currently included genera (with synonyms): *Cribrostomoides* Cushman, *Plectorecurvoides* Noth (=*Globivalvulinella* Bukalova), *Pokornyammina* Neagu & Platon, *Recurvoides* Earland (=*Trochitendina* Alekseychik & Mitskevich), *Thalmannammina* Pokorny, *Thalmannorecurvoides* Sandulescu.

Tentatively included genera: *Budashevaella* Loeblich & Tappan, *Recurvoidatus* Saidova.

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Type reference	Original designation	Current name / status	material
Reuss (1863)	Haplophragmium nonioninoides	Labrospira nonioninoides	L
Grzybowski (1896)	Cyclammina retrosepta	Recurvoides retroseptus	S
	Cyclammina setosa	Recurvoides setosus	M
	Cyclammina globulosa	nomen dubium	N
Grzybowski (1898)	Haplophragmium subturbinatum	Thalmannammina subturbinata	L
	Haplophragmium immane	Recurvoides immane	L
	Haplophragmium walteri	Recurvoides walteri	L, P
	Trochammina nucleolus	Bulbobaculites? nucleolus	L
Friedberg (1901)	Trochammina bifaciata	nomen dubium	none
Noth (1912)	Trochammina deflexiformis	nomen dubium	none
	Endothyra barwinekensis	nomen dubium	none
Geroch (1962)	Plectorecurvoides irregularis	Plectorecurvoides irregularis	H
	Thalmannammina neocomiensis	Thalmannammina neocomiensis	H
Hanzlíková (1966)	Haplophragmoides imperfectus	Recurvoides imperfectus	H
Hanzlíková (1972)	Recurvoides gerochi	primary homonym	H
Hanzlíková (1973)	Recurvoides godulensis	Thalmannammina meandertornata (N.&T.)	H, P
	Recurvoides variabilis	Recurvoides variabilis	H, P
Mjatliuk (1970)	Recurvoides anormis	Recurvoides anormis	H
	Recurvoides dissonus	Cribrostomoides? dissonus	H
	Recurvoides nadvornensis	Recurvoides anormis Mjatl.	H
	Recurvoides primus	Recurvoides imperfectus (Hanzl.)	H
	Recurvoides pseudoregularis	Recurvoides pseudoregularis	H
	Recurvoides smugarensis	Recurvoides smugarensis	H, P
	Recurvoides varius	Recurvoides varius	H, P
	Cribrostomoides? pocutiensis	Recurvoides cf. retroseptus (Grz.)	H
Jednorowska (1968)	Recurvoides globosus	nomen dubium	none
Soliman (1972)	Recurvoides praedeflexiformis	Thalmannammina praedeflexiformis	H
	Recurvoides praeimperfectus	Recurvoides imperfectus (Hanzl.)	H
	Thalmannammina mariensis	Pokornyammina mariensis	H
	Plectorecurvoides postalternans	Plectorecurvoides alternans Noth	H
Maslakova (1955)	Haplophragmoides enormis	nomen dubium	none
Sandulescu (1971)	Thalmannorecurvoides pluricameratus	Thalmannorecurvoides pluricameratus	M
	Thalmannorecurvoides simplex	Thalmannorecurvoides simplex	none
Sandulescu (1973)	Thalmannammina plectorecurvoidiformis	Recurvoides recurvoidiformis	H
Neagu (1970)	Thalmannammina meandertornata	Thalmannammina meandertornata	H, P
	Thalmannammina recurvoidiformis	Recurvoides recurvoidiformis	H, P
Neagu&Platon (1994)	Thalmannammina simpla	Thalmannammina simpla	H, P
	Recurvoides pseudononioninoides	Recurvoides pseudononioninoides	H, P
	Recurvoides simuloplanus	Recurvoides simuloplanus	H, P
	Recurvoides minimus	Recurvoides minimus	H, P
	Recurvoides labrospiriformis	Recurvoides minimus	H, P
	Pokornyammina clara	Pokornyammina clara	H, P
Noth (1952)	Plectorecurvoides alternans	Plectorecurvoides alternans	H
Fuchs (1971)	Recurvoides exiguus	Recurvoides exiguus	H

Tab. 1. Preliminary results of taxonomic revision of Recurvoidinae from Alpine-Carpathian realm.
Abbreviations: H- holotype, S - syntype, L – lectotype, P – paratype/paralectotype, N - neotype, M – metatype.

Agglutinated foraminifers response to KT boundary event in sub-CCD flysch facies

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Although the Cretaceous /Tertiary boundary (KTB) is one among the most frequent topics of geology in the last decades, the knowledge of changes in deep sea (sub-CCD) environments is still not sufficient. Generally it is known that the biota of the deep sea and high latitudes was affected much lesser than the tropic and shallow-marine ecosystems. The majority of the famous and well-studied KTB sections represent the bathyal calcareous sediments while the sections in the sub-CCD facies are few in number and foraminifers were studied in less detail.

In Carpathians the interesting KTB section was found in the Rača Unit of the Magura Flysch near Uzgruň settlement in northern Moravia (Bubík et al., 1999, in press). The undisturbed section consists of 9,1 m thick thin rhythmic alternation of claystones, marlstones, siltstones and sandstones. The absence of the tectonic disturbance, relatively high proportion of hemipelagites and relatively rich fossil record (foraminifers, radiolarians, calcareous nannofossils, dinocysts, ichnofossils) have made the Uzgruň section optimal for the KTB studies. Calcareous nannofossils and rare planktonic foraminifers were obtained only from the Maastrichtian part of the section as the higher part is solely non-calcareous. Biostratigraphic evidence of the KTB is based on dinocysts (Bubík et al., in press). Agglutinated foraminifers are abundant and well diversified in the hemipelagites.

Samples for the quantitative study were taken from the hemipelagites. The samples were washed on sieve 0.063 mm mesh size, weighed, quarted, the picked foraminifers counted and faunal density (number of specimens per 1 g of draught rock) calculated. A special attention was paid to *Rzehakina* representatives. The specimens were measured and the length-breath ratio (LB) and the involution index (Z) were calculated and compared with variability of single taxa in the LB-Z diagram constructed earlier (Bubík, 1999).

Biostratigraphic value of agglutinated taxa is relatively low due the low extinction rate, nevertheless some changes around the KTB were observed. At the Uzgruň section only *Hormosina trinitatensis* has local extinction near the KTB. The first occurrence of *Rzehakina fissistomata* in the sample 19C2 has evidenced the base of the R. fissistomata Zone sensu Geroch & Nowak (1984). The mentioned authors (l. c.) placed the base of the zone on the KTB. In the Uzgruň *R. fissistomata* starts apparently in the uppermost Maastrichtian (see fig. 1). Some atypical and transitional forms occur earlier (sample 19A, fig. 1). The Upper Maastrichtian occurrences of *R. fissistomata* are known also from other areas (Bubík & Kaminski, 2000). In the uppermost part of the Maastrichtian in Uzgruň the acme of *Remesella varians* was observed in more than 3 m thick interval including the KTB in its upper part. In the lower part of the Paleocene following taxa increase in their frequency: *Ammolagena clavata, Glomospira serpens, Glomospira* sp. 1. sensu Bubik, 1995, *Hyperammina nuda, Caudammina excelsa, C. ovuloides, Karrerulina conversa, Rhabdammina cylindrica*, and *Rzehakina fissistomata.*

Surprisingly in the lowermost Paleocene part of the section the faunal density values increase dramatically (fig. 1). This trend reflects probably the growing benthic productivity rather then decreasing sedimentation rate. The sedimentation rate may even increase due the increased proximity of turbidite sedimentation (Bubík et al., 1999). Increasing density fit not well with supposed collapse of trophic structure of the ocean and it further study on changes in diversity and structure of benthic community is needed.

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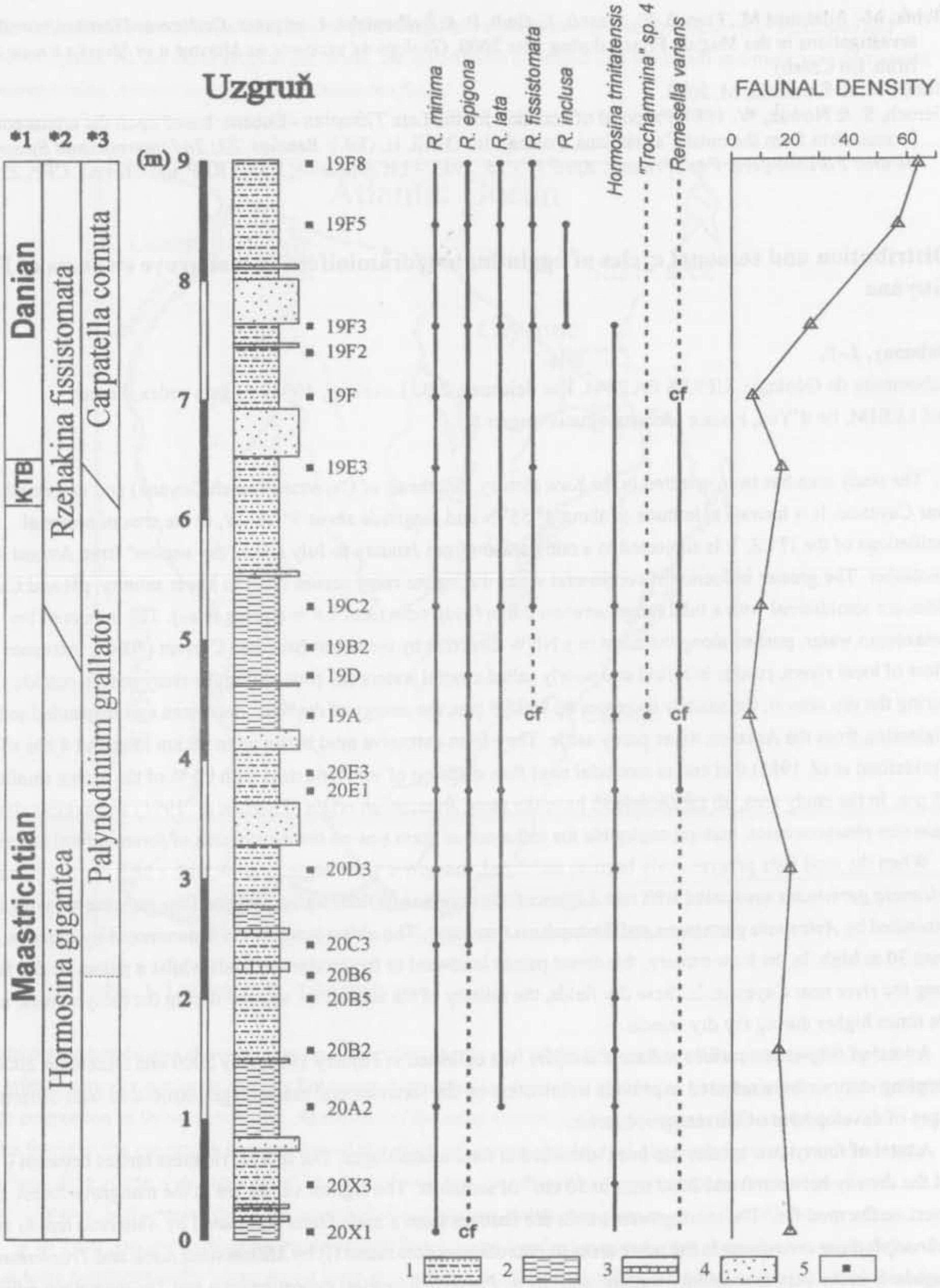

Fig. 1. Composed lithological chart of the Uzgruň section with selected samples position and distribution of stratigraphical marker agglutinated foraminifers (rzehakinids, etc.). Stratigraphy: *1 - chronostratigraphy: KTB - Cretaceous/Tertiary boundary interval, *2 - agglutinated foraminifera zones sensu Geroch - Nowak (1984), *3 - dinocyst zones applied by P. Gedl (Bubík et al., in press). Simplified lithology: 1 - alternation of non-calcareous turbidite a hemipelagite claystones, siltstones and thin sandstones, 2 - dtto with calcareous clastones, 3 - turbidite marlstones and pelocarbonates, 4 - sandstones, 5 - samples.

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Distribution and seasonal cycles of agglutinated foraminifera in mangrove swamps of French Guyana

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The study area has been selected in the Kaw estuary, Southeast of Cayenne (French Guyana) and in a small river near Cayenne. It is located at latitude of about 4° 55' N and longitude about 5° 10' W, in the area of seasonal oscillations of the ITCZ. It is subjected to a rainy season from January to July and a "dry season" from August to December. The greater influence of continental water during the rainy season leads to lower salinity, pH and Ca content. Tides are semidiurnal with a tidal range between 0.8 m (neap tides) and 2.9 m (spring tides). The impact of the Amazonian water, pushed along the coast in a NNW direction by the North Brazilian Current (NBC), increased by the effect of local rivers, results in turbid and poorly salted coastal waters (20 psu) during the rainy season outside Cayenne. During the dry season, the salinity increases up to 35.5 psu; the energy of the NBC decreases and suspended sediments originating from the Amazon River partly settle. They form extensive mud banks up to 50 km long and 4 km wide (Froidefond *et al.* 1985) that end in intertidal mud flats made up of very fine mud with 90 % of the grains smaller than 3.5 µm. In the study area, all the sediments have the same Amazonian origin (Eisma *et al.* 1991) and exhibit similar grain size characteristics, making negligible the influence of grain size on the distribution of foraminiferal assemblages.

When the mud flats progressively become stabilized, mangrove trees begin to grow with a high density population of *Avicennia germinans* associated with rare *Laguncularia racemosa*. Older well-stabilized flats are covered with a forest dominated by *Avicennia germinans* and *Rhizophora racemosa*. The oldest inner forest is dominated by *Avicennia* trees, about 30 m high. In the Kaw estuary, this forest passes landward to freshwater wetlands whilst it passes to dry fields along the river near Cayenne. In these dry fields, the salinity of the sediments, about 5 during the rainy season, may by five times higher during the dry season.

A total of fifty-seven surface sediment samples was collected in January 1999, July 2000 and December 2000. Sampling stations were selected to provide information on the foraminiferal assemblages associated with different stages of development of the mangrove forest.

A total of fourty-two species has been identified in total assemblages. The species richness ranges between 0 and 16, and the density between 0 and 2000 tests in 50 cm^3 of sediment. The highest values are in the mangrove forest, the lowest on the mud flat. The most general trends are changes from a microfauna dominated by *Ammonia tepida* and *Cribroelphidium excavatum* in the outer areas to microfaunas dominated (i) by *Miliammina fusca* and *Trochamminita irregularis* in the very low salinity wetland and (ii) by *Paratrochammina guaratibaensis* and *Trochammina inflata*, associated with widespread agglutinated species of mangroves and salt marshes, at the transition to the dry fields. These trends are compatible with the salinity-exposure model proposed by Hayward *et al.* (1999) in New Zealand where *Trochammina inflata* is the most characteristic of aerial exposure and *Trochamminita irregularis* the most characteristic of very low salinity.

Under the same conditions of vertical elevation and salinity, the presence of mangrove trees and litter that protect the microfauna from the sun and wind, clearly influences the foraminiferal assemblage. At the degraded margin of a well developed mangrove the microfauna was dominated by *Haplophragmoides wilberti, Arenoparrella mexicana* and *Trochammina inflata*. At the same vertical elevation, the microfauna collected in a litter-rich sediment was dominated by *Ammoastuta salsa, Ammotium* spp. and *Miliammina fusca*.

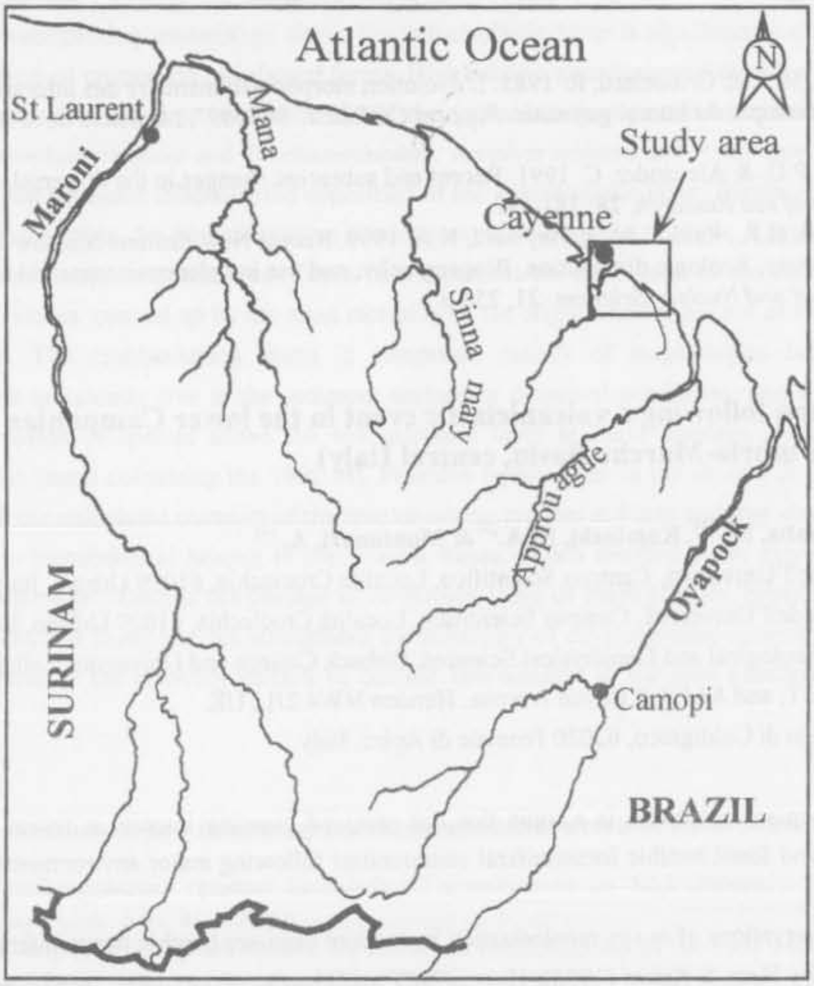

Fig. 1. Location map of the study area

Foraminiferal assemblages showed a strong seasonality. At the end of the dry season, all the samples, except at the transition with freshwater wetlands and dry fields, are dominated by *Ammonia tepida* and *Cribroelphidium excavatum*, with a high proportion of living specimens. At the end of the rainy season, living specimens of *Rectoelphidiella* cf. *aplata* were found in the mangrove swamps but all the other calcareous species had disapeared, except on the sea side open mud bank. In a young *Avicennia* forest, the microfauna was dominated by *Ammoastuta salsa* associated with *Ammotium dilatatus, Miliammina fusca, Rectoelphidiella* cf. *aplata, Ammotium salsum,* and a few *Arenoparrella mexicana*. In an older *Avicennia-Rhizophora* mangrove forest, some hundred meters farther from the sea most of the species that were dominant in the young forest were also present, but the composition of the assemblages was somewhat different with a lower percentage of *Ammoastuta salsa, Miliammina fusca* and *Ammotium salsum*, and a higher percentage of *Arenoparrella mexicana*. Moreover, *Haplophragmoides wilberti, Paratrochammina guaratibaensis* and *Trochammina inflata*, all absent in the young forest, were well represented in the older forest. In the oldest *Avicennia* mangrove at the transition to the freshwater wetlands, where the salinity of the water is 0 during the rainy season, the assemblage collected at the end of the rainy season had a high density (1200 individuals in 50 cm^3 of sediment). It was strongly dominated by *Miliammina fusca* and *Trochamminita irregularis*, with a high percentage of living specimens.

At the end of the dry season, *Miliammina fusca* was still dominant, associated with *Chitinosaccus* cf. *guaratibaensis*, but *Trochamminita irregularis* was very rare.

The seasonal change in various mangrove environments, where calcareous species, dominant at the end of the dry season, almost disappear at the end of the rainy season, shows that the influence of low-Ca fresh water is predominant when compared with the presence of mangrove trees and litter accumulation.

