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abstract volume

Novel approaches for the analysis of organic components in the test wall of agglutinated foraminifera with the use of Fourier Infrared and Pyrolysis Gas Chromatography Mass Spectrometry.

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Certain agglutinated foraminifera have organic cements. Morphological features have been previously distinguished. Chemical, and structural information about these organic components is lacking. Previous investigations indicate that the material is glycoproteinaceous in nature, recently termed a glycosamminoglycan.

Astrammina rara Rhumbler, an Antarctic shelf foraminifera and also temperate marsh agglutinated foraminifera *Jadammina macrescens* (Brady), *Trochammina inflata* Montagu and calcareous foraminifera *Ammonia Beccarii* (Linné) were used for the analysis. Analysis was performed observing traces of organic components within the overall shell, along with specific organic lining analysis. Fourier Transform Infra-Red (FT-IR) analyses of chitin, a typical glycosamminoglycan, and collagen, a typical glycoprotein were carried out for comparative purposes.

Whole shell analysis indicate that organic cements are detectable with FT-IR. Results from FT-IR on organic linings vary slightly with the type of foraminifera analysed, although lining material in all species analysed has a proteinaceous base with additional carbohydrate components. Locations of absorptions within the amide 1 ($1680/1630cm^{-1}$) region indicate that the complex materials within Antarctic and marsh foraminifera may be structurally different. The region between $1200\text{-}1250cm^{-1}$ may also indicate the presence of sulphated groups within the organic structures. Sulphated groups may be potential sites for binding of metal ions.

Pyrolysis Gas Chromatography Mass Spectrometry (Py-GCMS) produces detailed information about pyrolysis products from the foraminifera shells and linings. The predominant traces are from proteinaceous components, lacking in abundant carbohydrate/sugar moieties. Comparison of results from foraminiferal lining GC-Mass Spectrometry products and the standard glycosamminoglycan indicates that materials may not be as carbohydrate-rich as previously thought.

FT-IR, and Py-GCMS have provided structural and chemical information about the nature of organic lining material and cementation products, hence proving to be useful tools for the microanalysis of agglutinated foraminifera shells. Despite overall similarities, small differences have been highlighted between the organic components of agglutinated foraminifera genera and are continuing to be investigated.

Quaternary deep-water agglutinated foraminifera from the Gulf of Aden, northwestern Indian Ocean

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The distribution of agglutinated foraminifera was determined in core material taken in the Gulf of Aden, northwestern Indian Ocean (12°51.5'N/ 47°25.0'E, 1631 m water depth) by the R/V *Meteor* cruise 5, leg 2. The sedimentary record presents the last ~530 kyr (isotope stages [IS] 1-14) including six glacial/interglacial cycles. The core is located at the distal margins of the Arabian Sea and off Somalian active upwelling systems. Intermediate primary productivity levels characterize the G. Aden's region with a well developed OMZ at intermediate water depths, becoming more aerated towards the deep water mass. At present ~1.0% of organic carbon accumulates at the sea-floor and the carbonate content is nearly 50%.

The agglutinated foraminifers are a minor component among the relatively abundant and well diversified benthic foraminifers, comprising an average 7.5% of the benthic foraminiferal numerical abundance totaling 14.6 agglutinated foraminifers/g dry sediment. Maximal and minimal abundance peaks of the agglutinated foraminiferal group coincide with those of the calcareous benthic foraminifera pointing to a common paleoecological cause to these events. The diversity of the group is low with 7.9 species/sample in average, constituting only ~10% of the total raw diversity of the benthic foraminiferal community.

The Late Quaternary G. Aden's assemblage is composed mainly by the elongate trochospiral/tri-/bi-/uniserial, perforate, calcite-cemented agglutinated species. Eight species belonging to the genera: *Eggerella, Karreriella, Martinottiella, Siphotextularia* and *Textularia* dominate along the core. *Eggerella bradyi*, the most common species among the agglutinants, occurs in relative abundance varying between 0-84ý% of the total assemblage. In general *E. bradyi* is more common during the interglacial stages. The glacial/interglacial cyclicity of *E. bradyi* resembles the abundance pattern of the intermediate water planktic foraminifer *Globorotalia menardii*. The resemblance between these unrelated taxa, occupying different habitats may suggest that changes in the intensity of the OMZ at intermediate water depths reflecting large-scale fluctuations in primary productivity is controlling the abundance pattern of these two common species.

Textularia milletti, the 2nd in the agglutinated foraminiferal relative abundance ranking, is in general more abundant during the glacial stages. The opposite abundance pattern of *T. milletti* as compared to that of *E. bradyi* may suggests that the former species represents an end-member in its bottom water / food requirements compared to the later species.

During the glacial stages a rather higher species diversity occurs resulting also from the exclusive occurrence of some rare species like *Spiroplectammina* sp., *Textularia* cf. *T. sagittula* and *Textularia* sp.1 reflecting more tolerable bottom water conditions.

MOZ energy 100m - 1000m

Do calc-agglutinated and calcareous shelf foraminferal assemblages leave worthwhile ecological information after their dissolution?

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The most obvious features of the shelf seas to the west of southern England is the faunal change which occurs at around 80-100 m. Remarkably enough, this is recorded not only in the original dead assemblages (ODAs) but also when all the calcareous foraminifera (including calc-agglutinated ones), which make up more than 95% in most of the ODAs, are dissolved out leaving only the ATAs (= acid-treated assemblages). The second obvious feature is the widespread occurrence of abundant calc-agglutinated foraminifera in the ODAs.

The shelf off southern England has normal marine salinity and ranges from low energy in the Celtic Sea to high energy in the English Channel due to the tidal regime.

In this study we distinguish two species of *Eggerelloides*: *E. medius* (not previously recorded from the area) and *E. scabrus*. They show a negative correlation with one another. *E. medius* is present only at water depths greater than 90 m while *E. scabrus* is very abundant down to around 85 m and thereafter declines in abundance with increasing depth. *Adercotryma glomeratum* shows the same pattern as *E. medius*. Of the 3 *Cribrostomoides* species present, *C. jeffreysii* and *C. kosterensis* (tentative identification) are rare at depths of less than 80 m while *Cribrostomoides* sp. 1 occurs at all depths. *Cuneata arctica* (previously recorded as *Clavulina obscura*) is confined to depths of less than 100 m. The trochamminids are present as those with globose chambers and those which are watch-glass shaped. In general, trochamminids make up less than 10 % of the ATAs and all higher abundances are at depths > 80 m.

The total depth range investigated was 13-150 m. In this, four ODAs occur shallower and four deeper than 80-100 m. The non-calcareous agglutinated foraminifera show the same basic pattern with four and three ATAs respectively. Furthermore, both the ODAs and ATAs follow the same general diversity pattern with lowest values at around 80 m water depth. In the case of the ATAs, the latter is due to the high dominance of *Eggerelloides scabrus* at this depth.

Therefore, the answer to the question posed by the title is 'yes'.

Biostratigraphy of the scaglia rossa-type deposits, based on deep-water agglutinated Foraminifera in the Pieniny Klippen Belt, Carpathians, Poland.

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The aim of the research was to determine the biostratigraphy of the Upper Cretaceous (Cenomanian - Campanian) deposits in the Pieniny Klippen Belt, Carpathians, based on agglutinated Foraminifera. These deposits belong to the Jaworki Formation (mostly to the Macelowa Marl and Pustelnia Marl members). The Macelowa Marl Member is represented by red marls and marly limestones alternated with many thin-bedded greenish and bluish, calcareous mudstones and sandstones. The Pustelnia Marl Member is represented by strongly calcareous brick-red marls and marly limestones. These facies occur in many profiles in the Carpathians, known as the „Kysuca beds" in the Slovak part of the Pieniny Klippen Belt or as „Puchov beds" in the Ukrainian Carpathians. They are known in the Alps and Apennines as the "couches rouges" and "scalia rosa". In the Polish part of the Pieniny Klippen Belt these deposits occur in all Klippen successions. They are partly replaced with different types of terrigenous deposits.

Micropaleontological analysis were made on 273 samples from 16 profiles.

Agglutinated Foraminifera dominate in the assemblages of microfauna. They are useful to the stratigraphy of these deposits. Five biostratigraphical zones sensu Geroch and Nowak [1984] have been distinguished here. All zones are interval zones between first appearance datums, represented by: Plectorecurvoides alternans Zone (to Lower/Middle Cenomanian), Bulbobaculites problematicus Zone (Middle Cenomanian - Cenomanian/Turonian boundary), Uvigerinammina ex gr. jankoi Zone (Lower Turonian - uppermost Santonian), Goessela rugosa Zone (uppermost Santonian - lowermost Campanian) and Caudammina gigantea Zone (from lower Campanian).

The presence of abundant assemblages of planktonic Foraminifera enabled the author to calibrate the stratigraphic ranges of agglutinated taxa to the local zonal scheme [Bak, in print]. The calibration of the zones with chronostratigraphy is presented after Robaszynski and Caron [1995].

Upper Cretaceous - Paleogene agglutinated Foraminifera from the Magura Nappe (Bystrica subunit), Polish flysch Carpathians; biostratigraphy and palaeoecology.

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Forty two samples were collected from the Upper Cretaceous - Paleogene deposits in the Magura Nappe [Polish flysch Carpathians] for foraminiferal analyses. They represent flysch deposits of the Bystrica subunit.

Some parts of the studied section contain planktonic foraminifers and calcareous nannoplankton, which were used for detailed correlation with chronostratigraphy. However, most samples are devoid of calcareous plankton and nannoplankton, and deep-water agglutinated Foraminifera provided the only stratigraphic control to constrain the age of the sediments.

These deposits represent six zones, subzones and assemblages determined on the base of occurrence of agglutinated and planktonic taxa. There are: Caudammina gigantea Zone [middle Campanian-Maastrichtian], Remesella varians Zone [earliest Paleocene], Rzehakina fissistomata Zone (Early Paleocene, without the earliest part), Parasubbotina pseudobulloides-Globanomalina.compressa Assemblage Zone [= Spiroplectammina spectabilis acme Zone; upper part of Zone P1b and lower part of Zone P1c], Paratrochamminoides/Trochamminoides assemblage Subzone [Paleocene/Eocene boundary], Glomospira sp. div. Zone [early Eocene].

Morphogroup analysis of the agglutinated Foraminifera, diversity index of microfauna and content of $CaCO_3$ allowed the author to interpret the paleoenvironmental conditions during the sedimentation of the different lithostratigraphic units in this area. Changes in water depth, oxygenation, currents strength and accessibility to food characterized the sedimentation of the studied deposits during Senonian through early Eocene.

Black shales and chert bed, alternated with thin-bedded dark-grey mudstones and sandstones have been found in the studied area. Their stratigraphic position (between Uvigerinammina jankoi and Caudammina gigantea zones) suggests that they can represent the lower/middle Campanian anoxic event, known from many sections in the Tethyan and Atlantic regions. The microfauna from these deposits is characterized by drastically scarce Foraminifera [only pyritized "tubes"].

Palaeozoic Foraminiferal 'Linings'

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Numerous organic [?] 'linings' of agglutinated foraminifera have been recovered from residues of palynological processing of early-middle Palaeozoic rocks. These 'linings' have been observed in samples from shallow marine strata ranging in age from the Early Cambrian, Silurian and Early-Late Devonian. Studies to date have demonstrated a wide palaeogeographic spread from Australia, India, the United Kingdom, France and Siberia. We have established that the fossils are foraminiferal in origin [Winchester-Seeto and Bell, 1994], but their size range [30-300μm usually] is below normally recognised foraminiferal size.

Our work has centred on Early-Late Devonian. In the Early Devonian we have observed representatives of 6 of the 10 agglutinated families known from this time and 10 genera. Nine of the genera are free living forms, with only one attached genus, [Hemisphaerammina], being represented. We can subdivide the genera into morphological groups within each genus based on surface features, shape, wall thickness, number of apertures, etc.; all these characters have previously been accepted for discriminating species in normal sized foraminifera. Moreover, some of these groups are readily referable to known foraminiferal species.

Previously these 'linings' have been referred to as 'microforaminifera', but, given the similarity of these linings to established genera and species, perhaps this is an artificial and unnecessary division. Options as to their identity include: (1) these fossils are 'linings' of micromorphs of normal foraminifera, (2) they are 'linings' of normal foraminifera, and that 'normal' foraminifera range much smaller in size than previously recognised, (3) the 'linings' are naked homeomorphs and never had an agglutinated test [perhaps they should therefore be placed with the Allogromiidae], (4) these 'linings' are a mixture of dwarf forms, shrunken linings of normal sized foraminifera and of naked homeomorphs.

Taxonomically these may present a problem. If they are to be considered as micromorphs then taxonomically they fit into established terminology. However if they are naked homeomorphs then the division between the Allogromiina and Textulariina [based on test structure] becomes diffuse. We consider that the 'linings' we have so far found are a mixture of' 'linings' of normal foraminifera and naked homeomorphs and that the term 'microforaminifera' is unnecessary and misleading. We do not believe that form genera or species are necessary nor that an informal scheme is needed for these agglutinated forms as has been suggested for rotalid-type linings.

Because of their geographical and stratigraphic widespread occurrences these 'linings' have the potential of being useful in palaeoecology and biostratigraphy.

Agglutinating foraminifera from Miocene sediments of North-West Borneo

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Numerous outcrop and subsurface sections of Miocene-aged sediments from North-West Borneo (chiefly Brunei) have been studied with regard to their foraminiferal fauna. Although often poor in calcareous benthonics, samples are often reasonably rich in agglutinating foraminifera. An iterative process of integrating the palynological, sedimentological and foraminiferal characteristics of each sample has permitted the recognition of distinctive assemblages of agglutinating foraminifera characteristic of various depositional environments. The process has also been aided by reference to studies of Recent foraminiferal distribution in similar depositional settings.