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DWAF recolonisation following a volcaniclastic event in the lower Campanian of the Scaglia Rossa Formation (Umbria-Marche Basin, central Italy)

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Recolonisation of deep-sea substrates is a topic that has received growing interest in recent years with several studies on both modern and fossil benthic foraminiferal communities following major environmental disturbances (see Alve 1999 for a review).

However, the sole observations of *in situ* recolonisation by modern deep-sea benthic foraminifera in a vast disturbed habitat were carried out by Hess & Kuhnt (1996), Hess (1998), and Hess *et al.* (in press), who documented the initial stage of recolonisation on top of the tephra layer deposited in the South China Sea as a result of the 1991 eruption of Mount Pinatubo in the Philippines.

Similar processes of faunal decimation and recolonisation following tephra falls must undoubtedly be a common occurrence in the geological record, contributing to local differences in the patch structure and successional patterns observed in deep-sea benthic foraminifera. However, a major unknown question is whether or not this process leaves an observable fossil record, and if so what is the timescale of faunal recovery in the deep sea? In this study we address these questions by documenting the pattern of the recolonisation through a high resolution study of DWAF assemblages from below, within, and above a 15 cm-thick volcaniclastic layer in a deep sea sequence of the Scaglia Rossa Formation exposed in the Furlo Gorge (Umbria-Marche Apennines, Central Italy). The sudden deposition of a 15-cm thick (post-compaction thickness) volcaniclastic layer would have created a sudden disturbance of the sea floor ecosystem, including mass mortality of benthic organisms. This event, therefore, represents an interesting case for a high-resolution study of the pattern of recolonisation of the benthic community, which in this bathyal environment is normally characterised by a highly diversified assemblage of DWAF.

Significant differences in diversity, community structure, feeding and habitat preferences are observed among benthic foraminiferal assemblages below and above the volcaniclastic layer, which is barren of foraminifera. In particular, a peak in the proportion of endobenthic taxa is observed just above the volcaniclastic layer in the so-called "recolonisation interval".

Below the volcaniclastic layer, DWAF assemblages are diverse with 28 to 34 species, and only minor fluctuations in the relative abundance of taxonomic groups and faunal parameters are observed. Common taxa are *Paratrochamminoides* spp., *Trochamminoides dubius, Trochammina* spp., *Subreophax* spp., *Saccammina* spp. and tubular forms. The recolonising assemblage above the volcaniclastic layer is significantly different, showing reduced diversity and an increased proportion of infaunal forms. High relative abundances of *Reophax minutus, Pseudobolivina* cf. *munda*, are observed in the first centimeter above the volcaniclastic layer, in association with juvenile/dwarfed specimens of *Paratrochamminoides* and *Trochamminoides. Reophax minutus* and *P.* cf. *munda* probably represent the initial recolonisers that appeared following the deposition of the volcaniclastic layer. Between two and four centimetres above the volcaniclastic layer, the highest relative abundances of *Subreophax scalaris, S. splendidus, Hormosinella* cf. *distans,* and *Karrerulina* sp. are observed. These taxa represent the next stage in the recolonisation process, and although exploiting niches opened up by the mass mortality of the original fauna, are not as opportunistic as *R. minutus* and *P.* cf. *munda.* The recolonisation fauna is comprised mainly of mophologies belonging to the infaunal morphogroup, which apparently live at the sediment surface in disturbed conditions, and are dispersed by deep sea currents. The succession of species above the volcaniclastic layer at Furlo displays interesting similarities to the succession of species found colonising the 1991 Mt. Pinatubo tephra layer in the abyssal South China Sea. Profound differences between the calculated duration of the recolonisation process at Furlo and that observed in the South China Sea are attributed to biotubational mixing in the Scaglia Rossa, which resulted in an expanded record of the fossil "recolonisation assemblage". Despite the passage of 80 million years of Earth History, broad similarities at the generic level between modern and fossil analogs strengthens the reliability of environmental reconstructions based on DWAF and may serve to predict the recovery pattern of benthic foraminifera in the area affected by the Mount Pinatubo eruption.

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Behavior of *Bathysiphon* sp. under oxygenated and anoxic conditions (a laboratory study): implication for bioturbation phenomenon

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Laboratory experiments were investigated in order to understand the behavior of deep sea foraminifera under changing oxygen conditions. This ongoing work focuses on the agglutinating species *Bathysiphon* sp. which has a finely agglutinated test of white color because of probably calcareous grains.

Sediment from the Gulf of Biscay of Arcachon (France) was collected at 1000 m depth (Oxybent-10 cruise). Various parallel samples were transferred into aquaria for experimental studies under oxygenated, low oxygenated and anoxic conditions. At different times, aquaria were opened, pore water profiles of oxygen concentrations were immediately measured and subsequently the sediment was cut in 0.5 cm slices. *Bathysiphon* sp. from the fraction >125 μm were picked and placed on a thin sediment layer in order to observe their moving and to control its activities. The total number of living *Bathysiphon* sp. in various aquaria under oxygenated condition varied between 7 to 184 specimens/50cm^3 and between 17 to 124 specimens/50 cm^3 under low oxygenated condition. Under anoxic condition, the total number of living *Bathysiphon* sp. reach 68 specimens/50 cm^3. Specimens were observed living in all sediment depth (until the maximum depth of 4.2 cm). Some specimens were especially observed to calculated the average length of the test (n = 72 specimens) and the moving velocity. The average length is 2.4 cm (± 1.7 cm). The moving speed has been evaluated by measuring the burrow length within a thin sediment layer under oxygenated condition. The measurements were made roughly every hours and give a speed of 0.5 to 1 cm/hour. Specimens were also able to move for a rather long time over more than 50 cm within 3 days.

Because of their length and their high moving velocity, it seems that this species, who is able to live under anoxic conditions, plays an important role on the bioturbation in the sediment and on the reoxygenation of the sediment column.

The report of their provincialism is greatly exaggerated

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The distribution pattern of Uppermost Cretaceous through Paleogene Deep Water Agglutinated Foraminifera demonstrates their ability to rapidly spread through the world oceans and continental margin basins. Shallow marine barriers are readily crossed or circumvented. Endemism is remarkably limited, and where deemed operative may often reflect observer bias and/or phenotypic plasticity rather than Mayerian-type evolution in isolated populations.

Observers bias, which in this case means efforts in sampling and taxonomy, explains why we observed the largest number of Paleogene taxa in the Carpathians, North Sea, offshore Shetlands, offshore Norway and in Trinidad. Most of the thirty+ areas studied probably would yield similar number of taxa, given enough time and samples. Another bias, the stratigraphic one, which is a function of taxa having a stratigraphic range limited to parts of the interval studied, also must be taken into account. Curiously, remarkably few taxa are limited to specific regions, like *Ammoanita ingerlisae* and *Ammomarginulina auberta* in the North Atlantic, and *Conotrochammina voeringensis, Karreriella seiglei* and *Annectina biedae* in the Norwegian - and North Seas. In this respect the poverty of cyclamminid taxa in the Carpathians, and in abyssal DSDP and ODP Sites also is worth noting. The latter seem to thrive best in sedimentary wedges along continental margins like Labrador, northern Grand Banks, MacKenzie Delta-Beaufort Sea, North Sea and offshore Norway. Finally, it should be noted that taxa like *Psamminopelta gradsteini* and *Duquepsammina cubensis* are limited to mid-Cenozoic abyssal strata.

Although the stratigraphic range of individual taxa of deep water agglutinated benthic foraminifera may be relatively long when compared to that of planktonic foraminifera, the fact that we deal with a large number of stratigraphically rather closely staggered taxa, enhances stratigraphic resolution. Also, planktonics may be sparse or absent from sample intervals rich in agglutinated assemblages, the result of syn-, and post-sedimentary carbonate dissolution, which prevents their use. A relatively lower degree of specialisation of agglutinated benthic foraminifera compared to planktonic taxa, leading to more environmental tolerance in a paleoceanographic sense, and longer term stability of deep benthic environments over pelagic ones, maybe two reasons for such differences in species longevity.

As with organic-walled dinoflagellates, where stratigraphic ranges of many taxa also are relatively long, the local ranges of agglutinated benthic taxa in individual basins often are shorter than the known total stratigraphic ranges, taking into account the 'global' record. The latter ranges are more useful for a study of evolution than for regional stratigraphic analysis, although it must be reckoned with that a majority of taxa probably branched into new taxa long before becoming extinct. Hence, both local and total stratigraphic ranges must be explored in conjunction if we want to study interregional correlations. Our knowledge of the evolutionary connections of taxa and their geographic dispersal routes is still in its infancy.

One of the key questions, related to the phylogeny of individual taxa, is the rate and extent of evolutionary turnover, particularly temporal increases in rates of extinction and rate of appearance of new taxa. Although beyond the scope of this study, it may be provisionally stated that Albian - Turonian, early to middle Campanian, late Paleocene to early Eocene, and mid Miocene are periods when relatively larger number of deep water agglutinated taxa evolved. Disappearances, although locally dramatic when basins shallowed or became anoxic, in an evolutionary sense probably were more gradual. From an exploration micropaleontology average disappearance levels of taxa are practical tools that can be readily calculated with the Ranking and Scaling (RASC) program.

Miocene deep water Agglutinated foraminifera from the Gulf of Mexico

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Two exploration wells from the Gulf of Mexico have been studied in order to record the foraminiferal assemblages present in the Miocene. One well; Amoco LA V.K. 915, yielded a diverse assemblage of agglutinated and calcareous benthic foraminifera (2940m of ditch cutting recovery). The response of the agglutinated foraminifera assemblages to environmental parameters provides useful information on the palaeoenvironment and palaeobathymetry. The agglutinated assemblages are dominated by species of *Haplophragmoides, Cribrostomoides, Cyclammina, Trochammina,* and *Textularia*. The abundance of alveolar foraminifera suggests that the bottom water was oxygen deficient, indicating a habitat within the oxygen minimum zone, between 500 and 1000m depth. The presence of sand rich horizons within the sequence indicates proximity to a switching fan or channel system, with the foraminifera rich horizons occurring within the over-bank fines. The good preservation and high abundance of the agglutinated foraminifera may enable us to clarify some of the phylogenetic relationships between the alveolar foraminifera present. The development of alveolar structures in several evolutionary distant lineages indicates a convergent evolutionary response to environmental conditions. The evolution of the foraminifera can be tied into the stratigraphic framework using information provided from industrial well log. The images of the agglutinated foraminiferal assemblages will be presented on the poster to illustrate the relationships observed.

Cyst forming foraminifera – the origin of agglutinated foraminifera?

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Composition and test structure are important taxonomic characteristics of foraminifera to classify naked, agglutinated and calcareous foraminifera. Since the early Cambrian we observe a fantastic evolution in almost all groups of these unicellular protozoan leading to extremely complex structures. Long-time observations of living benthic foraminifera were performed in our laboratory cultures to observe their behavior and life style. A common features within all groups is the formation of sedimentary envelops (cysts). Various species of benthic foraminifera show the ability to build cysts by collecting sediment from the surrounding environment. Particles are fixed together by an auto-produced organic material enveloping the whole test. In addition, some species even surround their rhizopodial strands more than 100 μm in length. The foraminifer used to stay within a cyst for hours up to weeks, leave then the cysts and some starts building immediately a new cysts or stay free. We observed this in from both, deep-sea and shallow water benthic foraminifera. The role of these cysts is not really clear. Various activities can be observed while the foraminifer stays in the cyst: Feeding, resting, chamber formation, reproduction. These general observations may be used to speculate whether this features leads us back to the Precambrian, close to the origin of agglutinating foraminifera. Despite the fact that foraminifera appear first in the early Cambrian, the precursors might have developed a kind of test by enveloping the cytoplasm to be protected against any attack from outside. From these observations we suggest that the formation of cysts is a very basic character of foraminifera. It may be the origin of the development of agglutinated species which occur first, that anchor this ability and evolved until the formation of a constant solid test of collected sediment particles, tightened by secreted cement and organic material.

Silurian and Devonian Foraminifera from the Barrandian area (Czech Republic)

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First systematic study of Silurian and Devonian foraminifers of the Barrandian area included the analysis of 387 samples from 14 Silurian and 24 Devonian sections including stratotypes and auxiliary stratotypes of stages: Požáry Quarry, Klonk section, Budňany rock section, Homolka Hill at Velká Chuchle, Prastav Quarry. Foraminifers were studied from acid-insoluble residua. Foraminifers were found in 200 samples (51.7 %), and were abundant in 72 samples (18.6 %).

Eighty-one morphotypes of agglutinated foraminifers from families Psammosphaeridae, Hemisphaeramminidae, Saccamminidae, Hippocrepinidae, Ammodiscidae and Lituolidae and 6 morphotypes of calcareous foraminifers were distinguished.

In the Silurian sediments, foraminifers are rare and concentrate to thin horizons only in the sections. Foraminifers are the most abundant in the Ludfordian. In the Devonian sediments, foraminifers are common to abundant (with the exception of reefal limestones and the youngest Kačák and Roblín Mbs.).

Stratigraphical ranges of the Barrandian Silurian and Devonian foraminifers were summarized with the following species being of biostratigraphical value: (i) *Amphitremoida* and *Thurammina tubulata* occur only in the Ludlow; (ii) *Tolypammina tortuosa* appeared in the Lochkovian and can be a good marker of the Lochkovian–Zlichovian interval; (iii) *Thurammina quadritubulata*, *Th.* sp. 1, *Th.* sp. 2, *Hyperammina gracilenta* and *H. rockfordensis* (these FADs may serve good biostratigraphical markers because *H. rockfordensis* is a common species in different facies), *Ammobaculithes* sp. and small-sized *Ammodiscus* sp. first appeared in Pragian; (iv) the Dalejan assemblages can be characterized by the common occurrence of *Ammodiscus* ex gr. *incertus*. FADs of *Ammodiscus* ex gr. *incertus*, *Ammobaculithes* cf. *leptos*, *A. minutus*, *Tolypammina bulbosa*, *Thurammina sphaerica* were described in the Dalejan. As the distribution of foraminifers was influenced by paleoecological conditions, the stratigraphical ranges represent only ecostratigraphical data for the Barrandian area.

High abundance and diversity of foraminifers in the nodular Třebotov and Dvorce-Prokop limestones reflect fact that nodular limestones were deposited under optimum environmental conditions for foraminifers: low-energy, deeper water environment (below the wave base) with clastic components necessary for building agglutinated tests. Low abundances of foraminiferal tests characterize biomicritic to biodetrital limestones deposited in shallow-water, high- or medium-energy conditions. No foraminifers are present in reefal limestones. During the sedimentation of the youngest Barrandian Kačák and Roblín Mbs., unfavourable living conditions (?lowering of O_2-content, salinity) did not enable survival of foraminifers.

Foraminifers may pose a good paleogeographical indicator. The occurrence of identical foraminiferal species (well-determinable, non-cosmopolitan) in different areas indicates the existence of the following migration pathways: (i)between Siberia and the Barrandian area in the Ludlow; (ii) between the Barrandian area and E Victoria (Australia) in a certain time level from the Ludfordian to Lochkovian; (iii) some of the North American Silurian foraminifers successively penetrated to the Barrandian area from the Ludfordian to the Dalejan. Their migration pathways are unclear; (iv) the broad migration of foraminiferal fauna between the Dalejan of the Barrandian area and Upper Devonian of the Saxothuringicum; (v) close affinities of foraminiferal assemblages between the Dalejan of the Barrandian area, Upper Devonian of the Saxothuringicum and Rhenohercynicum confirm the hypothesis on the closure of the Rheic Ocean in the Late Devonian. Foraminifers migrated to the Rhenohercynicum (and also to Holy Cross Mts. where similar assemblages also appeared in the Late Devonian) probably from the Saxothuringicum in the Late Devonian. In the period of the Upper Devonian to the Lower Mississippian, the assemblages penetrated to the North American basins through an unknown pathway.

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Thecamoebians from the Šumava Mts (Czech Republic)

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The Šumava Mts. (with its foothills) represent a region very suitable for systematic analysis of variability of thecamoebian assemblages in many types of freshwater bodies in one area. All types of environments permitting fossilization of thecamoebians are present here: lakes, creeks and rivers, peat-bogs, ponds and the large Lipno Resorvoir. The Šumava Mts. were intensively hydrologically studied in the last years, and many hydrological, limnological, hydrobiological data as well as data about water chemistry and physical parameters of water were published.

All types of freshwater bodies were sampled and the following characteristics of the environment were recorded: type and size of freshwater body, pH, temperature, depth, character of bottom. Species composition of assemblages, dominant morphotypes of thecamoebians, size and shape variability of species, chemical composition of tests were determined in 62 samples analysed within the first phase of the study.

Only thecamoebians with agglutinated tests were recorded in the studied material. Shell compositions were analysed using the EDA. Spherical morphotypes are composed mainly of quartz grains (usually 70 % or more). Composition of grains of sack-type tests are more diversified. Feldspar and mica grains were observed. Diversified grains occur especially around the aperture. Both spherical and sack-type tests are composed of coarse grains. Beret-type tests are finely agglutinated. They are also composed mainly of quartz grains. Ochre to brown specimens have higher content of Fe.

The following morphotypes were distinguished:

(i) Sack-type, ovoid – analysis of width/lenght ratio enables to distinguish two morphotypes – (1) *Difflugia globulosa* DUJARDIN is common, represented by thick tests (w/l ratio varies between 0.74 and 0.86) of a wide range of test size (171-281 μm); (2) *Difflugia viscidula* PENARD is slender (w/l ratio of 0.54-0.73), with large tests (245-290 μm). This species is rare. Both species were recorded always together in one sample.

(ii) Sack-type, with a neck (*Difflugia* ex gr. *oblonga* EHRENBERG) – rare, morphometric variability cannot be studied.

(iii) Sack-type, flattened (*Nebela*) – w/l ratio is almost invariable for all analysed specimens (corr. coeficient of test width and lenght = 0.96).

(iv) Beret-type – plano-convex tests are small-sized, radially symmetrical with a circular aperture (*Centropyxis discoides* PENARD) and a triangular aperture (*Trigonopyxis*). Beret-type tests are rare at most of the localities, which precludes a detailed study of morphometric variability.

(v) Spherical – spheres without apertures, probable cysts. Organic cover of circular aperture with a small collar was observed in one specimen. Size distribution varies between 69 μm and 201 μm. The width/length ratio ranges between 0.79 and 0.99. Two samples from different sites of the same lake (Čertovo jezero Lake) show no statistically significant variation while the third sample from another lake (Plešné jezero Lake) shows statistically significant divergence in comparison with the others (tested by T-test).

Small-sized as well as large-sized species occur at all localities with diversified assemblages (i.e., localities with small-sized tests or large-sized tests of all species were not encountered).

Based on species composition of the assemblages as well as abundances of thecamoebians, seven types of assemblages were distinguished. One assemblage (1) characterizes larger lakes, other assemblages (2-6) were recorded in other freshwater bodies (creeks, small rivers, peat-bogs and peat-bog lakes, small lakes to 10 m in diameter and springs).

(1) Assemblages dominated by spheras were observed in large lakes.

(2) Assemblages dominated by sack-type, ovoid tests, thecamoebians are rare; they were found in different environments with the exception of large lakes. Common occurrences of sack-type ovoid tests were recorded in creeks; their substrate and pH may vary.

(3) Assemblages dominated by sack-type flattened tests; this type of assemblages was recorded in backwater parts of creeks with muddy layers.

(4) Assemblages dominated by beret-type of tests. This type of assemblages can tolerate all types of studied environments with the exception of large lakes. Common occurrences of beret-type tests were observed in peat-bog lakes.

(5) Diversified sack-types tests (ovoid, flattened, with necks) occur mainly in the layer of organic detritus in creeks and rarely in small lakes with muddy substrate.

(6) Diversified assemblages occur in springs and creeks with organic detritus and pH above 5.