Palaeoenvironments so recognised include outer shelf, inner shelf, estuary mouth (inner and outer), lagoon, tidal channel, mangrove-dominant and back-mangrove swamp. Relative abundance of the following genera permits palaeoenvironmental interpretation: *Miliammina*, *Trochammina*, *Haplophragmoides*, *Camurammina*, *Trematophragmoides*, *Ammobaculites*, *Cyclammina*, "*Pseudoepistomina*", *Spirillina* and *Glomospira*. Within the genera *Ammobaculites*, *Trochammina* and *Haplophragmoides* both brackish and marine morphotypes can be recognised.

In North-West Borneo, interpretation of agglutinated foraminifera dominated assemblages has previously been problematic. Our precise palaeoenvironmental assessment of agglutinated foraminifera associations helps constrain the depositional modelling (and hence reservoir modelling) of sands associated with agglutinated foraminifera-rich shales and mudstones.

Agglutinated foraminifera and thecamoebians from the ?Albian-Cenomanian estuarine sediments on the North Tethyan margin (Blansko graben, Czech Republic).

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The Cretaceous sediments preserved in the Blansko graben represent the unique record of step-by-step transgression from the north margin of Tethys to the Bohemian Cretaceous Basin. Recently the boreholes Spešov V-127, V-134, V-135 and Kunštát OK-2 provided new data on stratigraphy and facies development (Svobodová, 1992). Basal sandstone sequence with root horizons is interpreted as braided-river sediments. Above the basal sequence several cycles with root horizon at the base, higher with coal-bearing claystones and clayey-silty alternation at the top can be interpreted as repeated change from fresh-water swamp to salt-marsh and mud-flat environments in estuary.

The marine-influenced facies contained thanatocoenosis with agglutinated foraminifera of low-diversity and high dominance. Karrerulina sp., Trochammina cf. wickendeni Loeblich or Pseudobolivina? cf. rollaensis (Stelck&Wall) are highly dominant in single thanatocoenosis. The presence of Ammobaculites, Trochammina, Verneuilinoides, Storthosphaera or Ammodiscus representatives is characteristic. Rarely the tests of thecamoebians occur. Some of them can be compared with genera Sibynion or Citron described from Early Albian of Canada by Medioli et al. (1990).

Svobodová (1992) documented terrestrial-marine transition based on increasing ratio of marine microplankton to terrestrial spores and pollen in single cycles. She assigned the basal fluvial sediments and estuarine cycles to the ?Albian-Early Cenomanian based on the association of angiosperm pollen.

Barrier sandstones, near-shore clayey sandstone with glauconite and with Exogyra fauna and claystones overlay the mentioned cyclic sediments. The claystones contained the special agglutinated-foraminifera thanatocoenosis with dominance of Veleroninoides? sp. and a presence of various representatives of Haplophragmoides, Ammobaculites, Trochammina, Ammomarginulina, Hyperammina and Bathysiphon indicating probably the carbonate-less marine conditions.

During the off-shore sedimentation the broad river valley emptying to the Tethyan shelf in the Blansko area predisposed the seaway between Boreal and Tethyan realms that allows the faunal migrations since the ?Middle - Late Cenomanian.

A revision of Recurvoidinae (Foraminifera) described by Eva Hanzlíková from the Outer Carpathian Flysch.

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Eva Hanzlíková during her microbiostratigraphical investigations in the Outer Carpathian Flysch described in 50-s to 70-s several new taxa of deep-water agglutinated foraminifera. Among others, four representatives of genus Recurvoides. Although she described and figured internal arrangement of test it is difficult to recognise the relations of her species to some similar taxa described by other authors. Newly restudied type specimens allow to improve the type descriptions.

The holotypes and other specimens of the type series of Haplophragmoides imperfectus, Recurvoides gerochi, R. godulensis and R. variabilis are preserved in collection of the Czech Geological Survey, Prague. The holotype of Haplophragmoides (=Recurvoides) imperfectus Hanzlíková, 1966 is a sligtly deformed specimen with maximal test diameter 0.43 mm. Coiling mode is recurvoidiform (sensu Bubík, 1995) with ten chambers and three changes of coiling direction visible on the surface.

The holotype of Recurvoides gerochi Hanzlíková, 1972 is a specimen with maximum diameter 0.46 mm, recurvoidiform coiling with two changes of coiling direction and nine chambers visible on the surface. The figured topotype specimens designated by Hanzlíková as hypotypes as well as one unfigured topotype differs from the holotype having thalmannamminiform coiling (sensu Bubík, 1995) with three U-shaped meandres. The taxonomic concept of later authors does not correspond to the holotype but to this specimens which should be assigned to genus Thalmannammina. It is difficult to decide if the holotype can be extreme morphotype within the variability of this Thalmannammina species or represents distinct species of genus Recurvoides. Nevertheless the name Recurvoides gerochi Hanzlíková, 1972 is the younger primary homonym of Recurvoides gerochi Pflaumann, 1964 and is invalid according the Article 57(b) of the ICZN.

The holotype of Recurvoides godulensis Hanzlíková, 1973 is a specimen with thalmannamminiform coiling with two U-shaped meandres, eleven chambers visible on the surface and maximum test diameter 0.39 mm. Three paratypes show considerable variability in coiling mode with one or absent meander and nine to eleven chambers visible on the surface. Coiling mode is more variable and irregular comparing with above mentioned hypotypes of Recurvoides gerochi and could be considered intermediate to the recurvoidiform. According the coiling mode Recurvoides godulensis should be transferred to genus Thalmannammina. The holotype is closely similar to Thalmannammina meandertornata Neagu and can be younger synonym of this species.

The type series of Recurvoides variabilis Hanzlíková, 1973 consists of the holotype and one paratype. Coiling mode is recurvoidiform with one abrupt change of coiling direction, seven chambers is visible on the surface. Maximum diameter of holotype is 0.32 mm. The type collection contain numerous additional specimens accessable for biometric study.

Lower Paleozoic foraminifera from the Barrandian area (Czech Republic): pioneer investigations.

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The Barrandian is the classic area of the Lower Paleozoic paleontology and stratigraphy. The sedimentary and fossil record documents facies changes from fluvial to (predominantly) marine conditions and plate drift of this marginal part of the Gondwana across the climatic zones from the cold during the Ordovician to the tropic during the Devonian. The sedimentation changed from clastic/shaly up to the Lower Silurian to carbonate from the Upper Silurian to Devonian. Although the Barrandian is one of the best studied Lower Paleozoic areas of the World as concerns paleontology, the papers on Barrandian Lower Paleozoic foraminifers published till now can be counted on the fingers of one hand.

Newly we collected a set of 40 samples from practically all marine formations and restudied unpublished foraminifera collection of V. Pokorný and others deposited at the Charles University Prague. The agglutinated foraminifers are frequent in the Ordovician and Upper Silurian - Middle Devonian while the primitive calcareous fussulinids rarely occur in the Upper Ordovician and Lower Devonian.

Determination at the species level is problematic because the samples set is still too small to be representative and variability is unknown. Nevertheless, the determination at the generic level provides new data on their stratigraphic range. Earlier appearance was recorded for genera Thuramminoides, Psammosphaera, Storthosphaera, Sorosphaera, Rhabdammina, Subreophax, Thurammina, Bathysiphon, Ammodiscus, Sorosphaerella and Cribrosphaeroides when comparing with Loeblich and Tappan (1987).

Some genera of agglutinated foraminifers seem to be new and will be described after collecting representative set of specimens. The forms provisionally named Ammodiscacea gen. nov. consist of large sack-like proloculum rounded partially by second tubular chamber (incomplete whorl). The flattened tubular densely branched fragments were provisionally named Astrorhizacea gen. nov.

System	Series	Lithostratigraphy	Thuramminoides sp.	Psammosphaera sp.	Rhabdammina sp.	Ammodiscacea gen. nov.	Subreophax sp.	Sorosphaera sp.	Storthosphaera sp.	Amphitremoida sp.	Saccamininae	Thurammina sp.	Bathysiphon sp.	Tholosina sp.	Ammodiscus sp.	Astrorhizacea gen. nov.	Sorosphaerella sp.	Cribrosphaeroides sp.	Hyperammina sp.	Hemisphaerammina sp.	Ammodiscus similis DUSZ.
DEVONIAN	Middle	Srbsko Fm.																			
		Chotec Fm.		X	X						X	X		X	X						X
	Lower	Dalej-Trebotov Fm.		X											?						
		Zlíchov Fm.			X							X									X
		Praha Fm.		?	X							?						X			
		Lochkov Fm.																			
SILURIAN	Prídolí	Prídolí Fm.																			
	Ludlow	Kopanina Fm.		?	X	X		X			X								X	X	
	Wenlock	Liten Gr.																			
	Llandovery																				
ORDOVICIAN	Kosov	Kosov Fm.			?																
	Královdvor	Králuv Dvur Fm.	X	X					X	X	X	X					X	X			
	Beroun	Bohdalec Fm.	X		X	X	X			X	X	X			X	X					
		Zahorany Fm.	X					X				X		X							
		Vinice Fm.																			
		Letná Fm.	X	X	X				X				X								
		Liben Fm.	X	X	X	X		X		X	X	X									
	Dobrotiv	Dobrotivá Fm.	X	X	X	X				X	X	X									
	Llanvirn	Šárka Fm.	X	X					X		X										
	Arenig	Klabava Fm.	X	X	X	X	X	X	X	X											
	Tremadoc	Mílina/Trenice Fms.																			

On the relation of Trochammina subvesicularis Hanzlíková, 1955 and Trochammina quinqueloba Geroch, 1959.

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We revise the species Trochammina subvesicularis described by Hanzlíková (1955) from the Zukov 107 borehole in the Tešín District in Moravia (Eocene sediments of the external nappes of the Carpathian Flysch) and Trochammina quinqueloba described by Geroch (1959) from the Lower Cretaceous of the Silesian Unit in Poland. Geroch distinguished his morphologically similar species by several features, such as the higher spiral side, more constant number of chambers, and smaller test size. Nevertheless the disjunct stratigraphical range of the two species was considered to be most important. Trochammina quinqueloba has been subsequently reported by various authors from Lower Cretaceous world-wide, while the name T. subvesicularis in last decade was used by Gradstein & Berggren (1981) and alter authors for a species found in the upper Paleocene of North Sea and North Atlantic.

The foraminiferal assemblage of the type sample of T. subvesicularis in the slide housed in Hanzlíková's collection contains abundant agglutinated species, including Caudammina silesica, Plectorecurvoides alternans, P. irregularis, Thalmannammina neocomiensis, "Gaudryina" oblonga and Bulbobaculites problematicus, which furnish good evidence for an Albian-Cenomanian age. Hanzlíková assigned the type sample to the Eocene based on the co-occurrence of sporadic planktonics such as Acarinina spinuloinflata and Subbotina frontosa which are most probably present owing to downhole caving. The differences in the external morphology of T. subvesicularis and T. quinqueloba are of minor importance. The number of chambers in the last whorl is in fact practically the same in both taxa. Among the eight preserved type specimens of T. subvesicularis, seven have five chambers (including the holotype, if the irregular last chamber is excluded) and one specimen four and one-half. The type specimens of T. subvesicularis possess a flat to slightly concave spiral side. In the type description Hanzlíková, nevertheless, noted that rosette-like specimens with a high trochospire also occur. When comparing the specimens figured by Neagu (1962, 1972), Geroch & Nowak (1984), Weidich (1990) and Kaminski et al. (1992) from various regions, the forms with both high trochospiral sides and flat trochospiral sides are placed within the variability of T. quinqueloba. We conclude that Trochammina subvesicularis and T. quinqueloba should, therefore, be regarded as synonymous.

The North Sea species designated as Trochammina subvesicularis by Gradstein & Berggren (1981) and by Charnock & Jones (1990) as Trochammina (Insculptarenula) subvesicularis, or as Trochammina cf. subvesicularis by Gradstein et al (1994) probably belongs to a different species. It is restricted to the upper Paleocene (Zone NSR2 of Gradstein & Backstrom, 1996). It differs from the typical Trochammina subvesicularis in its less convex umbilical side. Specimens of this species possess up to 5 1/2 chambers in the last whorl.

A Review of Cretaceous Agglutinated Foraminiferida from DSDP Sites in the North-East Atlantic Ocean.