Palaeoenvironmental and sequence stratigraphic implications of *Pseudocyclammina lituus* events in the Upper Jurassic (Oxfordian), Hanifa Formation of Saudi Arabia

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The Hanifa Formation of Saudi Arabia consists of carbonates of Upper Jurassic (Oxfordian) age (Enay et al. 1987; Manivit 1987). They are well exposed along the Tuwaiq Mountain escarpment, and form anticlinal oil-bearing reservoirs in the Khurais and Ghawar Fields, approximately 200km and 300km respectively, east of the outcrop belt. Semi-quantitative micropalaeontological analysis of samples from Hanifa exposures and cores from four wells has revealed the presence of *Pseudocyclammina lituus,* in addition to rare benthonic foraminifera, calcareous algae, sponge spicules and various other microfossils and macrofossils.

The localized concentrations of *Pseudocyclammina lituus* are found typically within a biocomponent-depleted zone, although there is some overlap with *Kurnubia palastiniensis, Nautiloculina oolithica* and various undifferentiated miliolids. The coincidence of *P. lituus* with elevated gamma log values have been used to interpret episodes of regional marine transgressions. If the increased water depth favoured an adaptive response by the alveolar-walled *Pseudocyclammina lituus*, then the benefit of alveoli must be considered. The predominance of agglutinated

foraminifera at these events suggests adverse bottom conditions related to either water chemistry or nutrient supply. The presence of alveoli may have enabled the organism to construct a test of the required size in a muddy environment in which the normally available grains for test construction were rare. Another possibility is that the alveoli gave the organism greater protection from the possibly anoxic, or otherwise hostile, hydrogen sulphide-enriched bottom waters during the low circulation associated with the deeper water episode. The presence of symbiotic algae must also be considered, and it is possible that although the water depth remained within the photic zone, the symbiotic algae were sheltered within the alveoli from the abnormal water chemistry. The increased internal surface area provided by the undulatory alveoli may have increased the efficiency of the symbiotic algae, and thereby favourably contributed to the foraminiferal respiration.

In the Khurais Field, correlation of the *Pseudocyclammina lituus* cycles has been used to assist in correlating depositional layers in the subsurface, where correlation of gamma logs alone would be difficult. These events may possibly be associated with transgressive systems tracks of high frequency depositional cycles. The depositional layers indicate a basin topography that gradually deepened towards the south, and provide potential reservoir layers separated by the slightly denser, *Pseudocyclammina lituus* rich muds that may be responsible for unexpected intra-reservoir communication during future production. Regional correlation using the Pseudocyclammina event as an isochronous datum reveal a progressively basinward facies trend that passes laterally from a *Kurnubia palastiniensis* – dominated biofacies of lagoon affinity, a stromatoporoid bank biofacies, a mixed stromatoporoid – *Pseudocyclammina* biofacies of the fore-bank regime and the *Pseudocyclammina lituus* biofacies that is considered to represent the relatively deepest shelf palaeoenvironment. The stromatoporoid bank biofacies is seen to migrate southwards into the basin, and this trend is attributed to progradation of the biofacies during successive depositional sequences.

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Palaeoenvironments of Lower Aptian agglutinated foraminifera of Saudi Arabia

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Agglutinated foraminifera are common in the carbonates of the Shu'aiba Formation of Saudi Arabia, although they typically display low diversity (Hughes 2000). Semi-quantitative macropalaeontological and micropalaeontological analysis has revealed significant lateral and vertical bio-assemblage variations in the agglutinated foraminifera that developed in response to palaeoenvironmental variations. These have a potentially valuable contribution to understanding the distribution of hydrocarbon reservoir facies and subsequent reservoir architecture (Aktas et al. 1999) A Lower Aptian age is concluded for the Shu'aiba Formation that forms the major Shaybah Field, although a wedge of onlapping Upper Aptian carbonates is confirmed along the east flank (Hughes et al. 1999).

Palorbitolina lenticularis, Debarina hahounerensis, Vercorsella arenata, Praechrysalidina infracretacea and various biserial forms characterize the agglutinated foraminifera of the lower part of the formation. This deposited in an extensive, moderately deep platform environment in which open marine influence is indicated by the presence of planktonic foraminifera (Banner & Simmons 1994).

The development and expansion of a rudist shoal complex caused differentiation of the platform into lagoon and open marine provinces separated by the rudist shoals. *Palorbitolina lenticularis* dominate both the lagoonal and open marine flanks of the shoals, but there is a tendency for high trochoid forms to characterize the former, while the lower profile forms characterise the deeper, fore-shoal areas, such as described by Vilas et al.(1995).

The upper part of the Shu'aiba formation was deposited in response to a flooding of the area, and a return to extensive platform conditions with occasional open marine influence. The agglutinated assemblage displays a return to that found in the lower part of the formation, and includes *Debarina hahounerensis, Vercorsella arenata, Praechrysalidina infracretacea,* but *Palorbitolina lenticularis* is poorly represented.

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The palaeoenvironmental significance of agglutinated foraminifera of the Upper Jurassic Jubaila and Arab-D Formations of Saudi Arabia

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The Arab-D Formation is of Late Jurassic, Kimmeridgian-Tithonian age and consists entirely of carbonates. These carbonates were deposited with an extensive shallow marine platform; in which localized intra-shelf basins were present. In addition to foraminifera, the biocomponents include calcareous algae, massive and branched stromatoporoids, ostracods, brachiopods, gastropods and sponge spicules. Their distribution has been studied in cored exploration wells in the Ghawar and Khurais oilfields of eastern Saudi Arabia.

Agglutinated foraminifera are responsible for more than 70% of the total foraminiferal assemblage in the Formation. They display a consistent vertical order of appearance within the Jubaila and Arab Formations across the study area, and this consistency is considered as a response to regionally effective palaeoenvironmental variations through the time of deposition of both formations (Hughes 1996; 2000).

Kurnubia palastiniensis and the miliolids *Nautiloculina oolithica* are common throughout the succession, and they are considered to be tolerant of a wide variety of depositional environments, providing that salinity levels did not become elevated.

In the lowermost part of the studied section, the predominantly muddy succession contains the consistent presence of *Kurnubia palastiniensis,* with rare *Everticyclammina* spp., and *Alveosepta jacardi / powersi* and a variety of biserial agglutinated forms resembling *Textularia.* The presence of the calcareous foraminifera *Lenticulina* spp., undifferentiated polymorphinids, *Nodosaria* spp., together with sponge spicules suggests a moderately deep, normal salinity palaeoenvironment.

This assemblage is overlain by one containing massive and branched stromatoporoids, such as *Cladocoropsis mirabilis*. Foraminifera are sparse within this succession, except for the ubiquitous *Kurnubia palastiniensis* and *Nautiloculina oolithica*. A shallower depositional environment is concluded for this zone, in which a stromatoporid bank is considered to have established.

Mangashtia viennoti is typically found, together with the dasyclad alga *Clypeina jurassica*, above the stromatoporoid biozones, and is overlain by assemblages containing *Pfenderina salernitana*. These assemblages represent deposition within an extensive, gradually shallowing shallow marine platform, possibly incompletely rimmed by a stromatoporoid belt.

Towards the top of the Arab-D, the agglutinated species *Trocholina alpina* appears, often to the exclusion of the other species mentioned above. Very shallow hypersaline conditions are concluded for this bioassemblage.

The stratigraphically highest assemblage, prior to the anhydrite beds, display a very poor foraminiferal fauna, and mostly consist of cerithid gastropods within algal mats. This assemblage is considered to represent intertidal, hypersaline conditions.

As the levels of appearance and disappearance of these forms vary from well to well, their lateral and vertical distribution should provide important clues to regional palaeobathymetric variations and thereby assist sedimentary sequence determination and reservoir layering.

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Agglutinated foraminifera at the Lower/Upper Cretaceous boundary of Southern Croatia

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Approximately 440 m thick succession of the Upper Albian – Upper Cenomanian shallow-water carbonate strata outcrops near Sobra on the island of Mljet in the Southern Croatia (Fig. 1.). These deposits of the Adriatic carbonate platform, comprising the Lower/Upper Cretaceous transition, are represented by predominantly limestones and late-diagenetic dolomites, and contain some important agglutinated foraminifera. The underlying strata are represented by mostly micritic limestones without index fossils, while overlying strata are unknown due to the dipping of the Upper Cretaceous beds into the sea.

The initial 210 m of the succession is characterized by mudstones and fenestral mudstones irregularly alternating with peloid wackestone-packstones and peloid-intraclastic-skeletal packstone-grainstones with bivalves (*Chama* sp.), benthic foraminifera, gastropods and sporadically hydrozoans. Mudstones and peloid wackestone-packstones were formed in the low-energy subtidal environment, while peloid-intraclastic-skeletal packstone-grainstones deposited during periodical storms. Rather rare stromatolites are of peritidal origin. The emersion breccia horizons, indicating periodical sediment exposures to subaerial weathering, are very variable considering their thickness and lateral continuity. In order of their appearance up-section, the strata contain the following agglutinated foraminifera: "*Valdanchella dercourti*", *Neoiraqia insolita*, *Paracoskinolina fleuryi*, *Cuneolina pavonia*, *Vercorsella* sp., *V. scarselai*,

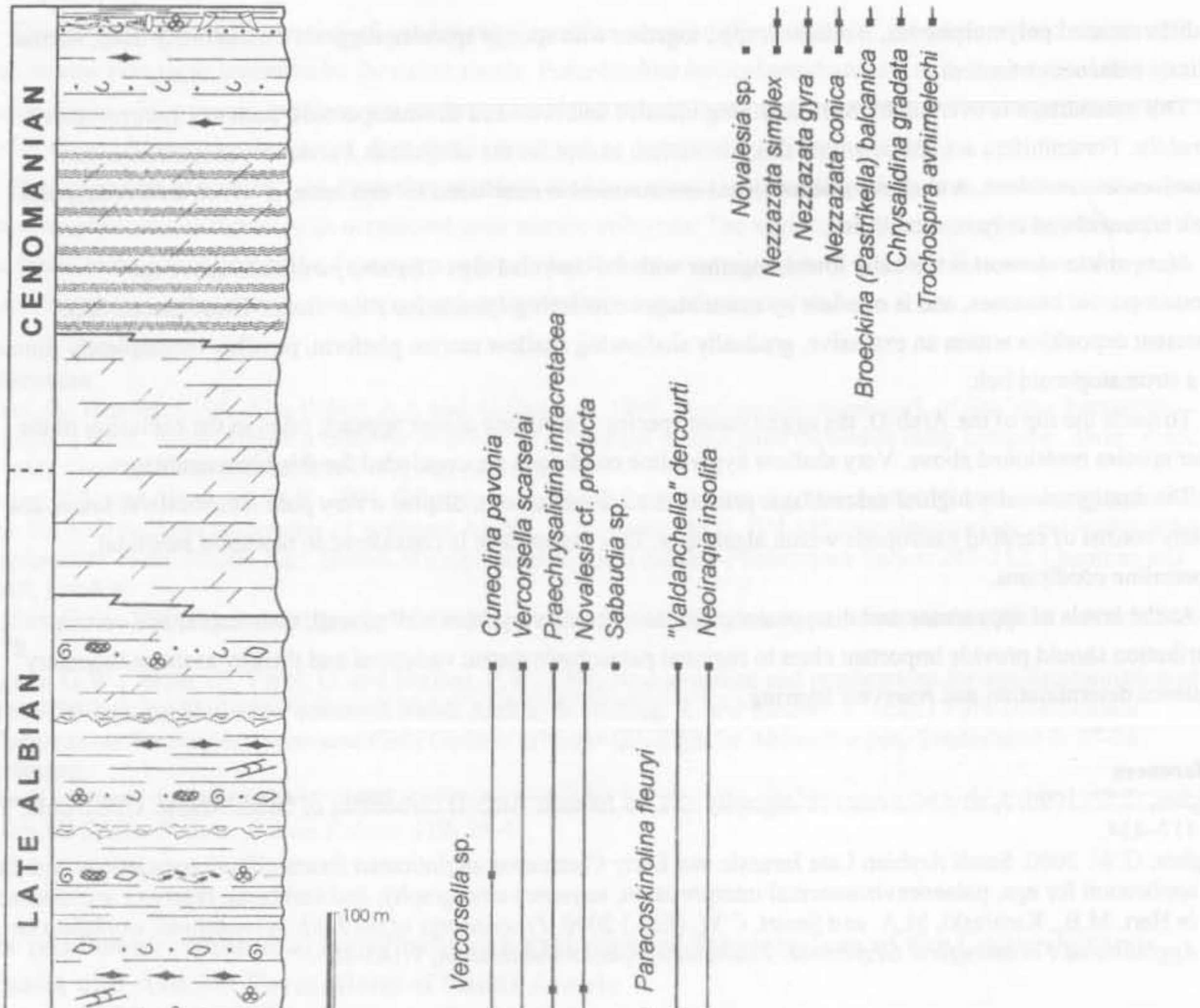

Fig. 1. Schematic geological column of the Late Albian-Cenomanian deposits near Sobra (Island of Mljet, Southern Croatia) with stratigraphic distribution ot the agglutinated foraminifera.

Praechrysalidina infracretacea, Novalesia cf. *producta* and *Sabaudia* sp. In addition to the agglutinated foraminifera, the strata include *Pseudonummoloculina heimi, ?Nubecularia* sp., *Spiroloculina* sp., *Scandonea* sp., as well as calcareous algae *Salpingoporella turgida, Cylindroporella* sp. and *Salpingoporella* sp. The most prominent taxa in terms of stratigraphy are "primitive" orbitolinids "*V.*" *dercourti, N. insolita* and *P. fleuryi*. These agglutinated foraminifera are very frequent in deposits of earliest late Albian age in the Karst Dinarides (e.g., Velic & Sokac 1979, 1983; Velic *et al.* 1979, 1989; Velic 1988; Husinec *et al.* 2000).

The Early to Late Cretaceous transition is characterized by approximately 100 m thick sequence of well-bedded to massive late-diagenetic dolomites, sporadically containing relics of micritic limestones that are devoid of fossils. Consequently, dolomites can be dated only on the basis of superpositional relations as latest Albian-early-mid Cenomanian. Similar is the case throughout the Karst Dinarides where these lithofacies is encountered very frequently and in great quantities at the Lower/Upper Cretaceous boundary (Velic *et al.* 1979).

Overlying dolomites is more than 125 m thick sequence of Cenomanian deposits. Its lower part lacks the index taxa and is marked by an irregular, peritidal alternation of early-diagenetic dolomitized limestones (predominantly stromatolites, sporadically laminated alternation of pelmicrite and fenestral micrite) and non-laminated micritic limestones, and an irregular alternation of mudstones, fenestral mudstones and peloid-skeletal packstone-grainstones. Agglutinated foraminifera are represented by *Nezzazata* simplex, *N.gyra, N. conica, Novalesia* sp. and small ataxophragmiids, while the remaining association includes *Pseudonummoloculina heimi, ?Salpingoporella* sp. and small miliolids. The upper part of the Cenomanian succession is characterized by the rhythmic alternation of rudistid floatstone-rudstones with pachydont bivalves, horizontally laminated mudstones, intraclastic-peloid wackestones and skeletal-peloid packstone-grainstones. The Middle and Late Cenomanian age is implied by findings of foraminifers *Broeckina (Pastrikella) balcanica* and *Chrysalidina gradata*, which occur for the first time in the terminal part of the succession. Besides the species mentioned above, the agglutinated foraminifera are represented by *Trochospira avnimelechi*, as well as by taxa already present in the older strata. The following microfossils have also been determined: *Pseudonummoloculina heimi, Spiroloculina* sp., *?Nubecularia* sp., *Peneroplis* cf. *turonicus*, *?Salpingoporella* sp. and *Aeolisaccus* sp.

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Agglutinated foraminifers in the framework of the Southwestern Bulgarian palaeoenvironmental evolution during the Upper Jurassic – Lower Cretaceous

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The recent stratigraphic theory is a synthesis of local, regional and global stratigraphic successions, biozonations based on many fossil groups in the framework of the palaeoenvironmental evolution.

The Jurassic system is well presented in the South- and Northwest Bulgaria. The Upper Jurassic - Lowermost Cretaceous sediments were deposited in a bathymetrically differentiated basin, associated with the gradual emergence of the southern landmass and the formation of the Central Moesian Basin. The West and East Moesian platforms are developed on both sides of the Central Moesian Basin. The proposed study deals with the carbonate buildups of the Late Jurassic - Early Cretaceous Western Moesian Carbonate Platform (Patrulius et al. 1976, fig. 4). The main part of this carbonate platform is situated in Yugoslavia and Romania. Only three small tongues of it reach into South- and Northwest Bulgaria (Lefeld et al. 1986). The sections under study are located in the southwestern prolongation of the Western Moesian Carbonate Platform and belong to the outcrops in the Dragoman positive block (Sapunov et al. 1985). The main part of this platform is represented by the limestones of the Slivnitsa Formation, introduced and designated as "Slivnitsa Limestone" (Zlatarski 1885) and later on it was classified as "formation (Nikolov & Sapunov 1970). The Slivnitsa Formation is built up by thick-bedded to massive light gray to whitish organogenic and less common micritic limestones containing a large number of benthic foraminifers and massive alga, colonial corals, rudists, brachiopods, crinoids, gastropods and other benthic forms.

The paper presents the biostratigraphic data on the foraminiferal occurrence in the Slivnitsa Formation. There have been sampled and studied two sections situated west and southwest of Sofia. These are the sections at Berende Izvor (Kalotina) – with 480,00 m thick succession and Velinovo – with 381 m thick succession. The Slivnitsa Formation is underlain by the Polaten Formation and cover by the Salash Formation in the Berende Izvor (Kalotina) section and by Upper Cretaceous (Senonian) sediments in the Velinovo section (Fig. 1).

The taxonomic identification of the microfossils and the analysis of the benthic foraminifers within the Middle Callovian – Valanginian interval is a result of the investigation of more than 140 thin sections. As a result the percentage interrelation between agglutinated and nonagglutinated foraminiferal genera in the Slivnitsa Formation have been calculated. This proportion is 53:47%. The higher abundance of the agglutinated foraminifers is connected with the shallow marine (shallower subtidal) environment. It is worth to note that the number of the foraminifers in the carbonate successions from the restricted platform (lagoon) is appreciable more than in the sediments from winnowed platform. In the shallower subtidal environment predominante the representatives of the following agglutinated genera: *Ammobaculites, Labyrinthina, Mesoendothyra, Everticyclammina, Pseudocyclammina, Pseudolituonella, Nautiloculina, Charentia, Verneuilinoides, Kurnubia, Valdanchella, Dobrogelina, Pfenderina, Valvulina* et al.

The studied carbonate successions were mainly generated in a shallow marine environment. According to Flügel (1982) this environment can be divided into a deeper and a shallower subtidal (Fig. 1). The peloidal limestones (packstones) from the lowermost parts of the Slivnitsa Formation were formed in a deeper subtidal. In these limestones a pelleting of the micrite matrix is observed. An open platform facies zone is detached. The shallower subtidal is presented by a winnowed platform and a restricted platform (lagoon) facies zone (Fig. 1). The winnowed platform consists chiefly of bioclastic limestones (packstones to grainstones). In these limestones the bioclasts considerably vary in sizes. Very interesting are lagoonal limestones (algal mudstones, wackestones and packstones). They were formed in a very shallow environment. These limestones are mainly composed of algal mats. In algal mudstones are established fenestrae filled with sparry calcite. In the Berende Izvor cross section the algal wackestones contain oncoids whereas the algal packstones from the Velinovo cross section are abundant in oncoids and gastropods.

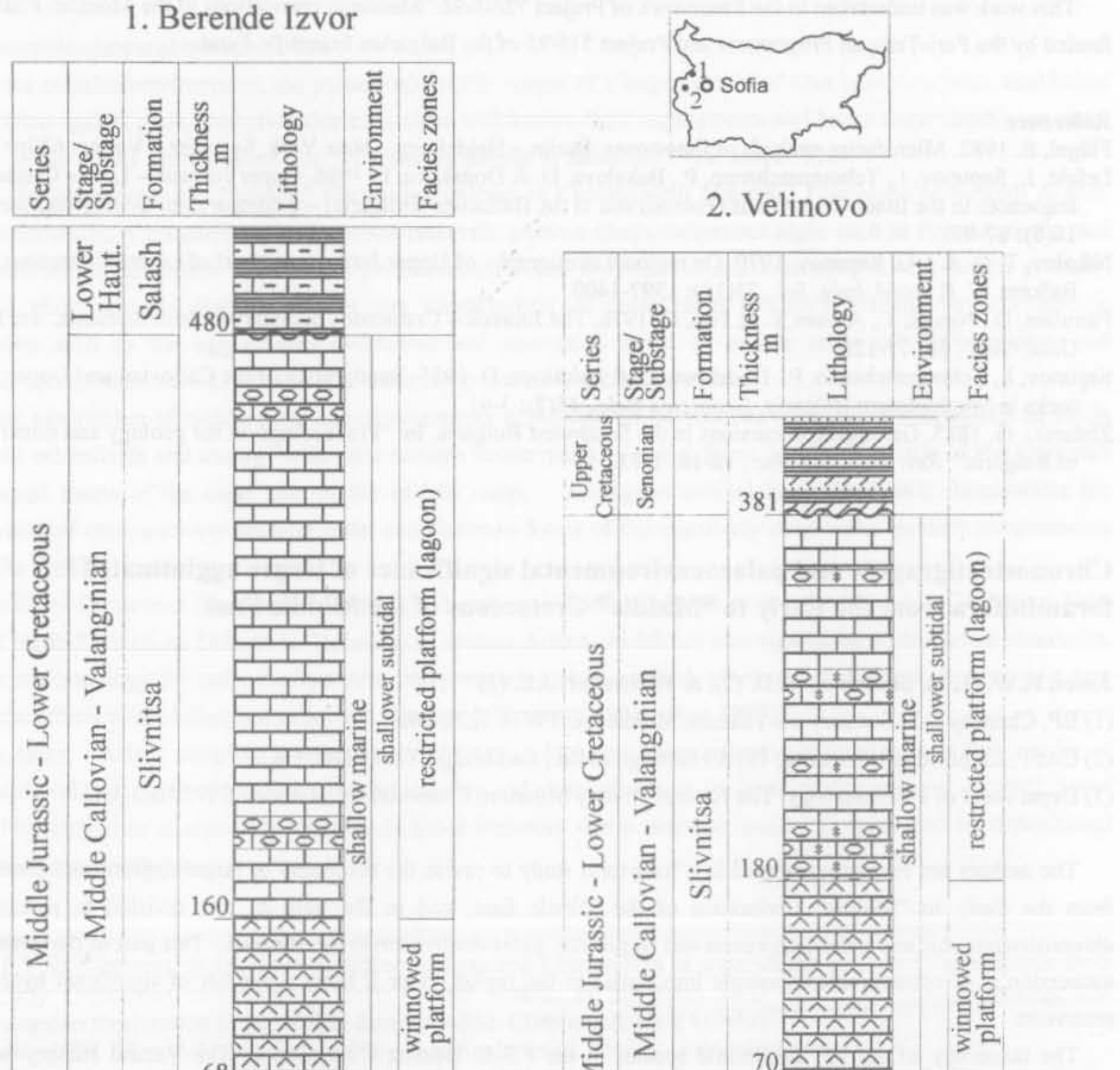

Fig. 1. Location of the studied sections and its typical lithological and environmental characterization. 1,2. Polaten Formation: 1. sandy crinoidal limestones (packstones); 2. oncoidal limestones (packstones); 3-7. Slivnitsa Formation: 3. peloidal limestones (packstones); 4. bioclastic limestones (packstones to grainstones); 5. algal limestones (packstones) with oncoids and gastropods; 6. algal limestones (wackestones) with oncoids; 7. algal limestones (mudstones); 8. Salash Formation – alternation of micritic limestones, clayey limestones and marls; 9. K_2 – sandstones, aleurolites and marls

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Chronostratigraphic and palaeoenvironmental significance of larger agglutinated foraminifera from the Early to "Middle" Cretaceous of the Middle East

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The authors are currently engaged in a long-term study to revise the taxonomy of larger agglutinated foraminifera from the Early to "Middle" Cretaceous of the Middle East, and in the light of this revision to reassess their chronostratigraphic and palaeoenvironmental (especially palaeobathymetric) significance. This part of the stratigraphic succession is of considerable economic importance in the region, since it hosts a number of significant hydrocarbon reservoirs.

The taxonomy of the key orbitolinid species in the F.R.S. Henson Collection in The Natural History Museum, London has already been revised in a publication in the proceedings of the last International Workshop on Agglutinated Foraminifera (Simmons *et al.* 2000).

This presentation provides an update on progress on chronostratigraphic and palaeoenvironmental applicability in the light of the founding taxonomic work, together with case histories of actual applications in western and eastern Arabia.

Chronostratigraphy

The chronostratigraphic ranges of a number of key species have now been established by means of comparison with illustrated age-controlled material from the Middle East and Mediterranean (see, for instance, Sharland *et al.* 2001 and additional references cited therein), supplemented by graphic correlation (unpublished BP (former AMOCO) studies; see also Simmons 1994).

Thus, for instance, *Orbitolina (Orbitolina) hensoni* is restricted to the latest Albian, *O. (O.) sefini* to the latest Albian to Early or early Middle Cenomanian, and *O. (O.) qatarica* to the Early-Middle Cenomanian. In turn, the Mauddud Formation of western Arabia (formerly colloquially known as the "*Orbitolina concava* limestone"), which contains *Orbitolina (Orbitolina) sefini* throughout, can now be confidently dated for the first time to the latest Albian to Early or early Middle Cenomanian. The upper part can be confirmed as Middle Cenomanian as it contains the porcelaneous-walled species *Ovalveolina ovum*, which ranges no older.

Palaeoenvironmental interpretation

In terms of palaeoenvironment, the palaeobathymetric ranges of a large number of taxa have now been established by calibration against photosynthetic calcareous algae with known light requirements and hence water depth – or, more correctly, water clarity - preferences (see, for instance, Banner & Simmons 1994; Jones 1996).

Thus, for instance, in the "Middle" Cretaceous (Albian to Cenomanian) Mauddud Formation of western Arabia, which, incidentally, is a significant hydrocarbon reservoir, photosynthetic calcareous algae such as *Permocalculus* and larger benthonic foraminifera such as the porcelaneous-walled *Ovalveolina* and associated forms, which probably harboured photosynthetic algal symbionts, are characteristic of inner ramp sub-environments, larger benthonic foraminifera such as the agglutinated *Orbitolina* and associated forms of middle ramp sub-environments, and planktonic foraminifera such as *Favusella* of outer ramp and basin sub-environments.

Further subdivision of middle ramp sub-environments is possible on the basis of observed morphological trends in the ancient orbitolinids and analogy with their modern counterparts. Conical forms are characteristic of the inner part and flattened forms of the outer part of the middle ramp. Analogous conical larger benthonic foraminifera are characteristic of comparatively shallow water and flattened forms of comparatively deep water modern environments (e.g., in the Gulf of Aqaba).

In the Early Cretaceous (Barremian to Aptian) Kharaib and Shuaiba Formations and the "Middle" Cretaceous Nahr Umr and Natih Formations (Albian to Turonian) of eastern Arabia, which are also significant hydrocarbon reservoirs, the same methodology for palaeobathymetric interpretation can be applied, albeit using different taxa to take into account the effects of evolution and extinction (Banner & Simmons 1994; Jones 1996).

In all cases, detailed sampling enables construction of a high-resolution palaeobathymetric curve that can be of considerable value in reservoir sequence characterisation and correlation (see, for instance, Simmons *et al.* 1992; Jones 1996). This technique is especially valuable in those instances where reservoir quality is controlled by depositional rather than diagenetic facies.

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The Phanerozoic Diversity of Agglutinated Foraminifera

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A Phanerozoic diversity curve for agglutinated foraminiferal genera was generated based on (updated) stratigraphic ranges reported by Loeblich and Tappan (1987). An Excel spreadsheet was constructed containing the following information:

- The 83 standard stages, using numerical dates from the timescale of Gradstein et al., (1995).
- The 746 genera of agglutinated foraminifera reported by Loeblich and Tappan (1987), including the 102 post-1986 genera included in the database "Agglut-2000" compiled by M.A. Kaminski.

Curves of total diversity, originations, extinctions, as well as diversity curves for individual superfamilies were plotted against the Gradstein et al. timescale.

The generic diversity curve of agglutinated foraminifera shows an increase through time with high origination rates in the Early Carboniferous, Early Triassic, and the Paleocene. These high origination rates often follow periods of extinction, indicating recovery phases. There are three distinct phases of diversity increase, the Cambrian Period, the Paleozoic Era, and the Mesozoic - Cenozoic Eras. Diversity gradually rises throughout the first era with a relatively stable phase through the Paleozoic. A rapid increase is then seen in the Mesozoic and Cenozoic to reach a peak in the mid Cretaceous. This rapid increase may be the result of the diversification of plankton as a result of the sea level rise and stratification of the water column and creation of a greater habitat availability.

Major extinctions occurred in the end Silurian, end Carboniferous, end Permian, throughout the mid and late Jurassic, in the mid Cretaceous and late Cretaceous; and in the late Eocene and end Miocene. Surprisingly, the end Miocene shows a major mass extincion with extinction of about 25% of the agglutinated genera.

Origination (diversification) is particularly rapid during the Silurian, the end Carboniferous, throughout the Jurassic and in the Mid Cretaceous. Nearly all of these increased periods of diversification correspond to long term sea level rises on sea level curves produced by Hallam (1992) and Haq et al. (1987). Only the Early Carboniferous and mid Miocene sea level rises do not correspond to an increase in agglutinated foraminiferal diversity.

Periodicity is clearly evident in the extinction metrics, and data plotted against the Gradstein et al. time scale gives a periodicity of about 28.5 m.y. The extinction metrics support Sepkoski's theory of periodicity illustrating the "big five" mass extinctions, as well as twenty smaller extinctions. Only two of the "big five" mass extinctions are evident in the diversity curve, however, they are illustrated by the extinction metrics. The two most prominent are the Permo/Triassic boundary and the Cretaceous/Tertiary boundary.

Environmental changes during the Upper Jurassic/Lower Cretaceous interval in the high latitudes (Off-Shore Norway)

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In recent years the understanding of Cretaceous palaeoclimates and palaeooceanography has changed quite substantially. Formerly warm equable conditions and sluggish ocean circulations have been argued for, while currently a much more varied view of the palaeoclimatic and oceanographic history of Cretaceous times is being held. Despite the fact that global palaeoenvironmental changes should be more clearly reflected in high latitudinal sites, the ongoing discussion very much concentrates on observations from the low latitudes, in particular from Tethyan sections. Information and data gathered so far from Cretaceous sediments of the Boreal Realm are mainly based on material from NW-Germany, the North Sea area and England. These areas do not reflect really high palaeolatitudes, and thus it seems justified to state that only few detailed data are available for high latitudes. In order to obtain a better picture of Cretaceous settings, data available from various low latitudinal ODP sites, France, Italy, Romania, Poland and NW Europe (Germany, North Sea, England) need to be complemented by material from high palaeolatitudes. To record the oceanographic conditions and the palaeoenvironmental framework of the Arctic-Boreal area, samples from the Norwegian Shelf and the Barents Sea have been studied by a multidisciplinary group from five Universities in Germany. Material from 3 cores is studied by each group with geochemical, sedimentological and micropalaeontological methods. Foraminiferal data in combination with geochemical data will show good possibilities to understand the environmental changes in these high palaeolatitudes.

Due to consistent subsidence of the basins of Mid Norway and the Barents Shelf in latest Jurassic – earliest Cretaceous times shales were deposited in sediment starved basins. Volgian to Lower Berriasian sedimentation was dominated by dark organic carbon-rich shales with an TOC content up to max. 25 % in the Barents Sea and max. 10 % in Mid Norway. In samples with high TOC values moderate foraminiferal diversities and abundances are present, samples with more than 6 % TOC contain no foraminfera. The genera *Haplophramoides* spp., *Recurvoides* spp. and *Evolutionella* spp. show the highest tolerance to environmental conditions during the deposition of organic rich mud, no calcareous foraminifera occur in this interval. A special basal Cretaceous fauna is found in one Mid Norway core (6307/07), which is marked by a strong *Evolutionell*a spp. and *Recurvoides* spp. flood with up to 2500 indivduals in 100 g. of sediment. This "arctic" foraminifera assemblage is also recorded from western Siberia (Dain 1972), the Sverdrup Basin (Wall 1983), Spitsbergen (Nagy & Basov 1998) and other localities from the high latitudes. In core 6307/07 samples of this assemblage have only a diversity between 2 and 4 different taxa, diversity in core 6814/04 and 7430/10 is generally higher. According to Nagy *et al.* (1997) all these taxa belong into the morphogroup M4a and are adapted to live in areas of increased organic flux and higher nutrient supply. Geochemical data, especially the Mo/Al-ratio, shows warm humid conditions for this interval.

Sedimentation changes from Berriasian to Hauterivian to grey carbonate rich marls. High diverse foraminifera assemblages with an increasing number of calcareous foraminifera (mainly *Lenticulina* spp., *Globulina prisca* and *Laevidentalina* spp.) and agglutinated foraminifera (mainly *Rhizammina* spp. and *Rhabdammina* spp.) occur in the Valanginian to Hauterivian and are reflecting the well known Valanginian transgression which is also proved in our samples by geochemical data like the Th/U and Th/K ratio (Davies & Ellioit 1996). Morphogroup interpretation shows a dominance of group M1, which is typical in environments with low organic flux to the seafloor (Schröder 1986). Some more tethyan foraminifers occur in this interval (e.g. *Tritaxia pyramidata*), samples with more than 25 calcareous taxa show good oxic bottom water conditions, generally open marine aerobic conditions are proposed for this interval. The Mo/Al-ratio shows cold arid conditions for this interval as well as the nannoplankton associations (Mutterlose & Kessels 2000).

Based on the current data the environmental changes at the late Jurassic-early Cretaceous sequence, recovered from offshore mid Norway and the Barents Sea, is thought to reflect two different signals causing superimposed one another and can be summarized as follows:

- a steady sea-level rise throughout the Volgian-Hauterivian period
- a climatic shift from warm-humid conditions in Volgian times to arid-cold climates in the early Hauterivian

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Agglutinated foraminifera from the Upper Cretaceous abyssal clays of the Pacific and Indian Oceans

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The northwestern part of the Pacific Ocean (the Pigafetta Basin) and the eastern part of the Indian Ocean (the Argo and Gascoyne Abyssal Plains) are treated as the areas with the oldest known oceanic crust and marked by great recent water depths (around 6000 m). Within these deep-water areas, the Upper Cretaceous deposits were penetrated by several boreholes in Legs 20 and 27 of "Glomar Challenger" (Krasheninnikov 1973, 1974). They are represented by abyssal red and brown zeolitic clays. Consequently, in the Late Cretaceous (Santonian-Campanian-Maastrichtian), these areas of the Pacific and Indian Oceans involved into the process of the oceanic subsidence have already occupied position well below the CCD (presumably around 5000 m). Non-calcareous clays are very often barren of organic remains or contain corroded radiolarians and (in turbiditic intelayers) redeposited calcareous fossils. Therefore, assemblages of peculiar benthic agglutinated foraminifera, found here in situ, are very important for the age determination.

These assemblages are diverse in taxonomic composition and include species of *Haplophragmoides, Labrospira (=Buzasina), Recurvoides, Paratrochamminoides, Haplophragmium, Pseudobolivina, Bolivinopsis, Plectorecurvoides, Trochammina, Praecystammina, Uvigerinammina, Verneuilina, Dorothia, Plectina, Glomospira, Glomospirella, Ammodiscus, Saccammina, Pilulina, Hormosina, Hyperammina, Adercotryma*, and *Trochamminoide*s genera. They are usually characterized by some morphological features in common: small dimensions of tests (0.15-0.40 mm), the wall structure – thin, fine-grained, homogenous, with a smooth surface, and sometimes, semitransparent when moistened with water. Rather numerous new species have been identified referred to the genera *Haplophragmoides, Buzasina, Paratrochamminoides, Recurvoides, Pseudobolivina, Bolivinopsis, Plectorecurvoides, Trochammina,* and *Pilulina* as well as the new genus *Praecystammina.* Taxonomic and morphologic peculiarities of these agglutinated foraminifera are related to abyssal paleoenvironments of red zeolitic non-calcareous clay formation. This facies type is virtually absent among deep-water Upper Cretaceous sediments on modern continents.

Later on, similar microfauna has been discovered in other areas of the Pacific and Indian Oceans as well as in the North Atlantic where the Upper Cretaceous sequences consist of abyssal red clays (Wightman & Kuhnt 1992; Moullade, Kuhnt & Thurov 1988; Hemleben & Troelster 1984; Kuhnt, Kaminski & Moullade 1989; and others). Elements of the abyssal assemblages of agglutinated foraminifera occur in non-calcareous (flysch-type) sediments and deep-water carbonates of the Alpine-Carpathians realm (Bubik 1995; Kuhnt 1990; Kuhnt & Kaminski 1989, 1990). These investigations showed wide geographic distribution of the abyssal *Haplophragmoides–Labrospira–Recurvoides–Plectorecurvoides–Praecystammina* assemblage, its significance for the correlation of the Upper Cretaceous

(Santonian-Campanian) sediments, and put some questions concerning paleoecology, biogeography, morphology (structure of the test wall), and taxonomy of agglutinated foraminifera.

Stratigraphy and bathymetry of the Cretaceous near Turek (central Poland): micropaleontological study

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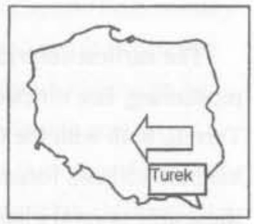

The exploitation of the Miocene lignite near Turek has given unique chance to study the Cretaceous sediments in the central part of Poland. Recently, the new outcrop of the Upper Cretaceous marls was excarated in the "Adamów" Coal Mine (Widera 1999). The new profile is very useful in the micropaleontological study.

Material and methods

The outcropping rocks form the 8-metre high wall of marls and (in the lower part) clay marls. There are no sedimentary structures in the macroscopic observations. 3-kilogramme samples were taken from the outcrop, and 1-kilogramme of them was macerated. In addition thin-sections were prepared to study microfossils and microfacies.

Stratigraphy and bathymetry

In the preparated group of foraminifera following taxons were recognized:

Dorothia oxycona (Hanzlikowá, 1955), *Neoflabellina* sp, *Coryphosoma plaita* (Carsey, 1926), *Nodosaria* sp., *Praeobulimina arkadelphiana* (Cushman et Parker, 1935), *Spiroplectamina dentata* cf. (Alth, 1850), *Ataxiophragmum depressum* (Perner, 1892), *Ataxiophragmum rimosum* (Marsson, 1878), *Osangularia* sp., *Cibicides bembix* cf. (Marsson, 1878), *Allomorfina trochoides* (Reuss, 1845), *Ramulina* sp., *Anomalinoides pinguis* (Jennings, 1936).

Large amount of planktonic foraminifera is present in the sediments, although in thin-sections they are not easy to recognize. Ostracoda also occur together with foraminifera. The identified assemblage of microfossils is characteristic for the boreal Cretaceous of the Central Poland (Peryt 1980, Koch 1977). Agglutinated foraminifera are common, which shells are built from big, detrital grains of quartz. Abundant juvenile forms of planktonic foraminifera were also observed. The assemblage of microfossils and sediment microfacies were the basis to define: the environment of sedimentation as the shallow-marine with the influence of detrital material transported from the land (Koutsoukos & Hart 1990). The age of the studied rocks was determined as Upper Maastrichtian. The outcrop is situated in the horizon of Annomalinoides pinguis (Gawor-Biedowa 1984), which is correlated with the Abathomphalus mayaroensis horizon (Caron 1985). Probably, the studied profile occurs in the lower part of this horizon.

Foraminifera morphogroups and microfacies suggest, shallow and oxygen-rich marine environment.