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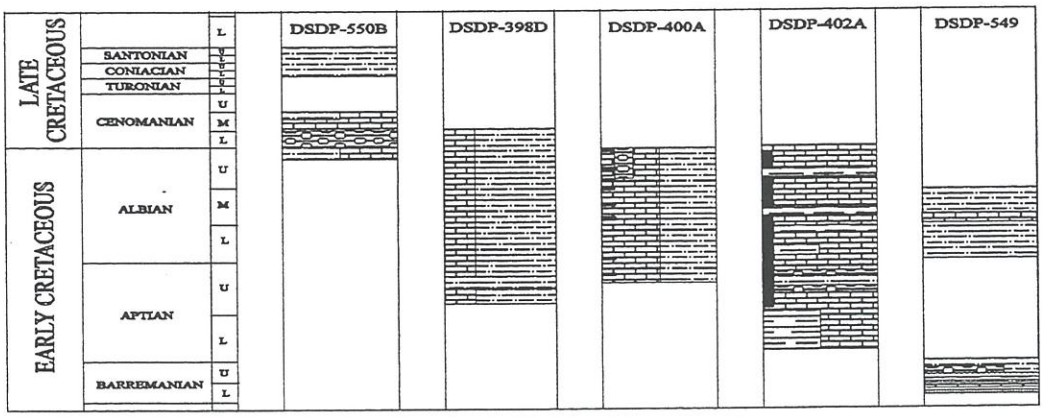
Samples have been re-evaluated from Deep Sea Drilling Project Sites 398D (Galicia Banks), 400A, 402A (Meriadzek Terrace), 549 and 550B (Goban Spur). The investigation into Cretaceous agglutinated Foraminiferida as been conducted in terms of new taxonomic, biostratigraphic and palaeoecological resolution as well as highlighting inconsistencies with previously published data. A synthesis of previously conducted DSDP agglutinated foraminiferal investigations is also presented from Legs 12, 13, 14, 41, 47, 48, 50, 79 and 80. The analysis of samples has provided a systematic taxonomy of foraminiferal species spanning an almost complete marine Cretaceous succession ranging from Hauterivian to Santonian with the agglutinated Foraminiferida generally constituting a low diversity, minor component of the benthic foraminifera. Stratigraphic ranges of selected agglutinating species are given as are North Atlantic bathymetric ranges of agglutinated assemblages dominated by straight, coiled and branching forms including, *Ammodiscus*, *Textularia*, *Marsonella*, *Hormosina*, *Verneuillina*, *Tritaxia*, *Rzehakina*, *Psammosphaera* and *Bathysiphon* which dominate the middle to lower bathyal zones.



Benthonic foraminifera have also been used to identify a number of distinctive communities using the Koutsoukos and Hart (1990) model. As in the case of the Brazilian continental margin the North-East Atlantic assemblages can be used to identify several episodes of bottom water anoxia. Using data from the various sites from these localities it is possible to investigate the onset of these anoxic/dysaerobic events in the deeper parts of the water column.

Unusual agglutinated Foraminifera from the Plymouth Sound area, South West England.

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A total of 150 surface sediment samples were collected from Plymouth Sound during December 1993 to November 1994 as part of a doctoral research study. A total of 141 taxa, the majority of which were identified to species or variety level, were recorded. The hyaline tests were most abundant (81 taxa), whilst porcellaneous and agglutinated forms comprised 30 taxa each.

The agglutinated Foraminifera were present living and dead in all environments, although they typified the low energy muds and very high energy gravel environments. The most abundant species are common British species such as *Eggerelloides scabrum, Textularia truncata, Textularia sagittula* and *Clavulina obscura.*

Several species (live and dead) of technitellids were recorded from the high energy sand and gravel environments of Plymouth Sound. These include *Technitella legumen* whose elongate cylindrical/conical tests were often found attached to large pebbles and shell fragments, *Technitella tavyensis* whose spherical, free, tests were observed in a range of sediment types and two unidentified species of technitellids which were also recorded in sand and gravel environments. They are constructed almost exclusively from sponge spicules. This group exhibits reasonable abundance and diversity within the high energy shell gravel environments of Plymouth Sound.

Another unusual agglutinated group which occurred with reasonable abundance within Plymouth Sound were the psammosphaerids, in particular *Psammosphaera bowmanni* which displayed a large range of morphological variation. The typical *Psammosphaera bowmanni* is sub-spherical and constructed from large, platy, opaque shell and rock fragments, and while these forms exist in Plymouth Sound the most common are constructed from transparent or translucent mica plates, whilst others are distinctly hemispherical and constructed around one very large plate of transparent/translucent mica and often contain a prominent green protoplasm.

The technitellids and psammosphaerids comprise a relatively small proportion of the Plymouth Sound fauna, but exhibit excellent potential for further study both to establish their biology (the psammosphaerids certainly display symbiotic characteristics) and a clearer taxonomy for the various species/varieties.

The use of sub-63μm fractions in the separation and identification of testate amoebae for multi-proxy studies of sea-level change

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Sea-level reconstructions from coastal sediments are frequently based on stratigraphic studies with data from one or more groups of indicator microfossils, such as pollen, diatoms and foraminifera. These are used to establish the indicative meaning (i.e., the elevation with respect to a reference tide level at the time of deposition) of organic sediments within the stratigraphy and hence to identify periods of marine transgression and regression. The project from which this paper is drawn is attempting to refine the indicative meaning of saltmarsh sediments by using testate amoebae ('thecamoebians') in addition to diatoms and foraminifera as sea-level indicators. Detailed surveys of modern distributions of the indicator organisms in relation to key environmental variables will be used to create transfer functions for indicative meaning and salinity. This paper describes a new technique for the extraction and identification of testate amoebae from saltmarsh samples and discusses the implications of the approach for multi-proxy sea-level reconstructions.

The study of testate amoebae in coastal situations has so far been restricted to a small number of locations in North America where similar approaches and methods used in foraminifera analysis have been adopted. This normally involves the examination of the sediment retained in a 63μm sieve and wet or dry counting of tests along with foraminifera. However, work on terrestrial peat deposits usually uses a broader size fraction (15-300μm) and frequently finds the majority of tests to be less than 63μm in size. Counts are undertaken using high powered (x400-x1000) light microscopy with samples mounted in an aqueous medium under a coverslip rather than in an open dish at magnifications up to x100. However, the techniques used in terrestrial peats cannot be easily transferred to saltmarsh sediments since the large amount of debris in the 15-300μm fraction obscures any tests which are present. A new technique combining the approaches from foraminiferal and terrestrial peat based studies involves low power examination of the >63μm size fraction with high power examination of the 15-63μm fraction.

Results from the Taf estuary, south Wales, show that testate amoebae occur in large numbers and high diversities throughout the surface of the upper marsh. The concentrations are much higher than has previously been reported in North American studies and up to 18 taxa have been encountered. Numbers in the small size fraction are much higher than in the large size fraction and the majority of taxa are restricted to the sub-63μm range. In addition, idiosomic taxa are reported in large numbers whereas previous studies generally found only xenosomic taxa. Further work will be needed to delimit the zonation of individual species and assemblages but these preliminary results suggest that analysis of small size fractions for testate amoebae in saltmarsh sediments has the potential to provide improved estimates of indicative meaning.

Test colour and agglutinated foraminifera. Can it provide additional palaeoenvironmental information?

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Abstract
"The present is the key to the past" is correctly the cornerstone of palaeoenvironmental studies on agglutinated foraminifera. Applying this principle has resulted in much useful research over the past 20 years and thanks largely to these workshops there is now general consensus as to the main conditions governing the distribution of assemblages dominated by agglutinated foraminifera such as those developed in the Palaeogene of the Central North Sea. However, within relatively deep water ie. off-shelf, slope and basin floor settings there are still variations within the composition of these *Rhabdammina* , "flysch-type" or deep water agglutinated associations (DWAF) as they are variously known, that need to be investigated and explained.
The distribution of individual agglutinated foraminifer are controlled by the interplay of biological, physical and chemical parameters within the microenvironment of the sediment and the immediately overlying water column. Unfortunately, due to problems of studying modern deep sea habitats there are still too few detailed studies related to this topic and so direct comparisons of extinct species cannot be made.
In an attempt to identifying some of the chemical factors which may govern the distribution of agglutinated foraminifera this study focuses on the relationship between test colour and individual species and genera .
The study is based on a review of a large database of nearly 150 wells from the Palaeogene succession of the Central and Viking Grabens of the Central North Sea. Within this stratigraphic interval and in what can be classified as a broadly similar deep marine palaeoenvironment the tests of agglutinated foraminifera maybe variously natural, bleached ie. white, green or red stained. Significantly, the downhole appearance of green stained specimens in the Central Graben is a reliable stratigraphic marker for the presence of Eocene sediments (when calibrated against an organic microplankton zonation) being associated with the development of light olive grey mudstones characteristic of the Horda Formation. Other horizons, most notably within the Early Eocene basal Horda Formation and intra-Late Paleocene Lista Formation yield vari-coloured red / green stained mudstones units. These mudstones of mainly hemipelagic origin are a widespread sedimentary facies type in deep marine settings of the Central Graben. Although these vari-coloured horizons must have been deposited in similar paleowater depths. the associated agglutinated foraminifera exhibit some variations in specific/generic composition. For example *Rzehakina minima, Spirosigmilinella naibensis* and *Ammomarginulina aubertae* are typically only found as green or bleached forms whereas *Marssonella oxycona* and *Gaudryina hiltermanni* tend to be red stained. Othe taxa such as *Usbekistania charoides* and *Karrerulina conversa* maybe either red or green stained. Full details of which are tabulated and a review of the literature has also been undertaken.
What factors control the colouration? In these instances the sediment or test colour is controlled by the chemical environment under which sediment was deposited. This is opposed to the colour/ maturation sequences recently proposed by McNeil (1996) as a result of the depth of burial and which is clearly applicable to foraminiferal assemblages recovered from deeper sections including those of the North Sea Jurassic. The main factors responsible for the colour are the mineralogical composition of which the iron minerals and haematite, in particular, are the most important and the amount of organic matter in the sediment. One other factor which maybe applicable in the case of the basal Horda Formation is that in the modern Pacific Ocean red clays are produced by the *in situ* alteration of volcanic material. The red or reddish brown colour of the tests and associated sediment reflects the presence of iron in oxidising form (Fe 3+) whereas those with iron in reducing form (Fe 2+) are grey to green. Factors governing the occurence of bleached ie. white tests are not known. In general therefore red or red/brown tests are indicative of oxidising palaeoenvironments whereas those with green tests are indicative of a reducing environment possibly with an enriched organic content. So how can such markedly different conditions exist in a unit that was deposited in broadly the same palaeowater depth and representing a depositional history of a few thousand years?. One possible explanation is that it maybe related to changes in the type of water mass that was prevalent in the basin.
Regardless of the controlling mechanism, different coloured agglutinated foraminiferal assemblages must indicate that these associations developed under a wide variety of chemical palaeoenvironments and not just in response to reducing conditions as generally proposed.
Furthermore is it possible to produce a heirarchial classification of agglutinated species/genera that will reflect their relative tolerance to reducing conditions? This could provide useful information for palaeoenvironmental analysis.
Finally, colour coding is also an important stratigraphic tool when dealing with ditch cuttings as it can be used to determine *in situ* and caved components in a mixed assemblage.

The Campanian and Maastrichtian Tethyan - Boreal connection: its influence on agglutinated foraminiferids assemblages.

(An example from the Andrychow Klippen Zone; Polish Flysch Carpathians)

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During the Late Cretaceous, the main part of the Outer Carpathians constituted the northern margin of the western Tethyan Realm. Detailed analyses of the foraminiferal assemblages from the Upper Cretaceous cover of the Andrychow Klippen Zone (AKZ; early Campanian - elevata zone to the late Maastrichtian - mayaroensis zone) has indicated that the location of the AKZ (also called the Inwald cordillera) was relatively far from its present position. Moreover, this cordillera was influenced by Boreal water masses. Possible migration of the Boreal microfauna was from the West (Waschberg-Tesnovice ´gate´) or partly from the Danish-Polish Furrow from the NE (Lvow ´gate´). However, a palaeomorphological barrier between Carpathian basins and Carpathian Foreland prevented migrations by benthic organisms. Only juvenile epipelagic stages of planktonic foraminifera most probably successfully passed to the Carpathian area (cf. Gasinski, 1997). Therefore, the most diagnostic microfossils for indicating the possible provincionality of the AKZ seem to be benthic foraminifera. Two possibilities of migration are proposed: ecotone - type assemblages (intermediate Boreal-Tethyan microfauna, created by the action of the "diversity pump") or Curtsinger´s phenomenon (traping of nutrients around seamounts, followed by colonization of r-strategists: cf. Curtsinger, 1996; Gasinski, 1997).

Agglutinated benthic assemblages of the AKZ cover have been analysed in terms of their ´morphogroup´, which are valuable for interpreting levels of the organic flux input, which is mainly related to sea level fluctuation.

The palaeobiogeographical location of the AKZ foraminiferal assemblages is placed in the framework of the neighbouring Carpathian basins. Detailed comparison with whole Campanian - Maastrichtian AKZ foraminiferal assemblages is presented separately. Here, only agglutinated foraminiferal assemblages have been analysed. In general, such assemblages are relatively scarce among AKZ associations. However, they display a differentiation with the time. Fortunately, the investigated assemblages are dominated by planktonic foraminiferids, therefore, almost all studied samples are biostratigraphically well-dated. Cluster analysis between several age-equivalent assemblages from the Carpathian area (Polish, Czech & Slovak parts) as well as from the Carpathian Foreland, Lublin Upland, and Eastern Alps, Austrian part of the Bohemian massif, Northern Germany and England has been performed. It is evident that AKZ agglutinated assemblages are different from those of the Carpathians (either relatively shallow water and DWAF assemblages).

The above analyses have confirmed the Transitional (between Tethyan and Boreal realms) character of the AKZ foraminiferal assemblages. However, we should remember that planktic foraminiferids are more indicative for the climatic changes than agglutinated forams, especially DWAF-type asociations. For these, the crossing any palaeomorphological barrier, which appeared relatively more often in such tectonically active areas as geosynclines, is more difficult, based on recent analogs.

On the basis of the above, independence of the AKZ area and the migration of the Boreal microfauna to the Carpathian - Tethyan realm during the Campanian-Maastrichtian have been confirmed.

Palaeoenvironmental significance of *Jadammina macrescens* (Brady) and *Balticammina pseudomacrescens* Brönnimann, Lutze & Whittaker in studies of sea-level change

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Foraminiferal distributions in saltmarshes in New England and Atlantic Canada have been used to derive sea-level information from cores, based on the assumption that foraminiferal assemblages are correlated with elevation. In these studies, *Balticammina pseudomacrescens* Brönnimann, Lutze and Whittaker and *Jadammina macrescens* (Brady) have been grouped as *Trochammina macrescens* Brady. This study presents data on the distribution of *B. pseudomacrescens* and *J. macrescens* in four saltmarshes in Maine and one saltmarsh in Connecticut (USA). The taxonomy follows De Rijk (1995), treating *J. macrescens* and *B. pseudomacrescens* as distinct species. The most diagnostic characteristic of *B. pseudomacrescens* is a wide umbilicus containing supplementary apertures, whereas *J. macrescens* has a closed umbilicus and may have supplementary areal apertures on the septal face. Palaeoenvironmental implications are demonstrated by the biostratigraphical analysis of two cores.

In marshes in Maine, *J. macrescens* occurs in high abundances near the upper edge of marshes, while numbers of *B. pseudomacrescens* are spatially variable. Relative abundances of *J. macrescens* are strongly correlated with tidal elevation, which makes *J. macrescens* a good sea-level indicator. *B. pseudomacrescens* does not show a relationship with tidal elevations. In Menunketesuck River marsh, Connecticut, *B. pseudomacrescens* is only present in very low numbers in modern samples, whereas *J. macrescens* is abundantly present but not correlated with elevation. *J. macrescens* and *B. pseudomacrescens* are both found in high numbers in cores from Maine and Connecticut marshes.

The recognition of *J. macrescens* and *B. pseudomacrescens* as distinct species has important palaeoenvironmental implications when foraminiferal stratigraphy is used as a tool to reconstruct former sea levels, not only in New England marshes, but potentially also in other areas where *B. pseudomacrescens* has been documented, including marshes in Germany, Britain and Nova Scotia. In Maine, separating *B. pseudomacrescens* and *J. macrescens* in counts of fossil data increases the accuracy of reconstructing sea-level histories from the biostratigraphical record. In Connecticut, interpretation of fossil data is impeded by the lack of a clear vertical zonation of saltmarsh foraminifera. Because of the regional variability between northern and southern New England saltmarshes it is necessary to conduct detailed surface sampling and taphonomic studies to aid palaeoecological interpretations of fossil data.

Palaeobathymetry and palaeowater depths, Offshore Norway. An integrated applied biostratigraphic approach to structural reconstruction.

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Abstract.

This study has been to develop the use of foraminifera (including DWAF) and dinoflagellates as a combined tool in palaeoecological reconstruction. This integrated approach can be used to outline palaeobathymetric trends and assess lateral faunal/floral changes. Two wells were selected for a quantitative study from the North Sea along a palaeoslope transect.

This study enabled the building of dynamic palaeobathymetric models taking into account variations in palaeowater depth. Different assemblage fluctuations were plotted according to different palaeoenvironmental settings (e.g., shelf, slope).

The main objectives of this study have been to:-

1. Further develop the use of foraminifera in palaeowater depth estimates.
2. Calibrate dinoflagellate cysts, as a palaeowater depth tool, against foraminifera.
3. To delineate palaeobathymetric trends along a palaeoslope transect.
4. To define a palaeobathymetric model, taking into account depositional sequenes and stacking patterns.

Foraminiferal assemblages have been widely used for palaeoenvironmental interpretations in the Mesozoic and Cenozoic, and a limited number of such models have been proposed (Olsson and Nyong 1984).

The various techniques used in foraminiferal studies have included: planktonic:benthonic ratios (Murray 1976, 1991); percentages of non-calcareous agglutinants against P:B ratios (King 1989); the distribution of Total Organic Carbon (TOC) compared to genera/species (Nagy *et al.* 1988); Fisher alpha index (Murray 1991); heterogeneity (Shannon-Wiener and Shannon-Weaver index, Murray 1991; Jones 1988); the use of palaeoslope transects (Jones 1988); cluster analysis (Olsson and Nyong 1984) and factor analysis (Kaminski *et al.* 1988). Several authors have emphasised the need to interpret faunas in the light of trophic resources and substrates (Koutsoukos and Hart 1990).

The depth distribution of foraminifera is a function of several factors interacting; i.e. temperature, salinity, oxygen levels, nutrients and the nature of the substrate (Sliter and Baker 1972). The depth distribution of dinoflagellate cysts is also complex. This involves factors controlling the planktonic dinoflagellate stage; i.e. light, salinity, temperature, oxygen levels and nutrients (Dale 1983).

Recent publications, from the Jurassic to the Cenozoic, have demonstrated the importance of accurate palaeobathymetric estimates in assessing; the stratigraphic distribution of sediments and burial history (Gradstein and Bäckström 1996; Ingle 1980); source stratigraphy (Skibeli *et al.* 1985); source rock potential (Chandra *et al.* 1993).

Wall structure and variation in two large deep-sea agglutinated foraminifera, Rhabdammina abyssorum Sars, 1869 and Astrorhiza granulosa (Brady, 1879), and their possible taxonomic significance.

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Despite their importance in deep-sea communities, the biology of large agglutinated foraminiferal species, and the taxonomic relationships between them, remain poorly understood. In this paper we focus on two species, Astrorhiza granulosa and Rhabdammina abyssorum, represented by material from the NW African margin (32° 2'N, 11°19'W; 3000m depth) and Oman margin (19°N, 59°E; 3400m depth) respectively. These species share some hitherto unreported wall structure features and display a similar range of phenotypic variation. They are characterised by an inflated central region giving rise to a variable number of radiating arms, usually either two or three but sometimes more; in both species the two and three-rayed morphotypes were initially described as distinct species (A. granulosa/angulosa and R. discreta/abyssorum). In our material, both species also have a similar two layered wall structure in which a thinner, firmly-cemented inner layer is overlain by a thicker but more friable outer layer. In A. angulosa, the outer layer is composed almost exclusively of small, juvenile globigerinacean tests; in R. abyssorum it is composed of a loose jumble of particles, most of them quartz grains. This wall structure has never been clearly described before, despite the fact that both species have been known for well over 100 years. Their similar wall structures and patterns of variation lead us to suspect that the two species are more closely related than their present generic placements would indicate.

There is an additional complication. Examination of museum material, and clues contained in published descriptions and illustrations, suggest that the two layered wall structure is a consistent feature in Astrorhiza granulosa. On the other hand, we are not aware of any published descriptions or illustrations of Rhabdammina abyssorum that even hint at the existence of an outer layer. Atlantic specimens of Rhabdammina abyssorum have simple, one-layered walls which are consistent with these previous descriptions. Thus, either R. abyssorum has a variable wall structure (either one or two layers), or we are dealing with two distinct species which, at a gross level, have morphologically identical tests and display a similar spectrum of phenotypic variation. We do not believe that either type is the same as R. agglutissima Hofker, 1972 or R. radiata Cushman, 1917. A molecular approach may be the only way to resolve the relationships between these different forms.

Relationship between abundance of *Cyclammina* and source-rich organic sediments in the subsurface of the Krishna - Godavari Basin, India.

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In the east coast of India the Krishna-Godavari Basin is under active exploration for hydrocarbons both onshore and in the offshore waters of the Bay of Bengal. The basin has been tectonically subdivided from east to west as East Godavari, West Godavari and Krishna Sub-Basins with intervening ridges.

Nearly 4km thick Tertiary sediments rest over the Deccan volcanics in the East Godavari Sub-Basin. The dark grey shales of Paleocene age (Palakollu Formation) are overlying the Deccan volcanics. Laterally not much variation is seen in this unit. It is followed by an argillaceous unit of Early Eocene age (Pasarlapudi Formation) which laterally changes into an arenaceous unit. This unit is a prolific gaseous hydrocarbon producer. This formation is followed by dark shales of Middle Eocene age (Vadaparru Formation) in the south eastern part of the sub-basin. Laterally towards the north west it becomes carbonate rich (Bhimanapalli Formation) or arenaceous (Matsyspuri Formation).

During the foraminiferal studies of exploratory wells drilled in Mori, Mulikipalli, Magatapalli and Kommarada in this sub-basin (Fig.1) the dominance of agglutinated taxa at a specific level in the Vadaparru Formation has been recognised.

Among the agglutinated taxa *Cyclammina* constitutes 90-100% along with rare index planktic foraminifera. The occurrance of *Cyclammina* abundance has been dated as P9-P11. This infaunal suite seems to prefer orgain rich finer clastics where TOC values range from 2-4%. The pyritised tests, dark gray colour of the shale and high TOC values suggest low oxygen levels at the sediment-water interface in deep shelf. *Cyclammina* laterally disappear towards the northwest where lithofacies changes into carbonate and sand which support mainly calcareous benthic foraminifera. *Cyclammina* is represented by *C.amplectens* Grzybowski, *C.acutidorsata* (Hantken) and *C.rotundidorsata* (Hantken). These forms are illustrated and reported for the first time from this area.

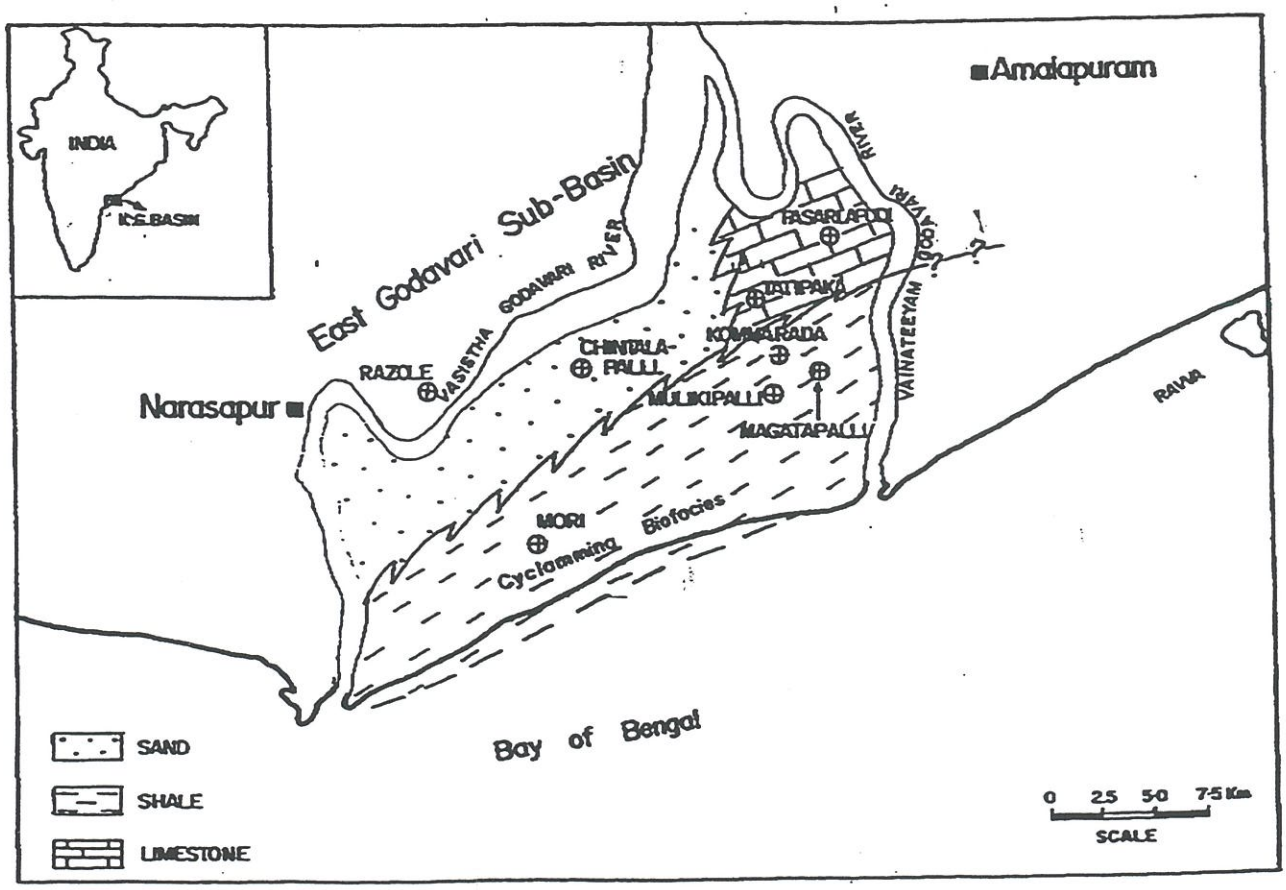

FIG.1. LOCATION MAP OF STUDIED WELLS IN K.G. BASIN

Influence of temperature, oxygen and food availability on the activity and bioturbation of benthic deep-sea foraminifera

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Laboratory experiments with living benthic deep-sea foraminifera in special microcosms have been conducted in order to study their biology. A number of experiments were set up to record the influence of physical factors on movements - in the following termed migration - and to document foraminiferal bioturbation in bottom sediments.

Benthic foraminifera from 2880 m and shallower water depth were successfully maintained and investigated. Three specific categories could be recognised due to the migrational behaviour: "slow" foraminiferal species were characterised by mean migration speeds of 2,5 µm/min at maximum, "fast" species exhibited average migration speeds of up to 5,0 µm/min and "very fast" foraminiferal species moved with average speeds greater than 5,0 µm/min.

By video documentation high mean migration speed of 20,02 µm/min (N = 22) was found for Hoeglundina elegans, followed by Cibicidoides floridanus (15,14 µm/min; N = 31) and Cassidulina leavigata (13,43 µm/min; N = 35). Migration speeds of the miliolide Pyrgo murrhina (22,27 µm/min; N = 16) and Quinqueloculina seminula (24,48 µm/min; N = 10) were also documented to have high velocities at 4°C. Some deep-sea foraminifera are thus shown not to be generally slower in their migration speeds than shallow water species.