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Atlas of Cretaceous foraminifera in the Western Canada Sedimentary Basin Part I. History of early work (pre-1950)

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The earliest contributions to the micropaleontology of the Western Canada Sedimentary Basin came from the pioneering, late nineteenth century, geological explorations and publications of George M. Dawson and Joseph B. Tyrrell, both with the Geological Survey of Canada (GSC). Neither of these two were primarily micropaleontologists, but both utilized foraminifera to establish the presence of Cretaceous strata in western Canada. Dawson (1875) illustrated several planktonic species, likely from the Upper Cretaceous Niobrara Formation, and made comparisons to the foraminiferal assemblages in the chalk deposits of Europe. Tyrrell (1891 and 1892) utilized foraminifera to interpret strata from outcrop and three boreholes drilled between 1888 and 1890 in Manitoba. Recently, samples from one of these boreholes (the "Deloraine well") were rediscovered in long forgotten antique pillboxes abandoned in a GSC office.

Formal analysis of foraminifera in western Canada did not begin until E.M. Kindle of the Geological Survey of Canada sent a collection of foraminiferal microslides to Joseph A. Cushman for examination. Cushman (1927) thus published the first micropaleontological paper on foraminifera from western Canada, naming five new species including *Haplophragmoides gigas*, *Ammobaculites "fragmentaria"*, *"Bigenerina" hastata*, *"Bigenerina" angulata*, and *Verneuilina canadensis*.

Robert T.D. Wickenden was the first Canadian micropaleontologist to publish on western Canadian foraminifera. After completion of his PhD at Harvard, under the supervision of J.A. Cushman in 1931, Wickenden (1932) described 12 new species from the Cretaceous of Alberta, Saskatchewan, and Manitoba. The species were *Haplophragmoides kirki*, *Haplophragmoides fraseri*, *"Gaudryina" painoides*, *Spiroplectammina mordenensis*, *"Heterostomella" boynensis*, *Loxostomum cushmani*, *Gaudryina bearpawensis*, *Verneuilina bearpawensis*, *Trochammina albertensis*, *"Tritaxia" manitobensis*, *Miliammina manitobensis*, and *Trochammina ribstonensis*.

The pre-1950 history of foraminiferal studies in western Canada ended with a finely illustrated publication on Cretaceous foraminifera in Alberta by Arthur W. Nauss. As was typical of the early works on micropaleontology, Nauss (1947) described numerous new species of benthic foraminifera including one planktonic, *"Globigerina" loetterlei*. Nine agglutinated species were described: *Ammobaculites humei*, *Bathysiphon vitta*, *Gaudryina hectori*, *Miliammina sproulei*, *Haplophragmoides rota*, *Haplophragmoides collyra*, *"Verneuilina" cummingensis*, *Haplophragmoides linki*, and *Haplophragmoides gigas minor*.

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Calibrated sequence stratigraphic models and agglutinated foraminifera in the Albian of east central Saskatchewan, Canada

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Agglutinated foraminifera occur widely in marine terrigenous clastic sediments of the Western Canada Sedimentary Basin. Their distribution is controlled by many of the same processes that control sedimentation and result in discrete environments of deposition. This close link to depositional environment means that agglutinated foraminifera can be used to demarcate, test, and refine the basic components of applied sequence stratigraphic models. In this context, foraminiferal assemblages have been analyzed from a relatively complete depositional sequence in the upper Albian of east central Saskatchewan comprising the upper Viking Formation and the overlying Westgate Formation (Miliammina manitobensis Zone).

The Viking contains the lower boundary of the sequence, which is marked by a change from terrestrial microfossils to marine. Lagoonal and marginal marine foraminiferal assemblages occur in the initial transgressive systems tract constituting the upper Viking Formation. At the base of the Westgate, marine mudstones overlying transgressive lag deposits (a flooding surface) contain shallow-marine, coarse-grained, agglutinated foraminifera. Foraminiferal diversity and abundance increase upsection until a maximum is reached and deeper water species dominate (maximum marine flooding). Data suggests that a maximum flooding surface could be drawn at several different, but closely spaced horizons. For practical purposes, a flooding zone is recognized rather than a flooding surface. The upper Westgate contains a lower diversity assemblage of agglutinated foraminifera indicating the regressive systems tract. The upper sequence boundary is marked by last occurrences of species. Application of sequence stratigraphy, coupled with detailed foraminiferal distributions, provides a reliable framework for correlation through central Saskatchewan. The geochronology of the section is constrained by a limited number of radiometric dates (Pb/U).

Sequence stratigraphic interpretations and biostratigraphic data complement each other and can be combined, but the most commonly used graphic methods are not well suited to display both data sets together. The most widely used sequence stratigraphic model (the Exxon model) is conceptually based on seismic reflection profiles, typically across a continental margin sequence. Biostratigraphic data is most often summarized in a distribution chart showing species occurrence data from a single stratigraphic section. To combine the two inherently different sets of data, it is necessary to use other graphic methods that can illustrate information from both sequence stratigraphy and biostratigraphy. Two models that are calibrated by time and water depth will be presented. Neither model illustrates detailed paleontological data, but both rely substantially on paleontological interpretations for determining the nature and age of key surfaces that are essential to sequence stratigraphy. Sequence stratigraphic interpretations have often been remarkably unconstrained because paleontological data was lacking. Interpretations on the significance of sequence stratigraphy relative to sea level should follow local calibration, regional correlation, and inter-regional correlation, rather than precede it.

Agglutinated foraminifera from the santonian Al-Hilal Formation, northeastern Libya

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Exposed Al-Hilal Formation, outcrops in two localities in Al Jabal al Akhdar (northeast Libya) were analyzed for their foraminiferal content. Well preserved agglutinated and calcareous benthic and planktic foraminiferal assemblages, retrieved from argillaceous limestones, were assigned to the Concavutruncana concavata and C. asymetrica Zones. Twenty agglutinated species, belonging to thirteen genera, and diagnostic planktic species were documented and illustrated. This formation is conformably overlain by the chalky inoceramid limestones of Al Athrun Formation, whereas the lower boundary is not exposed. According to the diagnostic planktic foraminifers Al Hilal Formation ranges in age between late Early to Late Santonian. The lithological nature and dominance of keeled planktic foraminifera, with deep marine agglutinated and calcareous benthic foraminifera, are attributed to upper slope - bathyal environment.

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Bini-organization of the animate nature is the basis of the organic world classification

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It is well known that synergetics is especially brightly and diversely observed in biology. The synergetic processes take place here, as &Haken (1983), Prigogine & Stengers (1984) and others notice, in the muscular contractions, electric oscillation in the cerebral cortex, immune system, dynamics of populations, morphogenesis and evolution, i.e. on all hierarchical levels of the animate nature functioning and development. Synergetics can be given the status of interdisciplinary science because it fixes the objective reality of the self-organization and self-development of substance, exemplifying such situation in different fields of natural sciences. But the synergetics has nothing to do with problems of the structural formation of the processes of the self-organization and self-development of substance. It means that new taxons and new states of substance after bifurcation are not analyzed in comparison to each other, quantitative and qualitative regularities of new taxons formation are not investigated.

In this case biniology (1999) pretending to the role of interdisciplinary science as well answers these questions: how many taxons are generated in the points of instabilities (bifurcations); what are new taxons by their characteristics in comparison to each other; how universal are ascertained regularities bifurcation (dichotomy); if these regularities are observed on all hierarchical levels?

In all fields of natural sciences there are many indisputable examples of dichotomy or binial (from Latin bini - pair) structure, when the whole, on the lower level, is divided only into two constituents, then each of them is divided into two ones again and so on. The analysis of such phenomena shows the following.

Firstly, binial structure is observed on all hierarchical levels of the animate nature organization. So a protoplasm and a nucleus are observed in the structure of a living cell. On the lower hierarchical level the cell nucleus consists of the deoxyribonucleic (DNA) and ribonucleic (RNA) acids. In their turn DNA is presented by two filaments spirally wound round each other. Every filament is made of nucleotides of purine and pyrimidine types. On the one hand there is adenine and guanine in composition of the purine type, on the other hand there is thymine and cytosine in composition of the pyrimidine type. As for the highest levels of the organic world classification it is enough to remember here that all living beings are divided into Procaryota and Eucaryota by construction of the cells. By way of feeding both the Procaryota and Eucaryota are separated into two kingdoms: Procaryota - into Cyanobionta and Bacteria, Eucaryota - into Phyta and Zoa (Animalia) and so on.

Secondly, two constituents, which we call binitaxons, forming the whole, are directly contrary to each other as plus and minus according to presence or absence of some features in their characteristics. They are female and male beginnings, Dicotyledonous and Monocotyledonous plants, Procariota and Eucariota, Protostomia and Deuterostomia and so on. As experience shows to reveal binitaxons is not easy in many cases. No researcher considers the hinge line of Bivalvia shells to be an important taxonomical feature. This line is presented by one (anterior) or two (anterior and posterior) branches. Two groups of Bivalvia shells singled out by this feature are absolutely distinguished on the level of plus and minus.

Thirdly, there is a third component of the whole together with two main ones. It is convenient to call it an intertaxon because it has intermediate features, sharply suppressed in quantity, and its evolutional development is much lower. For example, Mycetalia taxon (group of mushrooms) is a bright pattern of the intertaxon which has intermediate position between Zoa and Phyta kingdoms. In the group with regular shells of agglutinated Foraminifera there are three subgroups: spiral, clewshaped and monoaxial. One of them, the group with the clewshaped shells, can be considered an intertaxon. Probably the third component (intertaxon) can be expressed as a boundary or a boundary zone between two main binitaxons. So it is more correctly to acknowledge the trinomial structure of the organic World or trichotomy. But taking into account that the third component is always sharply suppressed in quantity and usually it is not clearly expressed it makes sense to use the term "dichotomy". It reflects the structure of the World more generally because the binomial structure is much more evident and two constituents of the whole are approximately equal.

Fourthly, binitaxons are homologous to each other and have identical changeability. Among the Bivalvia groups with one and two branches of the hinge line there are shells of the same types. This gives us the opportunity to predict the presence and characteristics of an unknown taxon if we know the taxon which is binial to the first one.

The cases of conflicting with the principles mentioned above are explained by mixture of hierarchic ranks, insufficient study and artificial separation of intermediate taxons.

As for Foraminifera classification we suggest acknowledging the presence of two large groups (agglutinated and secreted Foraminifera) and giving them the rank of the superorders. According to the principles of biniology mentioned above these binitaxons, i.e. the superorders of Agglutinida and Secretida, are contrary to each other by way of shell construction and they are homologous by their diversity of shells. On the lower hierarchical levels classification of agglutinated Foraminifera can be constructed using forms and structures of shells in accordance with the principles of biniology and synergetics characterized above.

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Miocene *Silicoplacentina* (Testacea) from northern part of the Carpathian Foredeep (Poland)

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Fossil Thecamoebians representing genus *Silicoplacentina* was for the first time described by Kövàry (1956) from Pannonian deposit of Hungary. He distinguished the 4 species. A variety of deformation styles resulting from sedimentary compactions causes difficulties in the application of this subdivision. That is why, in 1985, O. S. Schreiber *et al.* proposed the use of only two species: *Silicoplacentna majzoni* Kővàry (1956) and *S. irregularis* Kővàry (1956). The range of occurrence of those species is limited and that is why they are good indicators for the boundary between Sarmat/Pannon on the territory of Paratethys (Fuchs & Schreiber 1988).

This group was identified in the Polish part of Carpathian Foredeep a while ago. *S. majzoni* and *S. Irregularis* were described from Machów Formation, from younger series Krakowiec Clays, from two positions of Jamnica S-119 borehole and in an open pit at the Machów mine (Paruch-Kulczycka 1999). Their presence was mentioned also in Jaksmanowice 250 and Ryszkowa Wola boreholes (Olszewska 1999).

In positions of Jamnica S-119 borehole and in an open pit at the Machów mine *S. majzoni* and *S. Irregularis* occur in mudstone-sandstone sediments. Their representatives appear in sandy-marly sediments, which were deposited in shallow-marine, low-salinity basin, strongly swelled by terrigenous material. In the early part they are accompanied by relatively numerous endemic relict sarmatian foraminifera: *Porosononion, Articulina, Quinqueloculina, Elphidium, Nonion, Bolivina, Cassidulina,* of characteristic little size and tiny, pellucid, ornamented shells.

In the higher part of profiles *Silicoplacentina* coexists with the agglutinated foraminifera and few *Nonion* and *Elphidium*, similarly as in the basins Lowermost Pannonian in Paratethys. Such a micro fauna succession may suggest, that microfossil assemblage found in the of Jamnica S-119 borehole and in an open pit at the Machów mine comes from still younger series of the Krakowiec Clays (Paruch-Kulczycka 1999). Mentioned suggestion can be confirmed by the research of the same material, of E. Gaździcka (1994), who recognised the nannoplancton zone NN 8/9 convenient to the Pannonian age for this deposits.

Paleomagnetic investigations conducted by Król & Jeleńska (1999) in the Jamnica S-119 borehole have shown a succession of changes in geomagnetic field polarity corresponding to the time span of 11-7.5 Ma -Upper Badenian to Sarmattian/beginning of Pannonian (?).

It appears that better documentation of the positions indicating the occurrence of sediments younger than Volhynian in the Polish Part of Carpathian Foredeep, contributes to reinforcing the opinion, that persistence of sedimentation could continue much longer than it was considered till now. Further research will enable the better paleographic and biofacial correlation with other parts of Central and Eastern Paratethys.

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Agglutinated foraminifers and their response to the Cretaceous/Paleogene (K/P) boundary event at Aïn Settara, Tunisia

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The Aïn Settara section is exposed about 50 km south of the El Kef stratotype section, in the Kalaat Senan area, central Tunisia. The K/P boundary, identified on the basis of general lithological characteristics, species extinction and the occurrence of cosmic markers, is located within the lower part of the marly El Haria Formation (Arenillas *et al.* 2000; Robaszynski et al. 2000; Tribovillard *et al.* 2000).

The studied interval extends from 2.5 m below to 9.6 m above the Cretaceous/Paleogene (K/P) boundary and encompasses the uppermost 2.5-m-thick part of the *Plummerita hantkeninoides* Zone and *Guembelitria cretacea* (0.6-m-thick), *Parvulogoglobigerina eugubina* (4.5-m-thick) and lower 4.5-m-thick part of the *Parasubbotina pseudobulloides* Zones.

Combined quantitative data on foraminiferal assemblages indicate outer shelf – upper bathyal marine environment during latest Maastrichtian-early Danian time at the Aïn Settara section (Alegret *et al.* 1999).

Benthic foraminifera are abundant and very well preserved in studied material except for a 5-cm-thick layer of sediment overlying the impact layer where benthic foraminifers are scarse and poorly preserved and the impact layer - where they are not recorded.

Agglutinated foraminifers are minor component of benthic foraminiferal assemblages and agglutinated species form up to 26% of the assemblages in the studied interval. In the uppermost Maastrichtian benthic foraminiferal assemblages *Heterostomella*, *Bolivinopsis*, *Tritaxia* and *Gaudryina* are the most common agglutinated taxa and they represent infaunal morphogroup; within the epifaunal morphogroup *Recurvoides* and *Haplophragmoides* are also common.

The dramatic change in the structure of benthic foraminiferal assemblages corresponds to the layer with geochemical anomalies, i.e. at the base of the *Guembelitria cretacea* Zone. At this level all agglutinated species with inferred infaunal mode of life disappeared. Some of them went extinct (e.g. *Heterostomella austiniana*, *Bolivinopsis clotho*), whereas others (e.g. *Clavulinoides* spp., *Gaudryina* spp., *Tritaxia* spp.) – reappeared in the Lower Danian as Lazarus taxa after shorter or longer period of habitation in refugia. On the contrary, *Ammodiscus cretaceus* and *Glomospirella* sp. – epifaunal morphotypes – bloomed in this very short interval as disaster species.

Faunal turnover across the K/P boundary at Aïn Settara points to a sudden breakdown of the food supply to benthic organisms. A drastic decline in primary productivity is evidenced by a negative carbon isotope excursion across the K/P boundary (Zachos & Arthur 1986). The drop in primary productivity was responsible for the very limited food flux to the bottom of the sea. In such situation all metabolizable food particles were consumed at the sediment surface; this resulted in extinction and/or temporary emigration of most of the infaunal morphogroups.

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Aglutinated foraminifera of Cenomanian-Turonian boundary in the Arctic biogeographical realm

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The Senomanian-Turonian assemblages of West Siberian agglutinated foraminifera are of great similarity to those of Northern Alaska and Canada (Canadian province) assigned to the Arctic biogeographical realm.

The investigations on the Senomanian-Turonian assemblages of these provinces within the common realm resulted in revealing the similarity of not only the foraminiferal systematical composition on the level of genera and species within separate horizons but also of the quantitative distributions of taxa through a section (Stelck & Wall 1955; Tappan 1962; Wall 1967).

The Upper Senomanian zone *Verneuilinoides kansasensis* from the northern area of Western Siberia (almost black clays of the upper strata of the Uvatskian horizon) is identical in the taxonomic composition both for West-Siberian (Podobina 2000) and Canadian provinces (Wall 1967). In the territory of Canada it has been established by J. Wall in the lower part of the formation Blackstone (Sunkay member) characterized by the Late Senomanian *Danveganoceras*. In both the provinces the assemblage *Verneuilinoides kansasensis* is well correlated and represented mainly by quartz-siliceous tests of the genera *Labrospira, Haplophragmoides, Trochammina, Verneuilinoides.* Probably, this part of the section conforms to the lower strata of the *Trochammina rutherfordi, Gaudryina* (?) *irenensis* zone in Northern Alaska where *Verneuilinoides* are indicated.

The West Siberian overlying beds (the upper parts of the Uvatskian horizon) enclosing the assemblage *Trochammina wetteri, T. subbotinae* (Podobina 2000) may be correlated to the upper part of the *Trochammina rutherfordi, Gaudryina* (?) *irenensis* zone of Northern Alaska (Ninuluk formation) (Tappan 1962). When comparing the Late Senomanian assemblage of Northern Alaska with West Siberian ones it may be noted that *Gaudryina* (?) *irenensis* Stelck et Wall is the vicarian species for *Gaudryinopsis angustus* Podobina; *Trochammina ribstonensis* Wickenden *rutherfordi* Stelck et Wall seems to be the junior synonym in relation to *T. subbotinae* Zaspelova, because it is almost identical with the compared species in the morphological characteristics.

As it could be seen from the comparison reported above, the species of the West Siberian Late Senomanian assemblages occur among those of the same age from Northern Alaska, Canada and most of them are typical for this part of the section.

The analysis of the Turonian assemblages of Western Siberia also permits to detect the meaningful similarity in them. The Early Turonian assemblages of Western Siberia from the *Gaudryinopsis angustus* zone have been confined to the lower part of the Kuznetsovskian horizon and characterized with rare finds of *Inoceramus labiatus.* They have much in common in the specific composition with the assemblages of the same age from Northern Alaska. On evidence derived from H. Tappan's works (Tappan 1962) the Turonian foraminifera of this region have been confined to the Seabee formation. From foraminifera there have been detected predominantly the agglutinated tests of the genera Saccammina, Ammodiscus, Haplophragmoides, Ammobaculites, Spiroplectammina, Trochammina, Gaudryina (Gaudryinopsis), Verneuilinoides. Some species of Haplophragmoides are common with West Siberian ones: *Haplophragmoides rota* Nauss, *H. crickmayi* Stelck et Wall and others. The *Gaudryina* (?) *irenensis* Stelck et Wall species is vicarian in relation to the West Siberian *Gaudryinopsis angustus* Podobina; *Trochammina whittingtoni* Tappan to *T. subbotinae* Zaspelowa.