Environmental factors such as temperature, oxygen content and food concentration showed a marked influence on migration of some species. For example, an increase of 5 °C in temperature (from 10 °- 15 °C) resulted in a increase of 35 % in migration speed for Allogromia spp. Higher food concentration within the substrate resulted generally in a decrease in migration speed. Only a few species (e.g., Adercotryma glomerata) were positively affected by increased organic matter supply. While the migration speed was not greatly affected by a low oxygen content in the sediment for Quinqueloculina laevigata, most foraminifera responded in a migration shift to the surface layers. No differences in migration speed for epifaunal or infaunal foraminifera were observed.

In order to study bioturbation of benthic foraminifera a microsphere experiment was conducted. Particle displacement (e. g. tracer particles, ∅ =10 µm) showed a high turnover rate and was achieved either by burrowing or pseudopodial activity. Sediment ingesting species showed accelerated particle transport. Close to the sediment-water interface (0-0,5 cm) bioturbation rate was elevated compared to the deeper horizons (0,5-1,5 cm). A biological mixing coefficient (Db) of 0,4 cm^2/d was calculated from long-time experiments. Assuming a population of 100 individuals /10 cm^2 of Allogromia spp. (∅ = 1 mm) a sediment displacement rate of 400 cm^3/y is calculated. Thus, bioturbation via foraminiferal migration may alter more significantly the sediment regime in the deep-sea then recognised before.

Deep sea agglutinated foraminifera as important recolonizers of the 1991 Mt. Pinatubo ash layer in the South China Sea

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The 1991 Mt. Pinatubo eruption caused mass mortality of benthic foraminifera in a vast area of the eastern South China Sea followed by step-wise recolonization of the new ash substrate.
The benthic foraminiferal assemblages of several deep sea stations containing this ash layer (2 to 8 cm thick) were examined. Significant differences in diversity, community structure, and feeding and habitat preferences were observed between foraminiferal assemblages before and after the ashfall. The total number of benthic foraminifera in the surface samples is low and the ratio of living individuals to empty tests is high, possibly indicating a "young" population which recently colonized the ash substrate. Specific diversity is low, with a significant dominance of agglutinated infaunal morphotypes including species such as *Reophax scorpiurus, R. bilocularis* and *R. dentaliniformis*. The faunal assemblages below the ash layer are highly diversified and contain large numbers of epifaunal agglutinated foraminifera (e.g. *Saccorhiza ramosa*). Already by 1994, three years after the eruption, the recolonization of the ash substrate had started. Two years later, in 1996, significant changes in the surface assemblages were observed: the specific diversity increased and first epifaunal agglutinated forms (Saccorhizids, Rhizamminids, Xenophyrophorids) have been observed, however the benthic foraminiferal community structure is still far from recovery to background levels.

Ash grains of the 1991 Mt. Pinatubo eruption as a tracer in stained agglutinated deep sea foraminifera tests: how old is Freddy?

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The use of ash grains from the 1991 Mt. Pinatubo eruption as test material by Rose Bengal stained agglutinated deep sea foraminifera, collected in the spring of 1994 and in the winter of 1996 from the South China Sea, presents the possibility to form an idea about foraminiferal lifespan and their rate of growth.

In several surface samples from an area influenced by a thin, fine grained ash layer, recent agglutinated foraminifera were found to have changed their tests as a result of the ejecta material available. The older parts of the test are built up by the use of normal sediment particles, mostly quartz grains. After the Mt.Pinatubo eruption the formaninifera used the new material, e.g. volcanic glass, pumice or black phenocrystals. Some of the benthic forminifera were alive at the time of sampling because a Rose Bengal stained cytoplasm body is visible. The use of ash particles in the stained tests as a tracer allow us to propose that the stained agglutinated foraminifera sampled in 1996 were at least 5 years old. Comparison of the number of chambers with and without ash particles were used to calculate the growth rate of agglutinated foraminifera under oligotrophic environments.

An exceptionally well preserved stained individual of the species *Cyclammina pusilla* (called Freddy) was collected during Sonne Cruise 114 in November 1996. The last three chambers of Freddy consists mainly of Pinatubo ash material indicating that Freddy was building approximately 0.6 chambers per year.

ENDEMIC AND COSMOPOLITAN UPPER CRETACEOUS AGGLUTINATED FORAMINIFERA FROM WEST AFRICAN COASTAL BASINS: TAXONOMY, PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY

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Upper Cretaceous agglutinated foraminifera (32 taxa belonging to 22 genera) from the Casamance transect, Senegal and the Tarfaya Coastal Basin, Morocco are documented and comparisons are made with coeval assemblages from adjacent coastal basins in Western Africa (Benue Trough in Nigeria, Deep Ivorian Basin, Cape Verde Rise, Cape Verde Basin and Gabon).

Coniacian to Santonian marginal marine assemblages from Well CM2, Casamance Transect are dominated by *Ammotium nkalagum, Kutsevella* sp. 1 and *Ammobaculites* spp. and show close resemblance to assemblages from the Benue Trough, Nigeria and from Gabon. These low diversity assemblages display a significant degree of endemism, which point to the existence of migration barriers restricting distribution in equatorial African coastal basins during the Coniacian to Santonian.

Campanian to Maastrichtian shelf assemblages from Well CM10, Casamance Transect contain mainly diverse buliminid associations, which suggest that an Oxygen Minimum Zone was established on the outer shelf. These assemblages are intermittently dominated by agglutinated taxa, including *Ammomarginulina* sp. 1, *Hyperammina* and *Textulariopsis* spp. The faunal changes probably reflect episodic increases in clastic flux from mainland Africa, when the oxygen minimum zone shifted further out basinwards to depths below the depositional site.

Lower Campanian upper bathyal assemblages from the Tarfaya Coastal Basin, Morocco contain variable proportions of agglutinated foraminifera including *Marssonella oxycona, Spiroplectinella cretosa, Tritaxia capitosa, Pseudoclavulina clavata, Gaudryina cretacea, Haplophragmoides* sp. A and *Gaudryina* spp. Changes in the composition of the assemblages appear related to TOC variations and probably reflect cyclic fluctuations in oceanic productivity and organic matter accumulation. The agglutinated foraminifera are predominantly cosmopolitan, indicating that the basin had open connections with the Atlantic.

The Campanian to Maastrichtian assemblages of the Casamance Transect and the lower Campanian assemblages of the Tarfaya Coastal Basin differ markedly from coeval asssemblages of the Deep Ivorian Basin (ODP Hole 959, Leg 159), Cape Verde Basin (DSDP Hole 367, Leg 41) and Cape Verde Rise (DSDP Site 368, Leg 41), which consist exclusively of organically cemented agglutinated taxa. The assemblages from these holes contain many Deep Water Agglutinated Foraminifera (DWAF) commonly recorded at ODP and DSDP holes in the North Atlantic, which provide evidence that sub-CCD depths had been reached along the western African equatorial margin and that a deep circulation system was already established between the North and South Atlantic by the early Campanian.

Occurrence of agglutinated foraminifera in the organic-rich (versus carbonate-rich) levels of the Boom Clay Formation (Rupelian, Belgium): Selective preservation by dissolution of calcareous tests.

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The Boom Formation (Early Oligocene) of Northern Belgium, representing the "body-stratotype" of the Rupelian stage, consists of some 75 m of clays, of which the lower 50 m are visible in three classical outcrops at Sint-Niklaas, Rumst-Terhagen, and Kruibeke (three overlapping sections). At first sight this formation is formed by a monotonous clay succession, but a closer look shows that - at the meter scale - the lithology rather strongly differs from level to level (Fig. 1):
(a) Granulometry: Alternations of heavy clays to silty (or sandy) clays form - in average - ca. 1m cycles, which have tentatively been equated with Milankovitch cycles.
(b) Calcareous matter: In the lower interval of 30 m, i.e. the Belsele-Waas and Terhagen Members, the clays are calcareous, and comprise common calcitic micro- and macrofossils, whereas in the overlying interval (grossly corresponding to the "black" Putte Member), the clays are generally decalcified, and only contain some very rare microfossils, predominantly agglutinated foraminifera.
But in all three members some - irregularly spaced - layers of 20-30 cm occur which are very rich in calcareous matter and which are generally characterised by "septaria", i.e. carbonatic concretions.
(c) Organic matter: Whereas in the two lower members the concentration of organic matter is less than 2%, in the Putte Member it clearly exceeds these values and averages 3 to 4 %. From the darker colours of the organic rich levels, it appears that within these "Milankovitch" cycles of the Putte Member, the organic matter is mainly concentrated in the basal part of each small cycle, i.e. directly overlying the silty intervals.

Closely spaced samples (2 to 3 per m representing all facies changes) have been taken of the 50m Boom Clay succession, and have been analysed - among others - for their foraminiferal content.
The resulting foraminiferal range charts have been juxtaposed to the granulometry, $CaCO_3$ content, and organic matter content curves of the Boom Clay lithocolumn. From these data it appears, that the high amounts of calcitic foraminifera (> 85% of the assemblages) and low amounts of agglutinated taxa (10-15%) of the lower part of the Terhagen Member coincide with the calcareous-rich interval, whereas the calcareous-poor interval of the Putte Member (and of the upper - or "impoverished" - part of the Terhagen Member) only comprises some rare agglutinated foraminifera. The paleobathymetry of the Boom Clay in Belgium is thought to be middle neritic (ca. 50-100 m?).
Since the absolute amounts of agglutinated foraminifera are approximately the same in the calcareous-rich part of the Terhagen Member, as in the organic-rich/calcareous-poor Putte Member, it may be accepted that the observed strong differences in these assemblages are merely the result of selective dissolution of calcareous tests in the (acidic) depositional environment of the organic-rich Putte Clay. But it also appears that the agglutinated taxa are virtually the same in the two members. Except for the taxa *Spiroplectammina carinata, S. spp.* and *Textularia gramen*, which occur over the whole (calcareous-rich to calcareous-poor) column, only some very rare *Bathysiphon/ Rhabdammina* specimens have been found so far in the calcareous-poor/ organic-rich deposits of the Putte Clay. The observation of these rare specimens may be the result of the more thorough search of foraminifera in these decalcified and poorly fossiliferous strata.
A comparison of the Belgian Boom Clay with its lateral equivalent, the Septaria Clay (or "Rupelton" Frmation) in Northern Germany indicates that the Putte Clay Member can roughly be correlated with the so-called "Rupel 3" interval, i.e. the calcareous-poor/organic-rich "middle part" of the Rupelian in Germany, which is also characterised by foraminiferal assemblages consisting predominantly to exclusively of agglutinated taxa. Its environment of deposition (probably generally outer neritic, ca.100-200m?) was probably somewhat deeper than in Belgium, and the agglutinated foraminifera assemblages may therefore be somewhat more diversified (Spiegler, 1965), and generally with larger specimen sizes.
In the Mainz Basin of west-central Germany (Grimm, 1991,1994,1996), the "Fischschiefer", i.e. the middle part of the local "Rupelton", is also organic-rich and of a similar decalcified facies, containing some (partly different) agglutinated taxa only. This member is roughly another lateral equivalent of the above discussed Putte Clay Member of Belgium, and its bathymetry is thought to be in the order of 100-150m (Grimm, in preparation).
In the central and northern North Sea (e.g. Gradstein & Berggren, 1981; King, 1983) bathyal conditions (ca. 200-600m?) occurred during the Rupelian, with typically more diversified "deeper water" assemblages of agglutinated taxa, and generally significantly larger sizes of the specimens.
The organic-rich interval in the middle part of the Rupelian of Belgium (Putte Clay) predominantly contains organic matter of terrestrial origin (pyroclasts). In this interval the palynological content also contains more pollen and spores than dinocysts. This facies may therefore be interpreted as the result of a more humid and warmer climatic phase, with higher supply of continental organic matter by the rivers to the continental shelf / epicontinental sea of NW Europe.