In Canada (the Peace River in the west of Alberta) the middle part of the formation Kaskapau belongs doubtlessly to the Lower Turonian (Stelck & Wall 1955). The foraminiferal zone *Haplophragmoides spiritensis* has been confined to it, as well as the Lower pelagic microfaunal zone enclosing the assemblage *Gaudryinopsis angustus*. There is a vague similarity between several species of the foraminiferal zone *Haplophragmoides spiritensis* and the West Siberian ones; for example: *Ammobaculites pacalis* Stelck et Wall is vicarian with *A. tyrrelli* Nauss *agglutinoides* Dain; *A. albertensis* with *A. tuaevi* Zaspelova; *Haplophragmoides hendersonensis* Stelck et Wall with *H. rota* Nauss *sibiricus* Zaspelova; *Dorothia* (?) *kaskapauensis gracilis* Stelck et Wall with *Gaudryinopsis angustus* Podobina. It is only *Trochammina wetteri* Stelck et Wall that is a common species.

The Upper Turonian *Pseudoclavulina hastata* zone has been established in the overlying deposits of the Kuznetsovskian horizon in the West Siberian province (Podobina 2000). The foraminiferal assemblage bears a vague similarity to the Lower Turonian one but has a peculiar species ratio. *Haplophragmoides* (*H. rota* Nauss *sibiricus* Zaspelova) and *Pseudoclavulina* (*P. hastata* Cushman) are dominant, the typical *Ammoscalaria* (*A. antis* Podobina) and *Trochammina* (*T. arguta* Podobina) species appear.

The Late Turonian foraminifera of the West Siberian *Pseudoclavulina hastata* zone and the forms of the same age from Northern Alaska have much in common as to the specific composition. On evidence derived from Tappan' data (1962) they are confined to the upper portion of the Seabee formation. The agglutinated tests of the genera *Saccammina, Haplophragmoides, Ammobaculites, Spiroplectammina, Trochammina, Gaudryina (Gaudryinopsis), Verneuilinoides* and others have been predominantly detected.

The Late Turonian assemblage of the *Pseudoclavulina hastata* zone from the West Siberian province is well comparable with the *Pseudoclavulina hastata, Arenobulimina torula* assemblage from Northern Alaska of Canadian province established in the upper part of the zone confined to the Seabee formation (Ayiyak member). On mollusks the Upper Turonian is distinguished as the *Inoceramus cuvieri* zone. In the *Pseudoclavulina hastata – Arenobulimina torula* zone the agglutinated tests of numerous typical Turonian species are also predominant. The Seabee formation bears close resemblance to the West Siberian Kuznetsovskian horizon and seems to correlate also with two Turonian substages.

Two overlying members (Haven member and Opabin member) of the Blackstone formation in Central and South Alberta are dated the Late Turonian by J.Wall, because they are defined by the Late Turonian pelecypods *Inoceramus lamarcki* and the foraminiferal assemblage *Pseudoclavulina* sp.

The majority of the species listed from Western Siberia, Northern Alaska and Canada are usually characteristic for the Upper Senomanian – Turonian deposits. However their ratio and quantity indicate their ranking as a foraminiferal zone confined within the more narrow stratigraphical limits.

Thus, West Siberian and North American foraminifera bear the resemblance in their taxonomic composition not only on the generic level but also on the specific one.

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Late Senonian secreted agglutinated foraminifera of Western Siberia

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Two categories of agglutinated types of foraminifera have been previously established by V.M. Podobina differing in the chemical composition of tests: 1 – quarts-siliceous, 2 – calcareous (Podobina 1978; Podobina 1993). Agglutinated tests of the 1st category are usually distributed within terrigenous, often siliceous rocks. Such forms are known from Senomanian-Santonian and Paleocene-Eocene deposits of West Siberian plain. The 2nd category includes tests formed by calcareous agglutinate and cement. They have been discovered in the carbonaceous rocks, for example, of the Upper Cretaceous of the European province. Besides the 1st (agglutinated) wall type and the 2nd (secreted) one the intermediate wall type – secreted-agglutinated – has been established by V.M. Podobina (Podobina 1978, 1998, fig.3). Two categories of the secreted-agglutinated forms have also been recognized by their chemical composition: 1 – siliceous tests and 2 – carbonaceous tests. In the present work calcareous secreted-agglutinated and agglutinated forms of the second category are being surveyed which have been detected in the Gankinskian horizon of the West Siberian province and in other provinces of the Boreal-Atlantic realm. The genera of *Gaudryina, Siphogaudryina, Dorothia, Ataxophragmium, Heterostomella, Martinottiella* fall into this group. Normally in the Siberian forms the agglutinate is rather fine-grained and the tests are of the so-called "microgranular" microstructure.

The presence of calcareous secreted-agglutinated forms, in particular, microgranular and agglutinated ones, in the families *Lituolidae, Verneuilinidae* and others has been reported by J. Sigal (1956). He stated that the representative genus *Lituola* Lamarck, 1804 possessed the former wall type of the indicated ones and couldn't remain in the same family with quarts-siliceous agglutinated forms. That's why J. Sigal separated the latter from *Lituolidae* to establish the independent family *Haplophragmiidae* Cushman, 1927. In the family *Lituolidae* Reuss, 1862 J. Sigal left only the genera with calcareous microgranular walls (the genus *Lituola* and others) which were formed by sparse agglutinated calcite particles among its small, almost invisible crystals comprising the cement. Unlike the agglutinated wall, this type (secreted-agglutinated) is composed of minor agglutinate quantity comprising not more than 25% of the wall area. However the instances of both its decrease up to zero and increase are possible. The agglutinate admixture as well as the peculiarity of predominating secreted material suggests the existence of the indicated intermediate wall type.

J. Sigal has given the exhaustive account of the agglutinated wall (1952). He has recorded the presence of the inner homogenous thin pseudochitinous layer (chitinous lining). The wall of the outer layer is composed of agglutinate and cement differing in their quantitative and qualitative characteristics.

J. Sigal (1952) was the first to notice a certain similarity in the aspects of microgranular calcareous tests, originally distinguished by him (secreted-agglutinated type of wall) and of the agglutinated tests known previously (agglutinated type of wall). This outward similarity, as well as the presence of a minor quantity of the agglutinated substance, led to integrating tests with different wall types into the same taxonomic groups (superfamilies, families and so on). Thus, in the well-known classifications (Principles of palaeontology 1959; Loeblich and Tappan 1988) the tests with agglutinated and secreted-agglutinated wall types, moreover having different chemical compositions, have been grouped into the family *Lituolidae*. The same is true for the taxonomy of *Ataxophragmiidae* and other taxonomic groups. For example, the tests with the indicated two wall types have been assigned to the same *Ataxophragmiidae* family (Principles of palaeontology, 1959). The detailed investigation of the Siberian Cretaceous *Gaudryina* wall has led to the conclusion that the compositions and microstructures of walls are of completely different chemical composition and microstructure. Thus, the representative type of the genus *Gaudryina* Orbigny, 1939 – *Gaudryina rugosa* Orb. *spinulosa* Neckaja, dwelling within the West-Siberian basin in the Maastrichtian, has a calcareous, microgranular wall of secreted-agglutinated and more seldom to the agglutinated type. The existence of such forms alongside the abundance of calcareous grained and hyaline tests is explained by the presence of sufficient calcium carbonate quantity in the water of the relatively warm basins of the Boreal-Atlantic realm. The other West-Siberian tests, also assigned previously to the genus *Gaudryina* (*Gaudryina angustus* Podobina, *G. vulgaris* Kyprianova) have been ascertained to have quite a different wall – agglutinated, composed of closely packed quartz grains (up to 80 to 90% of the wall surface) strengthened with siliceous cement. These species with quartz-siliceous agglutinated walls distinguished moreover by a number of morphological peculiarities have been assigned to the new genus *Gaudryinopsis* Podobina, 1975. The identical distinctions may exist between the genera *Verneuilina* Orbigny, 1840; *Verneuilinoides* Loeblich et Tappan, 1949 (the former hasn't been detected in Western Siberia yet) and others. The carbonaceous material is almost totally absent from the Cretaceous-Paleogene and Paleocene-Eocene terrigenous deposits of Western Siberia, where the types of the genera possessing agglutinated quartz-siliceous walls have been discovered; this pointing to a close association of foraminiferal tests with the composition of the substrate sediment on which foraminifera were dwelling as well as with the temperatural conditions of the basin. The same is true for the predominance of the secreted calcareous-walled tests in the late Senonian and early Oligocene basins of Western Siberia characterized with the carbonate-terrigenous sedimentation and more elevated temperature of water mass.

J. Sigal was also the first to notice the diverse composition of the test cement: siliceous, ferruginous and calcareous. But as J. Sigal considered, the calcareoferruginous cement is inherent in the most part of the tests. In this respect we have a somewhat different opinion. Along with calcareous cement, the siliceous one is widely spread, and it is attributable to the biochemical characteristics of foraminiferal protoplasm. The ferruginous cement is significantly restricted in occurrence, and, in our opinion, it is secondary. The tests, in which siliceous or calcareous cement is impregnated with iron compounds to a variable degree, are encounted more frequently.

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Evolutionary stages of agglutinated foraminifera and the Upper Cretaceous rhythmostratons of Western Siberia

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In the West Siberian basin agglutinated foraminifera were predominantly developing through the late Cretaceous. They responded sensitively to the slightest changes in the physicogeographical and bionomic conditions of the life environment and hence are the valuable indicators for such changes. The rhythmicity in the development of the late Cretaceous basin at the backgrounds of the transgressive-regressive cycles has been manifested in the alternations of rocks distinguished by the lithological peculiarities, as well as in the quantitative and qualitative characteristics of the rocks enclosing foraminiferal assemblages. It provided a possibility of stratifying the upper Cretaceous section in greater detail and establishing the local biostratigraphical (foraminiferal) zones (Podobina 2000).

Based on the peculiarities of the averaged quantitative distribution of foraminifers in the central area of Western Siberia, the generalized faunal curve (GFC) has been constructed, by which the transgressive-regressive cycles of the basin's development are well represented. Three distinct rhythms stand out in the GFC, corresponding to such considerable rhythmostratons as the Kuznetsovsko-Sedelnikovskian, Slavgorodskian and Gankinskian horizons. Every rhythm associated with the respective rhythmostratons is separated in the GFC by a borderline between two greatest bends corresponding to the maximal transgressions. Each of the three GFC's subdivisions corresponding to one or two horizons has been termed rhythmothems by the authors. The American investigators gave the other name to such subdivisions – the marine cyclothems (Caldwell, Diner, Eicher et al. 1993).

The qualitative characterization of foraminifers through the upper Cretaceous section reflects the alterations of their taxa on the level of orders and families which are usually similar in the composition within the separate rhythmothems. Horizons or their portions subordinate to the rhythmothems are somewhat diverse lithologically and characterized by the definite generic composition. In the hierarchy of rhythmostratons they may be equated to such rhythmostratigraphical subdivisions as rhythmotherms (the designation has been adopted by the authors from the Latin *termus* – a cut-off portion of a branch). The local biostratigraphical (foraminiferal) zones distinguished by the peculiar specific assemblages has been called rhythmolithes which are subordinate to rhythmotherms and these latter – to rhythmothems.

Annotation. GFC - Generalized Faunal Curve derived from the averaged quantitative distribution of foraminifers; T_1-T_3- transgressive cycles; R_1-R_3- regressive cycles;
----- - borderline between rhythmothems; ʌʌʌʌʌʌʌ- borderline between rhythmoterms;
-.-.-.-.-.- - borderline between rhythmolyths

Fig. 1. Rhythmostratigraphical scheme of the Upper Cretaceous in Western Siberia combined with rhythms of quantitative distribution of foraminifera.

The accompanying table brings the chart of the foraminifer zonal stratigraphy of the upper Cretaceous into coincidence with the GFC diagram based on the relative distribution of foraminifera. We have established three transgressive ($T_1 – T_3$) and three regressive ($R_1 – R_3$) cycles of the basin. Boundaries of separate rhythmothems, diverging both in their lithology and in the quantitative and qualitative (orders, families) foraminiferal compositions, are plotted between two maximum bends of the GFC correlating with the beginning of the transgressions. The boundaries of the rhythmotherms are plotted in the middle points of the GFC between two maximum transgressions. These rhythmotherms are peculiar for the generic composition and to a less extent families and are confined to separate horizons or their portions. The rhythmotherms are separated by the base of the maximal transgression curve at one side and by the middle point in the GFC – the boundary between the maximum transgressions, at the other one. The successive rhythmolithes are the layers (zones) of moderate thickness, containing peculiar foraminiferal assemblages and are marked by the middle points between the maximum and intermediate GFC values – the boundaries between the separate transgressive and regressive cycles of the basin.

Hence, the approach of the rhythmicity in the distribution of foraminifers involves the isolation of successive rhythmostratons through the upper Cretaceous section and is based on the peculiarities of the transgressive-regressive cycles of the basin, which are interrelated, as it has been mentioned, with the tectonic regime of the territory.

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Agglutinated foraminifers from the Upper Senonian to Paleogene flysch of the Middle Váh valley (Súľov, Javorníky, Biele Karpaty Mts) Slovakia

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The Upper Campanian-Maastrichtian Jarmuta Formation in the Kvašov Development (Kvašov, H. Breznica - Púchov) of the Czorsztyn and Biele Karpaty units is characterized by a relatively abundant occurrence of the species *Nothia robusta* (GRZYBOWSKI), *Karpatiella ovulum gigantea* (GEROCH) and small representatives of the genera *Rhabdammina* div. sp. and *Rhizammina* div. sp. In the Upper Maastrichtian the association of the species *Rzehakina epigona* (RZEHAK) is present. The Upper Campanian and Maastrichtan orbitoid foraminifers are redeposited from an orbitoid limestone platform (and deepening to the facies variegated marls) situated NW of the marine lagoon, in which the Jarmuta Flysch Formation deposited. Into this the detritus and remnants of plants were supplied from the archipelago zone of the Klippen Belt, mainly from differentiated area of sedimentation of the Czorsztyn Zone.

Overlying the Jarmuta Flysch and orbitoid limestones in the frame of gradual sedimentation to the SW (wedging out to the Klippen Belt) an are variegated Paleocene - Lower Eocene lagoonal claystones, with intercalations of calcareous aleuritic sands. These are predominating in many cases and practically merge with the underlying Jarmuta Flysch and overlying Eocene flysch. They differ from them in redeposited nummulites, orthophragmines, but also blocks of reef limestones. The latter are derived from the Paleocene archipelago zone of the Klippen Belt

The Beloveža Variegate Clays (in the strip Púchov, Horná and Dolná Breznica, Kvašov - Lednica) of the Middle and Late Paleocene of the *Karpatiella ovulum ovulum* Zone (Geroch & Nowak 1984) contain an agglutinated microfauna mainly reprezented by the species: *Saccammina placenta (*GRZYBOWSKI*), Rhabdammina discreta* BRADY, *Rhabdammina cylindrica* GLAESSNER, *Hyperammina carpatica* MASLAKOVA, *Rheophax pilulifera* BRADY, *Nodellum velascoense* (CUSHMAN), *Karpatilla ovulum ovulum* (GRZYBOWSKI), *Ammodiscus angygyrus* REUSS, *Ammodiscus umbonatus (*GRZYBOWSKI), *Glomospira gorayski* (GRZYBOWSKI), *Glomospira charoides* (JONES et PARKER), *Glomospira irregularis* (GRZYBOWSKI), *Glomospira serpens* (GRZYBOWSKI), *Haplophragmoides* div. sp.,*Recurvoides deflexiformis (*NOTH), *Recurvoides imperfectus* HANZLIKOVA, *Recurvoides turbinatus* BRADY, *Thalmannammina subturbinata* (GRZYBOWSKI), *Ammobaculites deflexus*

(GRZYBOWSKI), *Bolivinopsis carinatus (*d' ORBIGNY), *Bigenerina variabilis* VASICEK,,*Trochammina globigeriniformis* (JONES et PARKER) and *Gerochammina fallax* (GRZYBOWSKI).

The calcareous benthic and planktonic foraminifers are lacking in these sediments (only reworked species are present).

Unfavourable conditions for the foraminifers were at the Paleocene-Eocene boundary connected with distinct shallowing (the absence of the species *Globalveolina levis* (REICHEL). Most shallowing was in the Lower Eocene of the Javorníky Mts (Bystrica unit) with formation of coal marshes (formation of bony coals and coal parting) connected with rain period. In coal salty marshes to shallow laggons with normal salinity normal primitive tubular types of agglutinated foraminifers were living (*Nothia* div. sp.*Bathysiphon* sp., *Rhizammina* div. sp. and *Rhabdammina div. sp.),* in the structure (cement) of which scattered coal substance and pyrite took part. In deeper lagoonal environmet species of the genera *Ammodiscus* div. sp. and *Glomospira* div. sp. are mainly reprezented. In the uppermost Early Eocene (Ypresian), besides the above mentioned types of agglutinated foraminifers, specimens of the species *Saccamminoides carpathicus* GEROCH are found relatively scarcelly.

Besides light-coloured types of agglutinated species of normal lagoonal environment also dark types bound to a shallow reductional environment are present. These obviously could have been redeposited from cool lagoons and marshes in connection with short-term rise of the water table and transgression. This transgression is proved mainly in the Súľov type Paleogene (zone with *Alveolina oblonga* d' ORBIGNY and *Alveolina ruetimeyeri* HOTTINGER; SAMUEL et SALAJ 1963). A rapid regression is connected with formation of a large intermontane lake, in which the inundation cycles of the Súľov Conglomerates (Svinské Chlievy Formation) were deposited, in the lower part with 3 horizons of sterile clays and with layers of 13 horizons of the banded lacustrine Malenica Onyxites (Salaj 1993). In the middle and upper parts of the formation of the Súľov Conglomerates were deposited in the shallow neritic zone with 3-4 horizons of the nummulite sandy limestones, uppermost Ypresian in age.

The mentioned laminated Malenica Onyxites with dark and light-loloured laminae prove alternation of warm summer (obviously monsoon rains season) and could winter season.

The Middle-Upper Eocene flysch sediments of the Súľov type as well as Magura type Paleogene (Javorniky and Biele Karpaty Mts) are very poor in benhonic calcareous and agglutinated foraminifers and many horizons are completely without fossiles. The main reason was that the rains periods practically throughtout the Eocene caused distinct and rapid outwashes as well as transport of detrital (including pebbles) material at short distance into a large intermontane Súľov lake, in its connection also into a sea lagoon with normal salinity or into the open sea.

At the floor of seas in that time distinctly Fe-oxidation paleoenvironment with ferric concretion, often of microscopic dimension, mostly preserved as ooids wa taking place. These originally formed as secondary envelope of dead planctonic foraminifers fallen to the sea floor. The planctonic foraminifers were completely destructed except scarce finds. Obviously the Fe-oxidation environment was completely unfavourable for development of benthonic foraminifers.

In the Upper Lutetian, in which Fe-oxidation horizons are not present and/or occurring only scarcely, a rich microfauna of agglutinated foraminifers of the *Reticulophragmium amplectens* Zone is represented abundantly and differentiated in species.

The anoxic (reduction) events were in the time of the *Globigerinatheka semiinvoluta* Zone and of sedimentation of the Lower Oligocene Menilite Shales. The paleoenvironment on the sea floor was reductional with abundance of pyrite and manganese without conditions for development of benthonic foraminifers. Planktonic foraminifers were pyritized after death and deposition. Tropical elements of planktonic foraminifers in the Upper Eocene and Oligocene are lacking. In this time, although there was a significant deepening of the sedimentary environment, there was also evidently coaling, chiefly in the Middle Oligocene. The present planktonic as well as calcareous benthonic foraminifers are of very nannic dimensions. Agglutinated foraminifers, besides sporadical finds of nannic representatives of the genera *Rhizammina* and *Rhabdammina,* are more or less absent.

It is thus confirmed that aglutinated foraminifers were living in the Western Carpathians also in shallow-water lagunal to marshy environment (Alve & Murray 1995), but these are always without accompaniment of bethonic calcareous and planktonic foraminifer associationos so as it isalready mentioned (Bieda 1969; Salaj 1998) and in many cases nannoplankton is also missing.

A significant event why in many passages of Upper Senonian and Paleogene flysch sediments benthonic foraminifers are not present is, besides the anoxic event, also the Fe-oxidation event .