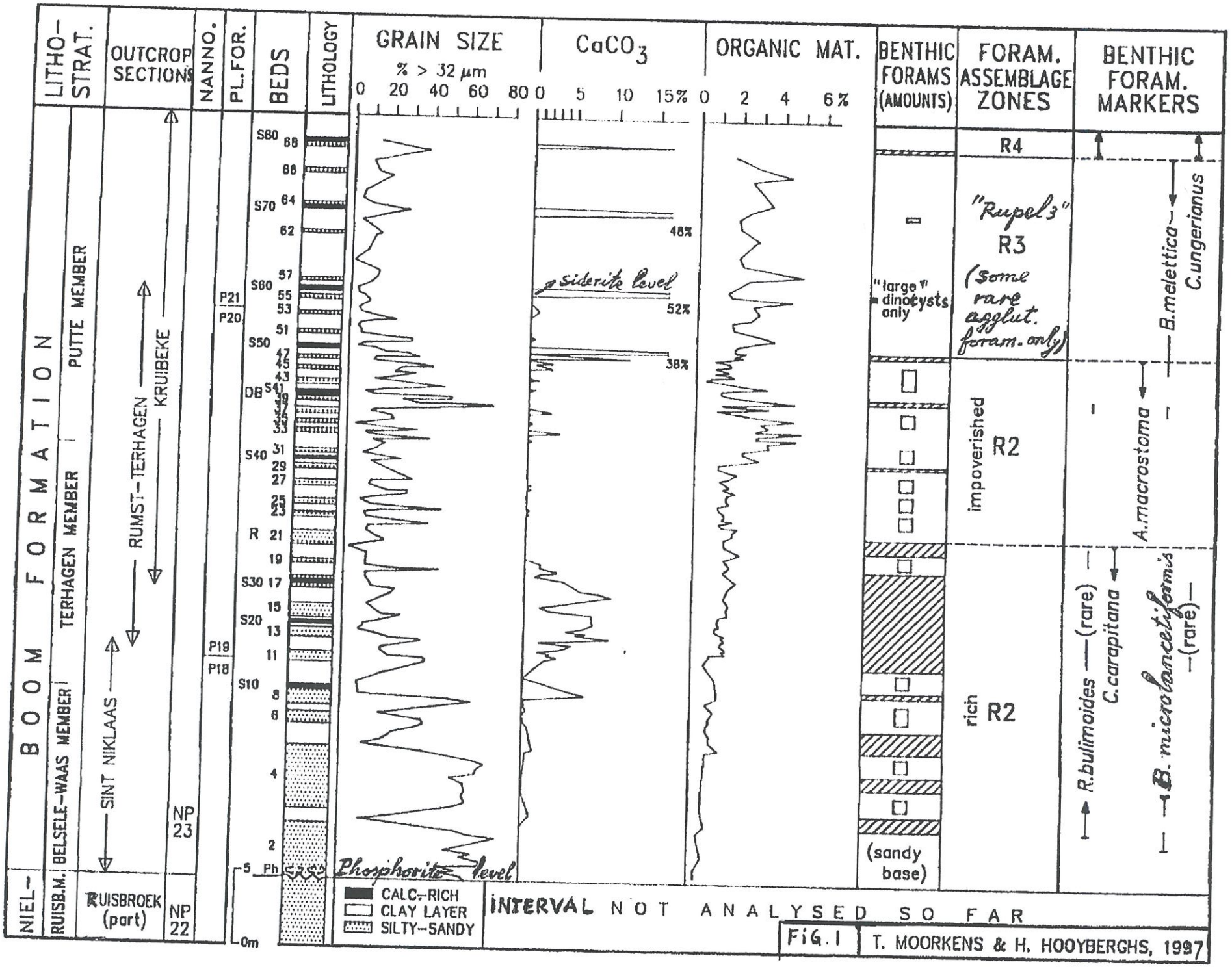

FIG. 1 T. MOORKENS & H. HOOYBERGHS, 1997

Saudi Arabian Upper Jurassic and Lower Cretaceous agglutinated foraminiferal associations and their palaeoenvironment

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Saudi Arabian Upper Jurassic and Lower Cretaceous carbonates constitute the world's largest hydrocarbon reservoirs. Optimum exploitation of these reservoirs is highly dependant upon an understanding of intra-reservoir flow layers that are mostly related to primary depositional layers. Within these uniform carbonate reservoirs, such stratification is not readily discernable by logs or lithofabric alone but often can be resolved with the integration of closely-spaced, semi-quantitative micropalaeontological data derived from exposure and core samples.

The Jubaila and Arab Formations represent an extensive development of platform carbonates of Upper Jurassic (Kimmeridgian - Tithonian) age. Four depositional sequences are recognised, each of which terminates with the deposition of sabkha evaporites. Micropalaeontological analysis Jubaila and Arab-D carbonates from oilwells has enabled a succession of agglutinated foraminiferal associations to be recognised, and provides new information on the palaeoenvironmental preferences of some Upper Jurassic agglutinated foraminifera. The lowermost association is muddy, with storm-derived, predominantly fining-upwards beds that contain probably allochthonous *Kurnubia palastiniensis*, with subsidiary *Alveosepta jaccardi*. This association passes vertically into one characterised by wackestones and packstones with predominantly coarsening-upwards beds that contain autochthonous *K. palastiniensis*, without *A. jaccardi*; stromatoporoids, *Cladocoropsis mirabilis* and the dasyclad *Clypeina jurassica* make their initial consistent appearance at this level. Higher in the succession, packstones and grainstones contain *K. palastiniensis* with *Mangashtia viennoti* and *Pfenderina salernitana*. The miliolid *Nautiloculina oolithica* is present throughout the succession. The studied section is considered to represent a gradually shallowing carbonate succession, passing from middle neritic through to shallow inner neritic water depths; the carbonates are overlain by a thick anhydrite unit of sabkha origin, considered to terminate this particular depositional megacycle. A simple threefold zonation is applicable throughout the region, in which predominantly aggradational sedimentation is suggested, although slight variations in the initial appearance of certain species suggests some evidence for regional progradation.

The Shu'aiba Formation in the Shaybah Field is of Lower Aptian age, and is characterised by rich biocomponent assemblages that are dominated by rudist bivalves, calcareous algae and benthonic foraminifera. *Palorbitolina lenticularis* is the most common benthonic foraminiferal species, and its variable coexistence with the other biocomponents provides potentially valuable insights for understanding its palaeoenvironmental preferences. The lowermost unit contains low-trochoid forms that co-occur with rare hedbergellid planktonic foraminifera and numerous benthonic foraminifera, including *Praechrysalidina infracretacea*, *Debarina hahounerensis* and *Vercorsella arenata*, within an regionally extensive, moderately deep shelf palaeoenvironment. Later rudist colonisation of the shelf margin caused differentiation of the shelf into a lagoon, fore-barrier, barrier, fore-barrier and slope palaeoenvironments. The lagoon assemblage is characterised by the co-occurrence of *P. lenticularis* with the calcareous alga *Lithocodium aggregatum;* other benthonic foraminifera are rare within this association but include *Trocholina alpina*. It is overlain by a back-barrier assemblage that has prograded into the gradually shallowing lagoon, in which the elevator rudist *Glossomyophorus costatus* is well represented. In the fore-barrier regime, specimens of *Palorbitolina lenticularis* display a low conical height and are interpreted to have occupied a deeper environment.

This new information supplements the meagre published palaeoenvironmental information available on these particular agglutinated species, and may assist in refining the palaeodepth scheme suggested by Banner and Simmons (1994). Additional regional investigations continue.

An investigation of the significance of foraminifera within the Kimmeridgian of the Tisbury Borehole, Southern England.

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Abstract:

This study investigates the nature of the benthic habitat of the foraminifera found in the seas of the Kimmeridgian Southern England. The evidence strongly suggests the presence of microbial mats on the surface of the sediment. This provides a good answer to the long-standing enigma of the presence of a strong anoxic signal in the Kimmeridge clay and yet the abundance of benthic foraminifera.

A detailed study investigating the Black Stone band was undertaken. The foraminiferal associations were studied. Tests were seen to be abundant but of low diversity. It was seen that the assemblages were dominated by five genera, *Reophax, Ammobaculites, Kutzevella, Textularia* and *Trochammina*.

An holistic approach is taken. The study suggests that the foraminifera found are exaerobic, being perched between anoxic sediments and the dysoxic water column, they are also able to withstand fluctuating oxygen levels, and are termed poikiloaerobic.

Newly recorded agglutinated foraminifera from the Qusseir Shales in Gebel Duwi and Abu Had, Eastern Desert, Egypt.

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This paper describes and illustrates 45 agglutinated foraminiferal species recorded for the first time from the Qusseir Shales in Gebel Abu Had and Duwi, Eastern Desert, Egypt.

The qusseir Shales are a series of greyish green to dark grey, laminated shales alternating with yellowish and brownish ferruginous fine-grained sandstone beds. These shales have a wide horizontal extent in Egypt. These have been described from such widely separated areas in Egypt as Dakhla, Kharga Oases to the west, the Nile Valley and the Qusseir Safaga to the east, area from Central Sinai

The age of the Qusseir Shales was subject of a great controversy in the Egyptian stratigraphy for a long time ago since they are devoid of mega and microfossils that can detect the age definitely.

The present work is the first which describes 45 agglutinated foraminiferal species from the Qusseir Shales. Through the analysis of the reported fauna 4 agglutinated zones were proposed and defined on the basis of these biozones, the age of the Qusseir Shales is assigned to Campanian and Maastrichtian.

These biozones are:-

Ammodiscus mangusi Zone
Trochammina undulosa Zone
Lituola difformis-taylorensis Zone
Ammobaculites khargensis Zone

Paleogene benthic foraminiferal biostratigraphy of the Halten Terrace area, Norway.

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Benthic foraminiferal assemblages from four wells on the Norwegian Shelf near the Halten Terrace have been studied. A biostratigraphic scheme based mainly on benthic foraminifers but also including planktic foraminifers, diatoms and radiolarians is proposed for the Paleogene which enables the correlation of the four wells and is applicable for the Norwegian Shelf. The scheme has also been correlated with other biostratigraphies from the same or adjacent areas.

The late Paleocene is characterised by abundant and diverse agglutinated assemblages with both calcareous and organically cemented foraminifers. The Paleocene/Eocene boundary marks the opening of the Norwegian-Greenland Sea and a change to more impoverished assemblages. Above this there is a brief interval where planktic foraminifers are recorded, before a return to wholly agglutinated, organically cemented assemblages. Biosiliceous sedimentation and deteriorating oxygenation start in the mid Eocene, and continue throughout the Oligocene and early Miocene.

Molecular relationships between Japanese and Californian *Trochammina hadai* Uchio (agglutinated foraminifer) inferred from nuclear LSU ribosomal DNA

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Trochammina hadai Uchio is an agglutinated foraminifer which is abundant in brackish water bays around the Japanese Islands. The life cycle, feeding preferences, and modes of reproduction are well documented both through field and laboratory observations. In natural environments this species exhibits a biphasic life cycle, alternating sexual and asexual reproduction.

It is believed that *Trochammina hadai* Uchio has recently been introduced into San Francisco Bay, California, U.S.A. The species was introduced into the bay sometime during the 1980s, based on numerous microfaunal studies of San Francisco Bay. Several questions arise from these observations. Is *Trochammina hadai* of San Francisco Bay the same species as in the Japanese Islands? If so, how was the Japanese species introduce into San Francisco Bay? If not, has there been ecophenotypic convergence among different trochammine species?

To elucidate the molecular relationships between *Trochammina hadai* on the east and west of the Pacific Ocean, nuclear large-subunit ribosomal DNA sequences were analysed for populations from Japan and California. Living specimens were collected at Matsushima Bay in Japan and San Francisco Bay in the USA. Specimens were cultured in filtered seawater over several days to empty food vacuoles and were rinsed several times in filtered and aspetic seawater. DNA was extracted from the specimens. DNA fragments of about 600 base pairs which were situated at 5' terminal region of the LSU rDNA were amplified by PCR. An unrooted tree was constructed using both the neighbor-joining and parsimony methods. *Trochammina* sp. from the Mediterranean Sea was selected as an outgroup species.

The divergence of nucleic acid sequences between the Japanese and Californian *T. hadai* populations is below 1 %. In contrast to this similarity, the divergence between Japanese and Mediterranean *T.* sp. is more than 15 %. This means that *Trochammina hadai* of California is likely conspecific with the Japanese species, though we analysed only one fragmental part of long DNA sequences. Although the amplified region is thought to be very conservative, the divergence between *T. hadai* of the Pacific and *T.* sp. of the Mediterranean is very large.

Further studies are required to know how and when *Trochammina hadai* was introduced in San Francisco Bay. The results should enable us to better understand how anthropogenic disturbances take place in ports and bay areas.

"Rhabdammmina-fauna" assemblages from the Cretaceous of Northeastern Brazil.

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The genera *Bathysiphon, Dendrophrya, Hyperammina, Rhabdammina, Rhizammina* and *Kalamopsis* are referable to a morphogroup of long-ranging, primitive elongate agglutinated foraminifera whose test is wholly or in part arenaceous, composed of single-chambered tubes, straight or branched, and regular or irregular in size and arrangement. Together with such genera as *Ammodiscus, Glomospira, Glomospirella, Hormosina, Psammosphaera, Saccammina, Rzehakina, Silicosigmoilina* and *Spirolocammina,* they belong to a characteristic deep-water assemblage of arenaceous agglutinated foraminifera which are commonly referred to as "*Rhabdammina*-faunas" (Brouwer, 1965; Winkler, 1984) or "flysch-type" (Gradstein & Berggren, 1981), the latter a direct allusion to the common occurrence of these taxa in hemipelagic layers of turbiditic sequences.

Two major events of "*Rhabdammina*-fauna" are recorded in the Cretaceous succession of NE Brazil: from upper Aptian to Albian (a mixed carbonate-siliciclastic platform system) and upper Coniacian to Maastrichtian (deep-water siliciclastic deposits). The complete absence of this assemblage from Cenomanian to middle Coniacian deposits, mostly represented by a massive succession of deep-water, fine-grained carbonates (carbonate ramp system), indicates inhibiting environmental conditions for the development of "*Rhabdammina*-fauna" under episodes of carbonate-dominated pelagic sedimentation.

Maximum species diversity values are recorded from upper Aptian to middle Albian organic-rich (TOC 2-12%), hemipelagic dark grey marls and calcareous black shales, locally associated with thick turbiditic sequences deposited within structural lows. These deposits accumulated during a period of intensified and widespread low-oxygen pelagic conditions in deep neritic to upper bathyal settings in the northern South Atlantic. The presence of tubular-shaped, single-chambered, agglutinated foraminifera (*Bathysiphon* ex gr. *vitta, Hyperammina* ex gr. *gaultina*) in the upper Aptian to upper Albian succession of NE Brazil represents the earliest known occurrence of these primitive agglutinated taxa in such early marine deposits of the northern South Atlantic. In addition, their close biogeographic affinities with Tethyan provinces is of further support to a postulated late Aptian connection and water-mass interchange, at probable intermediate (epi- to mesopelagic) depths, between the northern South Atlantic and the Central North Atlantic.

For the Upper Cretaceous, maximum diversity values, nearly five times higher in magnitude than in the late Aptian-mid Albian maximum, are recorded from upper Campanian shales deposited in middle to lower bathyal environments. These deposits correspond, approximately, to a palaeobathymetric maximum which appears to have occurred during Campanian times, when the deepest environments are recorded in all the studied sites and maximum diversity occurred in the benthic foraminiferal assemblages. The composition of the benthic foraminiferal assemblages demonstrate a cosmopolitan biogeographic distribution.

The total diversity of the "*Rhabdammina*-fauna" decline after the Campanian maximum, in a stepwise pattern. This is concomitant with the general trend of palaeobathymetric decrease (of 2nd order of magnitude) induced by the progradation of the continental margin, which earliest stages are coeval with the palaeobathymetric maximum.

Though typical of middle bathyal and deeper deposits, the occurrence of rare and low-diversity *Rhabdammmina*-assemblages in upper Aptian-Albian turbiditic and hemipelagic strata of NE Brazil, deposited in deep neritic to upper bathyal settings, serves as a further reminder that bathymetry, *per se,* should not be taken as a definitive constraint on the distribution of the group (e.g. Berggren, 1984).

REFERENCES

Berggren, W.A. 1984. Cenozoic deep water benthic foraminifera: a review of major developments since Benthonics' 75. *Benthos'83: 2nd International Symposium on Benthic Foraminifera* (Pau, Avril 1983), 41-43.

Brouwer, J., 1965. Agglutinated foraminiferal faunas from some turbiditic sequences. I + II. *Proceedings koninklijke nederlandse Akademie van Wetenschappen,* BB, **68**, 309-334.

Gradstein, F.M. & Berggren, W.A. 1981. Flysch-type agglutinated foraminiferal assemblages and the Maestrichtian through Paleocene history of the Labrador and North Seas. *Marine Micropaleontology,* **6**, 211-268.

Winkler, W. 1984. *Rhabdammina*-fauna: what relation to turbidites? Evidence from the Gurnigel-Schlieren flysch. *Benthos'83, Second International Symposium on Benthic Foraminifera* (Paul, April 1983), 611-617.

Taphonomy of deep water agglutinated foraminifera: observations, speculations and open questions

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In Recent Atlantic and Pacific deep-sea cores the number of agglutinated foraminifera drastically decreases in the uppermost 20 cm and generally very rare or no agglutinated species are found further downcore. Increasing fragmentation downcore and subsequent loss of first the fragile thin-walled specimens and later the well-cemented thick-walled taxa indicate that this decrease in species abundance is mainly caused by taphonomic processes such as bacterial decay of organic cements. Surprisingly Cretaceous and Paleogene deep-sea sediments show commonly rich and well-preserved agglutinated foraminiferal assemblages. Early diagenetic silification of the organic cement may have played an important role at the Mesozoic and Paleogene ocean floor. A better understanding of the taphonomic processes involved in the fossilisation of deep water agglutinated foraminifera (DWAF) thus may provide insight into a fundamentally different deep-sea paleoceanography during the Mesozoic and Paleogene.

As a first attempt to better understand this unsolved problem the taphonomy of recent and fossil DWAF is compared using distribution patterns within the sediment column and the wall ultrastructure of living, decaying and fossil agglutinated foraminifera. This initial study concentrates on the taphonomy of five environmentally characteristic groups that include extant and fossil forms of the same genera:

1. Smooth walled, finely agglutinated forms with organic cement, that preferrably occur in the central oceanic oligotrophic gyres (*Buzasina, Cystammina, Haplophragmoides*)
2. Coarsely agglutinated infaunal forms with organic cement, that are common in the central oceans and along the continental margins (*Ammobaculites, Discammina, Recurvoides, Reophax*)
3. Infaunal forms with calcitic cement (the Recent genera *Siphotextularia, Karreriella, Eggerella* and the Cretaceous *Clavulinoides, Spiroplectammina, Gaudryina*)
4. Epifaunal tubular forms with organic cement (*Rhabdammina, Saccorhiza)*
5. Thin-walled epifauna with large amounts of organic cement and occasionally flexible tests (*Rhizammina indivisa, Komokiacea* and attached agglutinates such as *Ammolagena* and *Tolypammina*)

A scaring aspect of these observations is the possibility, that assemblage composition of many fossil DWAF faunas may be largely controlled by taphonomic processes. This confronts investigators of fossil DWAF assemblages with two fundamental questions: (1) Is it possible that significantly differing fossil assemblages resulted from the same living populations through different taphonomic filters? (2) Are diversity fluctuations of DWAF in the geologic record only a result of changes in taphonomic conditions?

The foraminiferal colouration index (FCI)

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A new geothermal maturity index has been established on the basis of thermally controlled colour changes in the organic cement (glycosamminoglycans) of agglutinated foraminifera. The new index is referred to as FCI (Foraminiferal Colouration Index) and was derived empirically from fossil assemblages and backed up experimentally by anhydrous pyrolysis heating experiments on Recent and fossil foraminifera. FCI was established from data from the Beaufort-Mackenzie Basin of Arctic Canada, but has potential application in sedimentary basins world-wide containing agglutinated foraminifera.

The index is keyed to the Munsell Colour Chart but has a quantitative basis, as FCI values can be tabulated statistically from fossil assemblages to produce precise numerical values. FCI can be applied readily to both outcrop and subsurface core and cuttings samples and has been proven to be most sensitive to thermal change at lower geothermal maturity levels (0.3 to 0.7%VRo). It is therefore a useful index for the early stages of hydrocarbon generation.

In Beaufort-Mackenzie Basin exploration wells, FCI was found to be independent of the colour of associated rocks and to increase in a linear trend with depth. FCI was found also to be sensitive to heating rate, with the most rapidly deposited strata showing the lowest FCI values for a given temperature. A significant departure from the standard trend was documented in the Reindeer D-27 well in the Mackenzie Delta. FCI initially followed a linear trend, increasing with depth, but then was conspicuously depressed at a depth which coincided with a marked increase in geopressure as indicated by shale porosity trends and pore pressure measurements. This aberration of FCI in an overpressured zone is particularly significant as it points towards FCI as being a potential indicator of paleogeopressure.

Diamond-bearing kimberlites, agglutinated foraminifera, and Albian shales in central Saskatchewan, Canada.

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In central Saskatchewan, a multi-disciplinary study of one cored section indicates that diamond-bearing kimberlites were emplaced within Lower Cretaceous marine and non-marine clastic sediments during at least two phases of kimberlite volcanism. The events are constrained biostratigraphically by a minimum age of approximately 100 Ma for marine shales at the top of the kimberlite section. This date is consistent with a U-Pb pervoskite radiometric age determination of 101.1 Ma derived for a kimberlite lapillistone which underlies the shales.

The bulk of the kimberlites formed as airfall deposits interbedded with terrestrial sediments of the Aptian-Albian Cantuar Formation. Subsequent marine transgression partially bevelled the top of the kimberlite tephra cone and resulted in marine-reworked kimberlite deposits, including olivine beach sediments.

In the marine part of the section, transgressive lag deposits, containing mantle minerals such as diamond, Cr-pyrope, and Cr-diopside, overlie reworked kimberlite debris containing mytiliform bivalves. Silty, marginal-marine shales of the late Albian Westgate Formation overlie the transgressive lag deposits and contain conspicuously coarse-grained assemblages of agglutinated foraminifera dominated by abundant *Ammobaculites fragmentarius* and *A. tyrrelli*. Above this transgressive marginal-marine assemblage, the diversity and abundance decrease abruptly, but then increase steadily upsection until maximum abundance is reached in an assemblage dominated by *Paratrochammina*. The peak overall abundance of specimens, and the dominance of *Paratrochammina* which is more typical of deeper water environments, suggests that this is the point of maximum marine flooding. The agglutinated foraminiferal assemblage at this time consisted of species of *Saccammina*, *Glomospira*, *Miliammina*, *Psamminopelta*, *Haplophragmoides*, *Labrospira*, *Ammobaculites*, *Paratrochammina*,and *Trochammina*. The uppermost part of the cored section contains a lower diversity assemblage of agglutinated foraminifera possibly indicating regression of marine waters during the latest Albian.

Early? - Middle Cretaceous Foraminifera from Northeast Libya.

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Borehole A1-18 was the first oil exploratory well to be drilled in NE Libya. The Mid-Cretaceous part of this well, and its equivalent Jardas Formation (the oldest outcrops in the Al Jabal al Akhdar relief close to the Jardas al Abid village) have been examined lithostratigraphically and biostratigraphically.

The foraminiferal suite is generally identified from both sections as well as the closer selected wells; results are correlated with a previous study of Duronio *et al.* (1985).

Only two formations are recognised in this study: Jardas Formation (Cenomanian) and Daryanah Formation (Aptian-Albian). The former is characterised by deeper-water facies, indicated by the planktic foraminifera *Rotalipora* spp., *Favusella washitensis, Praeglobotruncana* spp. and *Hedbergella* spp., together with benthic forams *Textularia* spp. and *Haplophragmoides* spp., together with shallow marginal marine-lagoonal facies *Thomasinella punica* Schlumberger. The latter (Daryanah Formation) is characterised by a shallow marine carbonate facies with fresh water-continental facies influence indicated by Charophycaea (in Well A1-18).

Three assemblage zones have been recognised in the studied area which are:-

1) *Thomasinella punica - Textularia* assemblage zone
2) *Thomasinella punica - Orbitolina* sp. assemblage zone
3) *Orbitolina* sp. - *Choffatella decipiens* assemblage zone

The top of the Aptian has been identified as a horizon characterised by the disappearance of *T.punica* and the presence of *Orbitolina* sp. with the associated *Choffatella decipiens.*

It is recommended that the taxonomic position of *Thomasinella* Schlumberger, 1893 should be transferred from Hormosinacea Haeckel, 1894 to Coscinophragmatacea Thalmann, 1951 in the family level, as the initial coiled part shows attachment; this was previously suggested by Weidich & Al Harithi (1990).

Ammonite-calibrated foraminiferal biostratigraphy of Bathonian to Ryazanian strata in Spitsbergen

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ABSTRACT

The Bathonian to Ryazanian succession of Central Spitsbergen consists mainly of shales with high to intermediate organic content, and preserves an essentially continuous foraminiferal record composed almost exclusively of agglutinating taxa. The assemblages are re-examined in three extensively sampled sections, with supplementary material included from other localities in Spitsbergen and Russian Arctic.

The foraminiferal record of Spitsbergen is subdivided into eight interval zones, which are correlated with a Boreal ammonite zonal scheme using a graphic procedure. The age-thickness relationships reveal extremely low average sedimentation rates through the Upper Bathonian-Lower Kimmeridgian and Middle Volgian-Ryazanian intervals, suggesting the possible presence of minor hiatuses.

The taxonomical revision of foraminifera was accomplished in the light of comparisons with sample material from Russian occurrences. The emendation resulted in the proposal of two new genera, *Agardhella* and *Calyptammina*, and the following nine new species:
Thuramminoides lapilliformis, *Saccammina compacta*, *Scherochorella densiformis*, *Cribrostomoides subretusus*, *C. vallatus*, *Ammobaculites areniferus*, *Agardhella placula*, *Trochammina praerosacea* and *Gaudryina rostellata.*

Paleogene agglutinated foraminifera from Spitsbergen and the Barents Sea: a biofacies comparison

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Foraminiferal assemblages have been analysed from an exploratory well (7119/7-1) drilled in the Tromsø Basin (western Barents Sea) and from two onshore sections, Basilikaelva and Kovalskifjella, exposed in the Central Tertiary Basin of Spitsbergen. The assemblages reveal marked differences in taxonomic composition and diversity, reflecting inner neritic to middle bathyal conditions. Within this depth range, four foraminiferal biofacies (FB) are distinguished:

FB 1 occurs in the Kolthoffberget Member (of the Firkanten Formation, Late Paleocene) sampled in the Basilikaelva section. The member consists of interbedded shales siltstones and sandstones deposited in a transitional delta front - prodelta environment, according to current sedimentological interpretation. The foraminiferal assemblages are entirely agglutinated, show extremely low species diversities and are strongly dominated by *Reticulophragmium arcticum* followed by *Labrospira* aff. *turbida.*

FB 2 is recognised in the Basilika Formation (Late Paleocene) exposed in the Kovalskifjella section. The formation consists of silty claystones deposited in a prodelta shelf setting. The foraminiferal assemblages show an increased species diversity, and consist mainly of agglutinated taxa with a minor calcareous component in some samples. The two most abundant species are *R. arcticum* and *L.* aff. *turbida.* Species of *Verneuilinoides* and *Trochammina* occur in significant amounts while tubular taxa are seldom.

FB 3 is found in the Early Eocene clay interval composing the upper part of the Torsk Formation in well 7119/7-1. It contains entirely agglutinated assemblages with comparatively high diversities. The dominant species are *Recurvoides* aff. *turbinatus* and *Budashevaella multicamerata*, while *Reticulophragmium amplectens* is typical and common in these strata. Tubular forms referred to *Rhizammina* occur locally in significant quantities. The diversity and composition of the assemblages suggest an outer neritic to upper bathyal environment.

FB 4 is developed in Paleocene claystones composing the lower part of the Torsk Formation in well 7119/7-1. In this interval, the species diversity attains maximum values, as well as the frequency of tubular forms (referred to *Rhizammina, Bathysiphon* and *Hyperammina*). Other common to dominant taxa include *Spiroplectammina spectabilis, Haplophragmoides walteri, Ammosphaeroidina pseudopauciloculata* and *Recurvoides* sp. The assemblages are interpreted to reflect upper to middle bathyal conditions.