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Foraminifera in the Cambrian of Nova Scotia: the oldest multichambered foraminifera

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Foraminifera found in the Early to Middle Cambrian deposits in Nova Scotia (Canada), are discussed and illustrated. The apparent lack of evolution, and the agglutinated and complex multichambered nature of these foraminifera suggest: 1) that the environment in which these organisms lived had some unique characteristics which favored the development of a successful assemblage which appear to have survived almost unchanged since the Cambrian, 2) that the complex chamber arrangements must have started to develop before 500Ma, and 3) that the multichambered calcareous foraminifera - which are the dominant foraminiferal group today - probably evolved from these early multichambered agglutinated species.

Lower Cretaceous agglutinated foraminifera from the central Poland (biostratigraphy and paleogeography)

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The presented material originates from the Early Neocomian sediments (Berriasian, Valanginian) in the central Poland area (boreholes: Łowicz IG-1, Gostynin IG-1, Siemnówek and from Wąwał quarry near Tomaszów Mazowiecki).

The Early Neocomian sediments were deposited under brackish - fresh, brackish - marine and marine conditions. The lithology and stratigraphy on that area have been established by many authors (Marek 1997; Raczyńska 1979;

Sztejn 1991; Witkowski 1969). Due to terrigenous nature of sediments, the agglutinated foraminifera decidely predominate over the calcareous ones.

The first Lower Cretaceous appearance of agglutinated foraminifera is know from the Early Berriasian sediments in the ostracoda horizon C (English lower part of the Cypridea granulosa zone). In central Poland the Lower Berriasian sequences are developed in the Purbeckian facies. The transitional environments (brackish basins and hypersaline lagoons) are represented by anhydrites, gypsum, limestones, marls, silts and claystones sediments. The small agglutinated foraminifera as far as rich Cypridea fauna are found in claystones intercalations. They are represented by species: *Verneuilina subminuta* Gorbatchik, *Verneuilina angularis* Gorbatchik, *Verneuilinoides faraonica* (Said & Bakarat), *Verneuilinoides* sp. and *Dorothia subtrochus* (Bartenstain). These forms are known from the Berriasian and Valanginian in the Tethyan area of Bobrogea in Romania (Neagu 1997) and from the Crimea (Kuznetzova & Gorbatchik 1985). Its appearance is related to the first marine ingression into Purbeckian basin in the Lower Berriasian from south-east.

In the early Middle Berriasian marine – brackish sediments, ostracoda horizon A (late English Cypridea granulosa zone), agglutinated foraminifera co-occurs with brackish and marine ostracoda fauna. The foraminifera are represented by following species: *Rhizammina indivisa* Brady, *Rhabdammina cylindrica* Glaessner, *Ammobaculites kcyniensis* Sztejn and genera: *Saccammina, Trochammina* and *Haplophragmoides.* During the Late Berriasian a typical marine environment persisted. It is expressed in shallow - marine transgressive deposits (fine grained sands, sandstones, silts, clays and shales). In this period a very strong dominance of agglutinated taxa is observed in contrast to the sporadic occurrence or complete absence of calcareous forms. The most numerous species are: *Trochammina inflata* (Montagu), *Trochamminoides proteus* (Karrer), *Haplophragmoides cushmani* Loeblich & Tappan, *Haplophragmoides concavus* (Chapman), *Ammobaculites agglutinans* (d Orbigny), *Ammobaculites irregulariformis* Bartenstein & Brand, *Proteoina difflugiformis* Brady, *Bulbobaculites* ex. gr. *inconstans* (Bartenstein & Brand) and other species from genera: *Ammobaculites, Glomospirella, Recurvoides, Saccammina* and *Haplophragmium.* The agglutinated foraminifera still dominated also in the Lower Valanginian shallowing sediments of sandy shales and siltstones.

A strong transgresssion in the Upper Valanginian tooks place. The sediments rapidly pass up from sandy - silty to clayey with many fossils: fomaninifera, ostracoda, ammonites, belemnites, bivalves and brachiopods. They are characterized by a rapid increase in diversity of foraminifera fauna. In the central Poland the highest diversity and number of the calcareous forms has been observed. The agglutinated foraminifera assemblages are represented species: *Marsonella kummi* Zedler, *Dorothia hechti* Dieni & Massari, *Dorothia praeoxycona* Moullade, *Glomospirella gaultina* (Bethelin), *Ammodiscus tenuissimus* (Gumbel), *Trochammina inflata* (Montagu), *Haplophragmoides cushmani* Loeblich & Tappan and genera: ?*Kaminskia, Ammobaculites, Haplophragmium, Rhizammina, Reophax* and *Verneuilinoides.* The foraminifera from this part of Neocomian sediments are originated from both subboreal (West European) and Mediterranean area provinces.

In the latest Upper Valanginian the agglutinated foraminifera are scarce, the calcareous tests disappear completely. It is due to regression and slight shallowing of the depositional basin. The above date indicate that a large number of agglutinated forms are particulary abundant in sediments representing periods of shallow marine deposits, fewer of them occur in the sediments representing periods of regression and fresh water supply.

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Paleoenvironmental changes across the Karpatian/Badenian (Early/Middle Miocene) boundary in the Styrian Basin (Austria, Central Paratethys).

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The Styrian Basin is situated in the western part of the Intracarpathian Pannonian basin system (Fig. 1). It is separated by the South Burgenland Swell from the Danube Basin and is subdivided by ridges and faults in different subbasins. During an Early Miocene synrift phase (probably beginning in the Ottnangian) in the transition zone between the Eastern Alps and the Pannonian realm, basin formation started (Ebner & Sachsenhofer 1995; Sachsenhofer 1996; Tari 1996). Paleogeographically the Styrian Basin belongs to the Central Paratethys.
According to Kollmann (1965) sedimentation began with red clays, breccias, limnic-fluviatile sandstones and shales, interpreted as swamp and flood plain deposits. In the Western Styrian Subbasin coarse fan deposits are followed by a lignite bearing sequence. Synsedimentary fault tectonic and rapid subsidence caused an ingression of the sea in the Karpatian. This tectonic activity was accompanied by extensive volcanism. Karpatian basal comglomerates are recorded from some deep drill sites. Shales and silts of the *„Steirischer Schlier"* were deposited in a deep sea environment. Foraminiferal assemblages of the section in the old brickyard Wagna have been studied by quantitative analyses (Spezzaferri et al. 2001). The species composition was compared with assemblages from deep drillings. The benthic assemblages are dominated by agglutinated species with floods of *Gaudryinopsis beregoviensis* (Venglinskyi). In varying numbers occur also *Bathysiphon, Rhabdammina, Ammodiscus, Reophax, Haplophragmoides, Cribrostomoides, Budashevaella, Reticulophragmium, Alveolophragmium, Cyclammina, Spirorutilus, Textularia*, and *Martinotiella*. Canaliculate species are rare.
The „Styrian discordance" or „Styrian phase" of Stille (1924) is based on an erosional gap between the Karpatian and Badenian. This erosion surface is very distinctive along the Middle Styrian- or Sausal Swell, originating in the tilting of blocks and uplift. During Badenian time the sea reached its largest extent. In different drill sites the Badenian sedimentation started with a basal conglomerate, but the begin of sedimentation is time-transgressive in different parts of the basin. The section at Wagna exhibits a layer of gravels on top of the *„Steirischer Schlier"*. Dark grey silts follow concordantly but without a distinct faunal change. Shallow environment is shown upsection in fine sands by the assemblage of *Ammonia, Nonion, Elphidiella, Elphidium*, small globigerinids, and smooth-shelled ostracods. The calcareous nannoplankton is still of NN 4 zone. A distinct angular unconformity separates the shales from the calcareous sediments on top. The lower part of sandy marls and sands has still a rather poor shallow water fauna. The marly layers of the following corallinacean limstone yield a richer, badly preserved assemblage with elphidiids, cibicidids, *Eponides, Pararotalia*, and *Amphistegina*. The planktic species with *Globigerinoides bisphericus, Gs. trilobus,* and *Praeorbulina circularis* are indicative for Early Badenian.
The so-far earliest Badenian sediments were found in the deep drill site Petersdorf 1. On top of a basal conglomerate follow marine calcareous shales and sandstones with an indistinctive planktic fauna but an agglutinated assemblage similar to that of the Karpatian, with frequent *G. beregoviensis*. In the hanging wall part of the section silt and sand increase, and *Praeorbulina glomerosa* occurs. The benthic fauna with a dominance of agglutinated forms continues, indicating the same environmental conditions as in the deep basin of the *„Steirischer Schlier"*. Upsection the number of planktic and calcareous benthic specimens increases with a co-occurrence of *Praeorbulina glomerosa* and *Orbulina suturalis*. The agglutinated assemblages indicates shallowing upward tendencies by the more common occurrence of,

e.g., *Karreriella bradyi, Paragaudryina interjuncta, Pseudogaudryina mayeriana, Bigenerina agglutinans, Cylindroclavulina rudis,* and *Martinotiella communis*. In the higher part, without *Praeorbulina*, agglutinated specimens are scarce.

In the Gnas Subbasin the sedimentation begins in deep drilling Perbersdorf 1 (Kollmann 1965) with a conglomeratic limnic-fluviatile sequence, followed by Karpatian marine shales with tuffites. The partly rich fauna is dominated by agglutinated assemblages. The stratigraphically important *Uvigerina graciliformis* occurs thoughout, whereas *Globigerinoides bisphericus* appears only in the higher part of the Karpatian. Separated by a distinct discordance follow Early Badenian silty and sandy marls with *Praeorbulina*. In the Fürstenfeld Subbasin the Karpatian sequence of Übersbach 1 is similar with basal conglomerates and the „*Steirischer Schlier*". In contrast the Badenian begins also with a basal conglomerate. But the marls contain already *Orbulina suturalis* and rich calcareous benthic fauna. This indicates that the lower part of Badenian with *Praeorbulina* and an agglutinated deep water fauna is missing.

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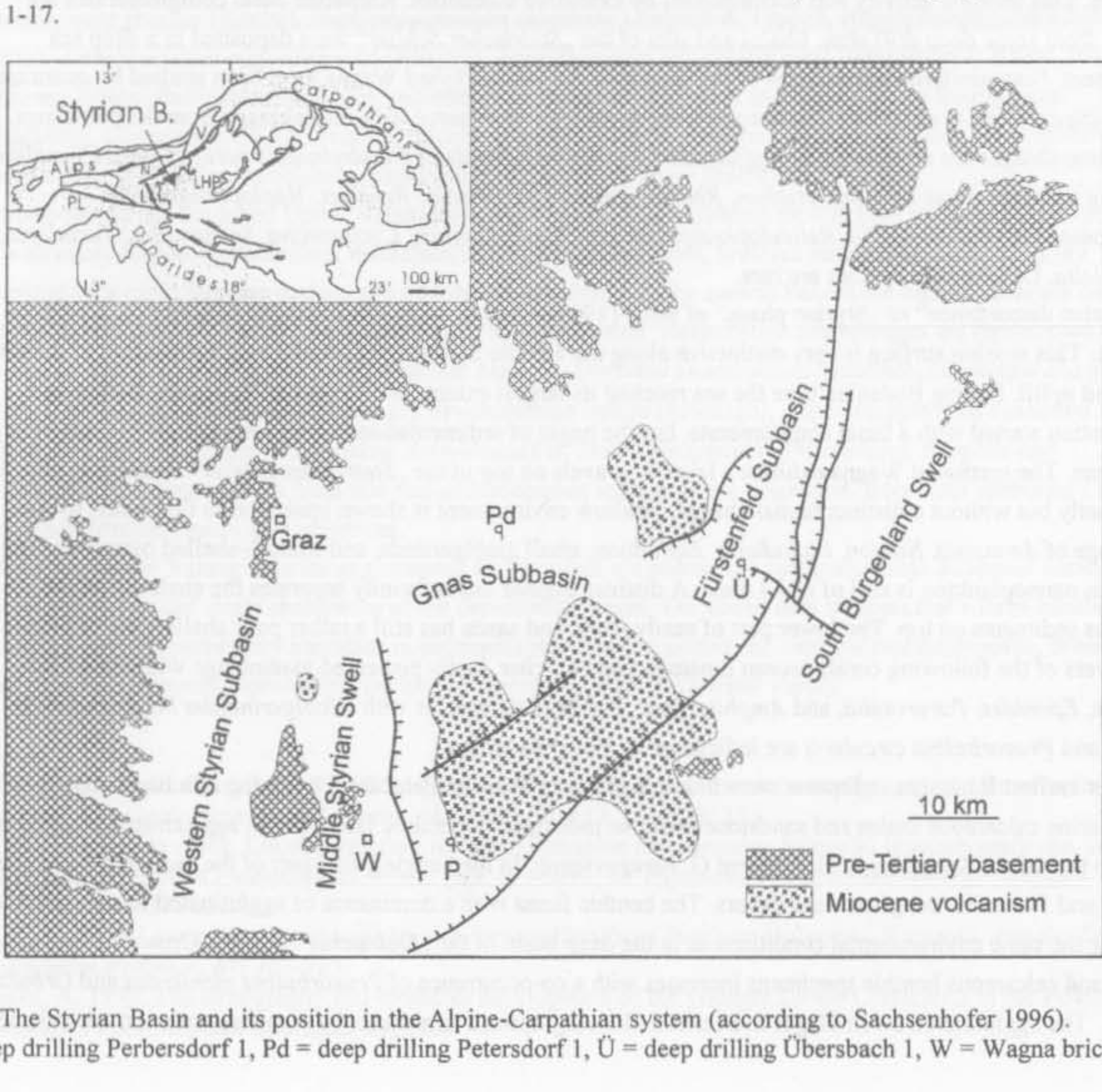

Fig. 1. The Styrian Basin and its position in the Alpine-Carpathian system (according to Sachsenhofer 1996). P = deep drilling Perbersdorf 1, Pd = deep drilling Petersdorf 1, Ü = deep drilling Übersbach 1, W = Wagna brickyard.

Distribution of Recent Agglutinated Foraminifera in South West England Estuaries

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It has become apparent from pollution impact studies (Sharifi 1991; Sharifi *et al.* 1991; Stubbles 1993; 1999; Stubbles *et al.* 1996a) and global changes in climate that it is highly desirable to document foraminiferal species distribution in our estuaries before deleterious effects remove or exert changes that would otherwise not have occurred. Baseline studies provide essential information that achieves this aim. As part of a metal pollution post-impact study of Restronguet Creek (south west Cornwall, England), an area heavily influenced by acid mine drainage for several centuries, other estuaries not previously investigated, were sampled to provide background data on species distribution. The estuaries sampled in Devon (south-west England) were the, Axe, Kingsbridge, Avon, Erme and Yealm. In Cornwall (south-west England) the Looe and Fowey estuaries and the main channel of the Carrick Roads (estuary of the Fal River) with its associated small creeks were also sampled. For the Erme, Avon and Fowey Estuaries there are full seasonal data sets.

It is apparent from the baseline data that the estuaries have distinctively different species compositions relative to the Restronguet Creek and Carrick Roads data suite. The latter locations have an all calcareous assemblage throughout. Much of the dissimilarity shown between the estuaries, and Restronguet Creek/Carrick Roads is due to the high proportions of *Miliammina fusca* in the upper part and creeks of each estuary with low abundances of *Jadammina macrescens*, *Trochammina inflata* and *Reophax moniliforme*. The exception to this is the Kingsbridge Estuary (more accurately described as a coastal embayment), which has suffered catchment loss and receives very little freshwater flow. Consequently, salinity levels exceed the maximum values recorded in the other estuaries sampled (>37‰) and species distribution, therefore, differs to all other locations with assemblages dominated by *Ammonia beccarii*. With respect to the other baseline estuaries *M. fusca* only penetrates into the mid - estuary areas, as a dominant species, during the dormancy periods of the calcareous species; e.g., in the Erme Estuary (Stubbles 1995) during the winter. Spatial similarity only exists between Restronguet Creek and each baseline estuary when the proportions of the agglutinating species are reduced relative to the calcareous component; e.g., the Fowey Estuary in the summer during which the assemblages are dominated by *Haynesina germanica*. *Miliammina fusca* does not appear to be as well established in the Looe and Fowey Estuaries relative to the Axe, Yealm, Erme and Avon, but as with the latter four estuaries, this species is largely limited to the upper estuarine areas where salinity is lowest. Relative to the other estuaries, higher salinities were recorded in the Fowey Estuary, which is probably due to dredging in the lower estuary. This may be influencing the distribution of *M. fusca*, which shows a significant negative correlation with salinity, particularly in the Fowey Estuary. The dominant species *H. germanica* shows a significant positive association with salinity, and, more occasionally with temperature, which suggests that this species favours higher salinity and temperature regimes. The additional depth generated throughout the estuary by the dredging probably does not limit the distribution of *M. fusca* as this species has been found living (stained) to depths of 35m within lower salinity bottom waters (Hermelin 1987). The short core taken from the Fowey Estuary shows an all calcareous fauna below 34cm with an approximate date of 1885 (Pirrie & Camm 1999). It is evident from present day and historical data, therefore, that Restronguet Creek and the Fowey Estuary have had similar species colonisation histories and the more recent colonisation by the agglutinating species, into the latter estuary, has taken place after the main pulse of mining contamination had ceased and probably after dredging commenced in 1904 which promoted dilution of acid mine drainage from the abandoned mines.

It is evident by the spatial and temporal distribution of *M. fusca* in the baseline estuaries that it is seasonally out-competed by the rotalid species. This distributional behaviour exhibited by *M. fusca* would suggest that this species may be an opportunist and only expands its distribution when the environmental conditions favour it and most usually when the calcareous taxa are dormant or absent (Setty 1984). The temporal and spatial distribution and assemblage dominance shown by *Elphidium williamsoni* in the Erme and Avon Estuaries and with *H. germanica* in the Fowey Estuary, suggests that these species may prevent *M. fusca* colonising new locations. This response to competition is more pronounced in the Fowey Estuary, whereby the spatial distribution of *M. fusca* shows greater limitation. This may reflect past mining influence, in addition to the previously discussed higher salinity and temperature regimes in the main channel the conditions of which may favour the calcareous species (Buzas 1969). It may be significant that the extent and period of metal mining affecting Restronguet Creek and the Fowey Estuary are similar, whereas the Yealm, Erme and Avon Estuaries, which physiologically closely resemble each other, were only mildly influenced by mining. The Looe Estuary was only moderately influenced by silver-lead mining. The Axe and Kingsbridge Estuaries suffered no impact from mining and do not drain metalliferous geology.

The absence of the agglutinating species in Restronguet Creek and within the environs of the Carrick Roads may not have been caused by the major discharge in January 1992. At present, species competition may be the controlling factor but the core taken from the Fowey Estuary demonstrates that colonisation can take place after a relatively short period of reduced mining activity. The geographical distribution of the agglutinating species in south-west England would suggest that the frequency of occurrence and abundance of these species increases from west to east. This follows a similar trend exhibited by the geology and mining of polymineralic ores, (particularly copper) the presence of which decrease in the peninsular from west to east.

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Agglutinated foraminifers from the uppermost Jurassic-Neocomian Silesian Basin of the Polish Outer Carpathians

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In the Silesian Basin of the Polish Outer Carpathian the so-called Cieszyn Beds represent the uppermost Jurassic-Neocomian sediments. These sediments divided into informal litological units: Lower Cieszyn Beds, Cieszyn Limestones and Upper Cieszyn Shales yielded on specific foraminiferal assemblages. At the beginig of sedimentation correlated with nonflysch marly sediments in the Silesian Basin (Upper Tithonian Lower Cieszyn Shales) microfaunas are dominated by calcareous benthic foraminifers (nodosarids, polymorphinids, involutinids) which correspond to those of the carbonate platform of northern European margins of the Tethys (Szydlo & Jugowiec 1999). These shelf associations are accompanied by not so numerous foraminifers partly agglutining calcareous material. These forms belong mainly to superfamily Verneuilinacea (*Paleogaudryina varsoviensis*, *Belorussiella wolinensis*, *B. taurica*), Textulariacea (*Protomarssonella kummi*), Spiroplectamminacea (*Textulariopsis jurassica*, ?*Haghimashella arcuata*) and Cyclolinacea (*Pseudocyclammina*: *P. jaccardi P. lituus*). At the Jurassic-Cretaceous boundary, in the top of the Lower Cieszyn Shales, which contain olistolites (= Ropice horizon, Szydlo & Nescieruk in print) and also in coincident Cieszyn Limestones (Geroch 1966) the mass occurence of the shallow water foraminifers is noted. Apart from rare pseudocyclaminas frequent calcareous benthic forms are observed: andersenolinas, neotrocholinas, trocholinas and single discorbids.

This episode precedes the second stage of sedimentation in the Silesian Basin that is dated at Berriasian. Contemporary Cieszyn Limestones comprise completely different assemblages. The first of them includes rare *Verneuilinoides* and calcareous benthic forms of *Conorbina* and *Discorbis*. The second type is more typical and comprises practically only agglutinated genera: *Ammodiscus*, *Glomospira*, *Trochammina*, and *Pseudoreophax*. The two latest forms create acme zones (Olszewska 1996). The association with *Trochammina quinqueloba* is observed rather in the Cieszyn Limestones. On the other hand assemblage with *Pseudorephax cisovnicensis* seems to be typical for overlaying the Upper Cieszyn Shales dated at the Valanginian. At that time the third stage of developement of the Silesian Basin begins. The poor agglutinated assemblages are accompanied with very rare and badly preserved nodosariids. By the end of the Valanginian and at the begining of the Hauterivian more differentiated associations occur. These ones with *Bigenerina* (e.g. *B. jurassica*, ?*B. clavellata*) and *Uvigerinammina uvigeriniformis* are very rare. The others with *Vernuilinoides neocomiensis* and *Praedorothia hauteriviana* are much more frequent.

The succesion of agglutinated assemblages in Silesian Basin presented above seems to be more differented in comparision with schemas of Geroch & Nowak (1986), Geroch & Olszewska (1990) and Olszewska (1996). The distribution of acme zones based on agglutinated foraminifers depends, first of all, on ecological conditions Thus, succesion of the assemblages, as described in the papers quoted above, may reflect stable environments of central part of the basin. On the other hand, the part of the agglutinated forms described by author may be related to a more proximal part of the basin.

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An atlas of Albian foraminifera from the Lower Saxony Basin (Kirchrode I and II, Northern Germany)

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The Albian foraminifera from the Lower Saxony Basin have experienced a great interest since Reuss' (1863) monograph "Die Foraminiferen des norddeutschen Hils und Gault" was published. His monograph described remarkable number of new taxa, which still represent the most used species in the Albian and the Cretaceous taxonomy (latest review of Reuss' collection has been recently published by Meyn & Vespermann 1994). Since Reuss' time, many important papers on benthic foraminifers from the type area have been published. Nevertheless, to date there has been no attempt at compiling a comprehensive synthesis of the benthic foraminifera from the whole Albian succession in this area, partly due to the lack of complete sections. Unfortunately, soft Albian clays are poorly outcropped in clay pits, local channel sections, or boreholes.

Boreal Cretaceous Cycle Project offered an opportunity to drill a full succession of the Albian in the middle of the Lower Saxony Basin. Kirchrode I and II boreholes (latitude 52°22,40 N, longitude 9°49,39 E) were located in Hannover and recovered a more than 370 m thick section of the Albian. The cores consist of hemipelagic dark grey, pale and grey-green marlstones and contain no coarse terrigenous input (Fenner in press). The biostratigraphic framework is based on ammonites (Wiedmann and Owen in press). This study forms a part of the international ALBICORE Project, which is focused on a high resolution sedimentary record to analyze short- and long-term palaeoceanographic and climatic changes. The Lower Saxony Basin was chosen, because it is placed in the mid-latitudes, providing an example of the Cretaceous "Boreal" realm (see Fenner in press).

More than 400 samples gave a unique opportunity to describe a fairly complete list of benthic foraminiferal taxa in the most continuous and well biostratigraphically dated succession. The atlas presents a systematic documentation of Albian agglutinated and calcareous benthic foraminifera from both Kirchrode boreholes. This poster illustrates 93 species of small agglutinated foraminifera on 41 plates prepared for publication. Most of the agglutinated foraminiferal species occur in the whole succession. But some of them show limited distribution and can be used as regional biostratigraphic markers. These marker species includes: *Gaudryinella sherlocki* Bettensteadt, *Belorussiella textilarioides* (Reuss), *Spiroplectammina gaultana* Lalicker, *Eggerellina mariae* Ten Dam, *Arenobulimina chapmani* Cushman, *A. macfadyeni* Cushman, *A. frankei* Cushman, *Protomarssonella levis* (Magniez-Jannin); *Recurvoides imperfectus* (Hanzlikova), and some others. Authors are open for discussion and evaluation of taxonomic results of this work.

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Analysis of test ontogenesis in small foraminifera: *Pseudonodosinella*

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An overall shape of a foraminiferal test depends to a large extend on chamber arrangement during its ontogeny. This arrangement, size, proportions, expansion rate of chambers among other features (test composition, aperture type, ornamentation etc.) let us identify taxa and their variability. Earliest attempt in understanding of foraminiferal shell ontogeny was presented by D'Arcy W. Thompson (1942). Most studies of ontogenetic test trends focused on large foraminifera (e.g. see Scott 1974 for an overview). This study goes back to basics, discussing methods of presenting ontogenetic morphometric data and focusing on simple uniserial forms represented by agglutinated foraminifers, which belong to the genus *Pseudonodosinella* (see Fig. 1A, B, C). The analysis is based on the Albian foraminifers from the Lower Saxony (Kirchrode II borehole). Most of the specimens resemble *Scherochorella minuta* (Tappan). Recently, this deep-water species has been revised by Geroch & Kaminski (1995) and assigned to *P. troyeri* (Tappan) or *P. parvula* (Huss).

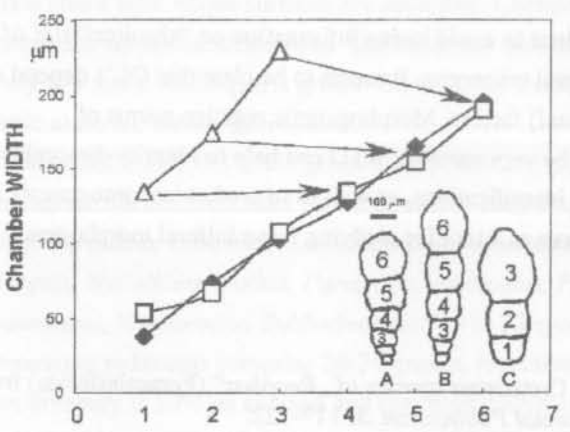

Fig. 1a

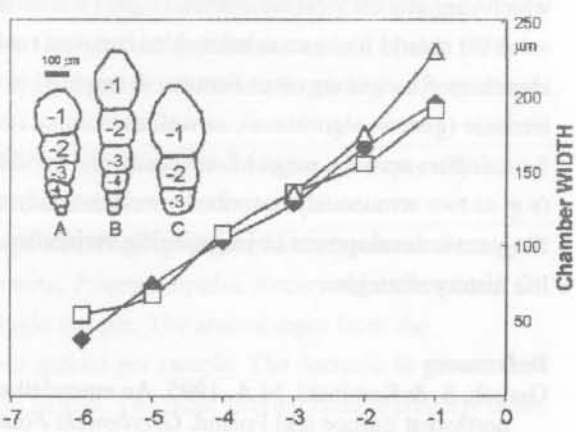

Fig. 1b

Analysis of test ontogenesis (ATO), as ontogenesis itself, has to be referred to the time scale. Time of chamber accretion can only be documented in cultures. Another way is to use events as a relative time reference, i.e. discrete growth steps (chambers) in this case. The most popular is to number successive chambers from the proloculus towards the final chamber. It seems to be very logical because numbers mimic growth steps during ontogeny. These chamber numbers are usually presented against chamber dimensions (width, height, diameter etc.). The result is often very difficult to interpret, because "ontogenetic lines" (OL or growth curves) are distinctly shifted (Fig. 1a).

"Backwards" counting from #1 for the last chamber and the highest # for a proloculus is proposed. But foraminifers do not grow backwards, thus, negative value for every number is preferred. It can be seen that OLs and numbering in all specimens fit much better (Fig. 1b). Final (terminal) chambers are here better reference points than proloculi. In case of *Pseudonodosinella* and probably many other taxa, it appears that the size and proportions of final chambers may serve as additional taxonomic (specific) feature.

Chamber number, as a reference point, is not perfect anyway, because integers (chamber numbers) are related to rational numbers (scalar values). Relationships between two scalar values of every successive chamber (height against width) give an alternative. Correlation of these points reveals a logarithmic curve (R^2=0.93) as the best fit for three monospecific specimens of *Pseudonodosinella* discussed here. This curve represents an average OL. It can be noted that the microspheric (Fig. 1: A, B) and megalospheric forms (such as C) of the same species follow the same OL (compare

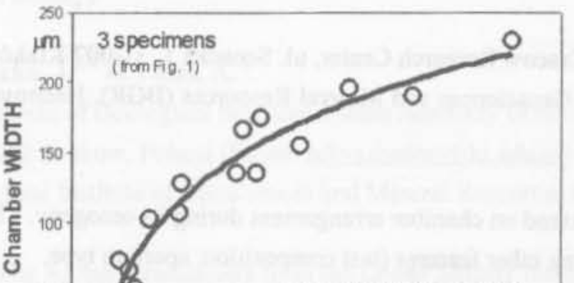

Fig. 2a

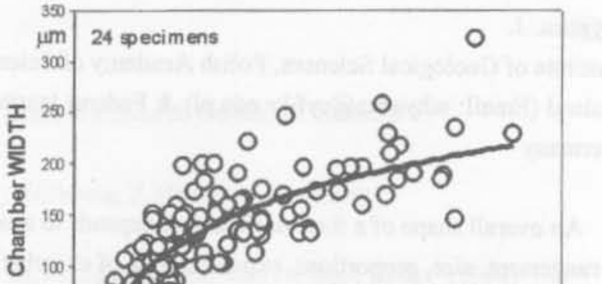

Fig. 2b

Figs 1b, 2a). All chambers from all specimens are treated here as separated units which don't yield any information on a specimen itself and the position in a succession of chambers. The logarithmic curve is an averaged OL. Logarithmic correlation of chamber dimensions from 24 randomly chosen specimens (Fig. 2b) shows a weak correlation (R^2=0.65), which suggests their heterospecific origin (at least 3 species).

ATO should focus on relationships between real scalar values to avoid losing information on "absolute" size of chambers. Size among other features is essential in foraminiferal taxonomy. It seems to be clear that OL's depend on intrinsic (genetic algorithms), as well as external (environmental) factors. Morphogenetic reaction norms of foraminifers across a range of environmental conditions may be very variable. ATO can help to identify dimorphism (e.g. as two erroneously described species), verify qualitative identifications, as well as to predict test ontogenesis in filogenetic development or intraspecific variability. It may serve as a tool for studying foraminiferal morphogenesis and life history strategies.

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Agglutinated foraminiferal assemblage from bentonite layers of the Subsilesian Unit (Polish Flysch Carpathians)

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Rocks of volcanic origin have been found in the Lower Palaeogene sediments of the Subsilesian Unit in the Żywiec tectonic window (Żarnówka stream). These are 14 thin white bentonite layers embedded within greenish-brown clayey shales (Leśniak & Waśkowska-Oliwa 2001).

Age of these sediments was determined from biostratigraphic ranges of agglutinated foraminifers, which dominate in the microfossil assemblage. Early Eocene age is indicated by numerous foraminifers of genera *Glomospira*, *Paratrochamminoides, Rhabdammina* and *Recurvoides*, scarce foraminifers of *Haplophragmoides walteri* (Grzybowski), *Reophax elongatus* Grzybowski, *Reophax pilulifer* Brady, *Spiroplectammina spectabilis* (Grzybowski). Single specimens of *Saccamminoides carpathicus* Geroch were present in some samples. This species is accepted as an index species for the Early Eocene in the operative biostratigraphic schemes for the Flysch Carpathians; its first occurrence is reported above the Palaeocene/Eocene boundary (Geroch & Nowak 1984; Olszewska 1997). The foraminifers represent the *Glomospira* div. sp. Zone, dated at the older part of the Early Eocene (the Zone *sensu* Olszewska 1997).

Foraminiferal assemblage consisted mostly of well-preserved agglutinated benthos. Calcareous foraminifers make up 0.4–5% of the assemblage and are rather poorly preserved. *Nuttallides truempyi* (Nuttall) – a species typical of bathial and abyssal zones (Tjalsma & Lohmann 1983) - is the most numerous among the calcareous benthos. Such assemblage of foraminifers could occur above the CCD, in the lower part of foraminiferal lysocline and at that depth the bentonite layers were laid down in the Early Eocene.

The analysis of microfauna in the bentonites and their encompassing sediments has revealed some variations in the foraminiferal assemblages. The first difference is the outer aspect of the tests, which depends on the environment in which the foraminifers lived, mainly on the type of material supplied to the basin bottom. In the assemblages from bentonites, 20 % of agglutinated foraminifers, on average, have grey tests – typical for all foraminifers from green-brown shales. These are mostly infaunal foraminifers. The other foraminiferal tests from bentonites (*ca* 80 %) are white, built of material finer than typical agglutinated tests. The difference in size of the grains that build the tests is especially well visible in genera *Rhabdammina* and *Gerochammina*; the fine-grained forms such as *Glomospira charoides* (Jones & Parker) have tests whose surfaces are smoother. Chemical analyses of the foraminiferal tests from both types of sediments did not reveal differences. The bentonite sediments are very fine-grained and consist mainly of clay particles and very few small white quartz grains. On the other hand, the encompassing shales include a much higher proportion of clastic material, mainly grey quartz.

Another difference lies in the genus and species composition of the foraminiferal assemblages. As expected, the assemblages from bentonites are less diversified. They consist of 12-14 genera (that is *Ammodiscus, Ammosphaeroidina, Cibicides, Gerochammina, Glomospira, Glomospirella, Haplophragmoides, Hyperammina, Kalamopsis, Nuttallides, Nothia, Paratrochamminoides, Praecystammina, Psamminopelta, Recurvoides, Reophax, Rhabdammina, Rhizammina, Subbotina*), and 15 to 23 species in a single sample. The assemblages from the encompassing sediments comprise 20-26 genera, represented by 31-43 species per sample. The decrease in generic and species diversity is 50% on average and concerns mainly the epifaunal genera. The most striking change consists in the proportion of genus *Glomospira*, represented mainly by *Glomospira charoides* (Jones & Parker) and somewhat less numerous *Glomospira gordialis* (Jones & Parker). The proportion of *Glomospira* in bentonite varies within 50-70%, while it is only 36-42% in the encompassing sediment. The bentonite layers include less suspension feeders, such as *Rhabdammina* or *Rhizammina*, which may be related to the somewhat different nature of sediment supply to the basin bottom. Relatively numerous is the group of infauna, including deep infauna, whose proportion does not differ between the assemblages from bentonites and the encompassing sediments. Considering the small thickness of the studied bentonite layers, varying from 0.5 to 2 cm (we do not know how thick they were before compaction), we must take into account that the infauna could be protected from the changes caused by the presence of volcanic ash during its deposition. Aggregate samples (from bentonite and encompassing sediment) included tests of genus *Gerochammina*, which had features characteristic for the epifaunal assemblage from the bentonites. They were smaller than typical tests and were built of white, fine-grained quartz. Additional studies of microfauna, based on detailed sampling of the sediment directly overlying the bentonites, may reveal if there were any changes in the infauna group.

Another important difference is discrepancies in the foraminifer size. The foraminifers from bentonites, with white tests, are distinctly smaller than typical foraminifers from the encompassing sediments – with grey tests. For a closer examination of this phenomenon, diameters of *Glomospira charoides* (Jones & Parker) tests – the most common species in both types of sediments – were measured. The diameters of tests in the shale were 0.28 mm to 0.83 mm, with most specimens falling within the 0.44-0.55 mm range. The range of test diameters in *Glomospira* from bentonites is 0.22-0.5 mm and 70% of them are within 0.28-0.4 mm in size. Similar differences in test size and in the number of foraminifers of the genus *Glomospira* were observed in bentonites of the same age from the Wiśniowa tectonic window. They were interpreted as a result of changes in environment (Salata *et al.* 2001).

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Biostratigraphy and paleoenvironmental analysis of benthic Foraminifera and radiolarians in Paleogene variegated shales of the Subsilesian unit Polish Flysh Carpathians

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Variegated shales are characteristic deposits in the Flysch Carpathians and include red, green and grey shales, claystones and mudstones. These deposits extend in the Flysch Carpathians from the Cenomanian to the Upper Eocene (Książkiewicz, 1962). Similar red clay facies occur also in the Alps, Appeninnes, North Atlantic and Pacific. Palaeogene variegated shales in the Subsilesian Unit of the Polish Flysch Carpathians have been studied in order to understand their depositional environments and biostratigraphy.

The studied section is located in the Wisniowa tectonic window (Czerwin stream). Greenish to brown clayey shales with thin sandstone intercalations are exposed here. These deposits are characterized by very abundant radiolarian assemblage and benthic foraminifera.

The foraminiferal assemblage consists of well-preserved and diversified agglutinated taxa. Numerous specimens of *Saccamminoides carpathicus* Geroch, *Gerochammina conversa* (Grzybowski), *Glomospira gordialis* (Jones et Parker), *G. charoides* (Jones et Parker), *Haplophragmoides walteri* Grzybowski, *H. kirki* Wickenden, *Paratrochamminoides* div. sp., *Recurvoides* div. sp. and *Rhabdammina* sp. are characteristic for this assemblage. These forms are accompanied by *Ammodiscus* div. sp., *Arenobulimina* sp., *Glomospirella grzybowskii* (Jurkiewicz), *Karrerulina coniformis* (Grzybowski), *Nothia excelsa* (Grzybowski), *Praecystammina* cf. *seveni* Gradstein et Kaminski, *Reophax elongatus* Grzybowski, *R. pilulifer* Brady, *Spiroplectammina spectabilis* (Grzybowski) and *Trochammina* div. sp. The foraminiferal assemblage can be placed in the *Saccamminoides carpathicus* foraminiferal zone of Geroch & Nowak (1984), an indicator of the lower part of the lower Eocene (Olszewska, 1997).

All radiolarian skeletons are well-preserved and pyritized. Radiolarian assemblage comprise species such as: *Calocycloma ampulla* (Ehrenberg), *Buryella clinata* Foreman, *Phormocyrtis striata striata* Brandt, *Lychnocanomma bellum* (Clark et Campbell), *L. auxilla* Foreman, *L. babylonis* (Clark et Campbell), *Amphisphaera minor* (Clark et Campbell) and *Stylosphaera coronata coronata* Ehrenberg. This assemblage can be placed in lower part of *Phormocyrtis striata striata* radiolarian zone of Sanfilippo *et al.* (1985).

The deposits investigated are devoid of foraminiferal plankton; only agglutinated benthic forms are present, also with some agglutinated specimens with calcareous cement as *Arenobulimina*. It may suggests that sedimentation took place in the lower part of lysocline.

The benthic foraminiferal assemblage consists of all type of morphogrups representing different microhabit preferences. It is characterised by numerous suspension feeding forms (35%) and high content (40%) of mobile epifauna. The whole content of epifaunal forms – nearly 80% - suggests that the sedimentation of these deposits took place under the high-energy conditions, where the food was supplied by distal turbidity currents. The presence of high amount of epifauna and infauna can be a result of well oxygenatation of bottom waters and the highest part of the sediments.

Large amount of radiolarians documents a high productivity within the surface waters caused by upwelling system. In the present-day oceans, high nutrient levels in upwelling regime promote higher phytoplankton productivity, in turn causing the higher rates of radiolarian productivity and deposition of radiolarian-rich deposits (Blueford, King 1983; Blueford, 1988). High productivity of organic matter generated a zone of anoxic water, which may caused dissolution of calcareous plankton and pyritization of radiolarian skeletons within a water column (model of Bak & Sawłowicz, 2000).

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