Bini-Systematization of the organic World and Foraminifera

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The phenomenon of sequential division of the whole into two parts and then division of each of these two parts into two ones and so on has been known for a long time and is called dichotomy. The latter becomes apparent in classifications of natural objects, in branching of the plants, in reproduction of organisms by division, in astronomy, chemistry, physics, geology and biology. One can speak about distribution of this phenomenon in the whole material world. We call this feature of the organic world bini-systematization (from latin bini - pair). Inside binial taxons of one and the same hierarchical level being in direct contradiction to each other one can find similar variation of features , that proves their homology. Strictly speaking, together with two basic components there is always the third component of the whole, i.e. a taxon has a three-part structure. But the third part is always suppressed in quantity and as to quality it represents «the blind» branch which has no future in its development. The third part is considered to be a boundary zone between two basic parts.

There are many examples of the organic world bini-systematization. It shows itself especially brightly on the highest hierarchical levels. By construction of cells all living beings are divided into Procaryota and Eucaryota. By way of feeding both the first and the second ones are separated into two kingdoms: Procaryota - into Cyanobionta and Bacteria, Eucaryota - into Phyta and Zoa (Animalia). In its turn Zoa is formed by two subkingdoms: Protozoa and Metazoa. In Metazoa composition there stand apart Parazoa and Eumetazoa. By type of the symmetry Eumetazoa is broken up into Radiata and Bilateralia. The latter consists of two groups which are called Protostomia and Deuterostomia.

There are many examples of bini-systematization on the level of types, classes and other taxons. The Angiospermae type is divided only into two classes: Dicotyledones and Monocotyledones. The Vertebrata subtype includes two infratypes: Agnatha and Gnathostomi. The first of them comprises Diplorhina and Monorhina classes, the second covering Pisces and Tetrapoda superclasses.

Even those existing classifications, in which bini-phenomenon is not observed on any level, do not disprove it because in these cases there are in principal different variants of taxonomy. So, the Bivalvia class is separated into several groups (from three to ten) on subclass (order) level according to the existing schemes. However there are some signs on base of which taxonomy of the Bivalvia class on higher hierarchical levels will be strait binial. Yu.S.Papin suggests to divide the Bivalvia class by type of the hinge line into two subclasses. One of them has the hinge line consisting of posterior branch - this is Monodorsa. The other subclass includes shells with the hinge line consisting of posterior and anterior branches - this is Bidorsa. Both subclasses are equal and homological according to the type of hinges and morphology. In particular on the following level each of the Bivalvia subclasses is divided again into two taxons (superorders). The first taxon includes isometric shells with a short hinge line, shells of the second taxon are developed by length or diagonal with a long hinge line.

The taxonomy of Foraminifera is considered in this paper only on two highest hierarchical levels. At present time widely used classifications of Foraminifera involve many orders (13) which differ one from the other by construction type of shells, their composition, quantity of cameras etc. At the same time all investigators acknowledge the presence of larger groups uniting some orders. First of all this is agglutinated and secreted Foraminifera, one- and many-cameras Foraminifera and so on. Among morphological and genetic features the highest rank can be given to shell construction and on the first level Foraminifera subclass can be divided only into two superorders: Agglutinida and Secretida. In its turn on the second level of taxonomy according to the number of cameras in shells Agglutinida can be broken up into two infraorders of Agmocamerida (*ag*glutinate+*mo*no+*camera*) and Agpocamerida (*ag*glutinate+*po*ly+*camera*). By the same feature we offer to divide Secretida superorder into the infraorders of Secmocamerida (*sec*rete+*mo*no+*camera*) and Secpocamerida (*sec*rete+*po*ly+*camera*).

Changes in agglutinated foraminiferal assemblages across the Cenomanian-Turonian boundary in Central and SE Poland.

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The studied interval comprises Upper Cenomanian and Lower Turonian strata from Central (outcrops from the Middle Vistula River valley and the Puławy borehole) and SE Poland (S-25 and S-19 boreholes near Sawin).

A major carbon stable isotope excursion with a shift of up to +2‰ $\delta^{13}C$ (PDB) is located a short distance above the Rotalipora cushmani - Whiteinella archaeocretacea boundary.

21 species of agglutinated foraminifers representing the following genera: Ammodiscus, Plectina, Eggerellina, Tritaxia, Arenobulimina, Ataxophragmium, Pseudotextulariella, Dorothia, Marssonella and Textularia have been recorded. Species of Tritaxia, Eggerellina and Plectina make 50 to 70% of the benthonic foraminiferal assemblages in the uppermost Cenomanian. A dramatic change took place at the Rotalipora cushmani - Whiteinella archaeocretacea zonal boundary. Most of the Upper Cenomanian agglutinated foraminifera species went extinct. For a short time benthonic foraminiferal assemblages became dominated by 2-3 calcareous species which were likely dysaerobes, becoming more abundant during OAE as they proliferated due to the absence of competition. In the Lower Turonian agglutinated foraminifera recovered. Assemblages are composed mainly of Lazarus species (e.g. Tritaxia tricarinata), new Turonian species (Arenobulimina preslii, Arenobulimina sp.) and immigrant taxa (Ammodiscus, Marssonella).

Agglutinated Paleogene foraminifera of the West-Siberian biogeographical province

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Agglutinated quartz-siliceous foraminifera are wide spread in Paleocene and Eocene of Western Siberia. They differ by their systematic composition from the ones in contiguous regions (Middle Asia, Europe) and are close to canadian ones and as well as to those from the adjacent territories of the Arctic. Within these regions the change of agglutinated quartz-siliceous foraminifera (Talizky, Lulinvorsky horizons and Reindeer, Richards formations) to secreted calcareous forms (Tavdinsky horizon and Kugmallit formation) was distinctly observed along marine Paleogene section (Podobina, 1975, 1988, 1989; McNeil, 1989, 1990).

After studing the change of foraminiferal complexes along the marine Paleogene section american investigators deciphered tectonic and oceanic events in separate Paleogene epochs in the following way. In Paleocene and Eocene marine circulations in the Arctic basin including Western Siberia were restricted that created conditions for the development of endemic agglutinated foraminifera. Paleogeographical reconstructions listed by american investigators (Briggs, 1987; McNeil, 1990 et al.) showed that Paleocene-Eocene Arctic ocean differed considerably by its outline from its modern analogue and was named conditionally as "the Arctic gulf". It is shown at the paleogeographic scheme that "the Arctic gulf" almost hadn't any connections with Atlantica, as Greenland and Norway were divided by narrow shallow-water straits that served appearently as the ecological barrier for the migration of calcareous foraminifera from Atlantic and vice versa. "The Arctic gulf" extended through Western Siberia and was in some places and for a short time connected with southern seas through the narrow Turgai straits.

Hence, agglutinated quartz-siliceous foraminifera of "the Arctic gulf" were developed separately in the Paleocene-Eocene phase of the Arctic marine history. Three transgressive cycles are observed on the territory of "the Arctic gulf": Late Paleocene, Early Eocene and Middle-Late Eocene. Different assemblages of agglutinated quartz-siliceous foraminifera and two levels of planktonic ones (possibly, Ypressian and Pryabonian) correspond to these cycles in Western Siberia.

In Oligocene "the Arctic gulf" turned little by little to the modern Arctic ocean thanks to sea floor spreading between Greenland and Norway (Briggs, 1987 et al.). Since beginning of Oligocene marine connections between Arctic and Atlantic oceans were opened and gradually expanded. As is was indicated, at this boundary within the Arctic region, including Western Siberia, Paleocene-Eocene agglutinated quartz-siliceous foraminifera were substituted by secreted calcareous ones, more similar with west-european foraminifera thanks to establishing of wide and deep straits between Greenland and Norway as well as to rising and some shallowing of Arctic. It promoted the settling and life of calcareous benthic forms (Podobina, 1989, 1996; McNeil, 1990).

The similarity of these organisms according to generic composition within the whole "Arctic gulf" was established on the basis of the analysis of agglutinated quartz-siliceous foraminifera from Paleocene-Eocene deposits of Arctic Canada, Alaska, adjacent territories of Arctic (McNeil, 1989, 1990) and Western Siberia (Podobina, 1988, 1989, 1990, 1996) conducted by the author on published works and her own numerous collectional materials. Thus, one Arctic circumpolar biogeographic area was traced there by the author, within which two provinces were established: West-Siberian and Arctic (Arctic Canada, Alaska with adjacent territory of Arctic), differing by generic and especially specific compositions of agglutinated foraminifera.

Within the West Siberian province agglutinated quartz-siliceous foraminifera are mainly presented by genera: Reophax, Glomospira, Labrospira, Haplophragmoides, Cyclammina, Ammoscalaria, Textularia, Trochammina, Gaudryinopsis, Verneuilinoides and others. The Late Paleocene assemblage with Ammoscalaria friabilis and Middle Eocene with Gaudryinopsis subbotinae are most wide spread among them.

Agglutinated foraminifera - Haplophragmoididae: composition of wall, peculiarities of morphology and evolution

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Late Cretaceous foraminiferal assemblages of Western Siberia are presented by agglutinated quartz-siliceous forms, representatives of Haplophragmoididae Maync, 1952 family are the most important among them.

The main morphological features taken as a principle of distinguishing this family are, in V.Podobina's opinion, following: chemical composition and type of wall (agglutinated), the character of spiral and many-chambered shell.

The composition, the microstructure of the wall and the internal structure of shells were investigated by means of their polishing and by using immersion liquids in all discribed taxa of Haplophargmoididae family. Petrographic immersion liquids suggested for the first time by V.Podobina were most widely used (Podobina, 1963).

The resulted oriented thinsections were studied under polarized microscope that gave the possibility to investigate the microstructure of shell's wall in details, to reveal the correlation of agglutinate and cement, as well as their composition. The given thinsections were studied also in the relation of the internal shell's structure, the position of foramens, outlines, sizes of initial and following chambers, the character of their attaching and distinguishing of separate generations of the species. These investigations allowed to delimit three to some extent morpholgically similar genera: Labrospira, Haplophragmoides, Cribrostomoides after proving their independence.

Thanks to the introduction of digital indices the varieties of planispiral type of Haplophragmoididae family were delimited more clearly. The digital values for the evoluteness degree in shells gave the additional criterion for the separation of similar genera - Trochamminoides, Labrospira, Haplophragmoides and others.

By using sets of parallel development the authors came to the conclusion about regular appearance at some stratigraphic levels the definite morphological features characteristic of different species similteniously by several genera that led sometimes to the considerable change in the external appearance of the lasts. The internal morphological features, as the investigations showed, remained however more stable. They allowed to reveal separate taxa in the systematics of the given family defined their volume and stratigraphic distribution. The conclusion was made that genera considerably changed at some stratigraphical level can acquire some morphological features of their ancestors by the reversion. So, some large, many-chambered genera, having evolute shells (Labrospira, Recurvoides) typical for Late Jurassic and Early Cretaceous, in Late Cretaceous are presented by smaller, more closely convolute forms with the less quantity of chambers. In modern deposits the enlargement of shells, some increasing of their involuteness and the common quantity of chambers are observed [species Labrospira crassimargo (Norman), Recurvoides contortus (Montfort) et. al.]

Major changes in morphology of shells of this family are marked in respect of three features: character of shell's evoluteness, the change of aperture's position and the degree of complicatedness of shell's structure. Investigating these forms by collectional materials, collected from many regions of the world as well as from published works the authors came to the conclusion about the blossoming of the family in Late Jurassic, Cretaceous and Paleogene. Its first representatives are traced however since Late Paleozoic and the great majority of genera were distributed up to now.

The evolution of representatives of the given family was more accelerated beginning with the Late Jurassic time and in the Cretaceous period. Boreal epicontinental basins widely spread at this time had appearently the great influence upon their relatively quick development and promoted dispersion and specialization of shells of separate genera.

Tertiary benthic foraminifera from the Agua Salada Group, State of Falcon, Venezuela. A preliminary re-evaluation and revision.

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Ninety Tertiary samples were studied from out crop sections in Eastern Falcon, Venezuela for benthic foraminifera. The fauna identified is the Agua Salada Fauna (ASF), a characteristic agglutinated benthic foraminiferal assemblage initially identified from the Oligocene - Miocene Agua Salada Formation of Venezuela. This cosmopolitan fauna is identified by the presence of *Valvulina flexilis* and is common to the Caribbean, Gulf of Mexico, within the Vienna Basin, Libya, Borneo and along the West African continental margin.

The Agua Salada Fauna was named by Renz (1948) and has received little attention. Originally examined by Cushman and Renz (1941) and mentioned by Akers (1954) the ASF was then re-evaluated by Blow some years later (1959). The type area in northern Venezuela then became a point of contention for a short period (Renz 1959). However, since this early work, the ASF has only received fleeting reference (Basou 1976) until the present (Moreno-Vaquez 1995; Kaminski *et. al.* in press; *Preece et. al.* in prep). We recognise in excess of 400 calcareous and agglutinated foraminiferal species within this section. Approximately 100 of these are omitted from Cushman and Renz (1941) and Renz (1941) in their original works.

The agglutinated component of this fauna is dominated by elongate tapering infaunal forms typical of modern dysaerobic environments. Their fluctuating relative abundances may be considered to be a record of fluctuating oxygen minimum zone (OMZ) intensification. The oxygen content of deep waters is regarded as one of the primary factors controlling the phylogeny of deep - sea benthic foraminifera, the evolutionary radiation of particular genera is considered to represent adaptation to life under an OMZ.

Akers, W. H. 1954. Ecologic aspects and stratigraphic significance of the foraminifera *Cyclammima cancellata* Brady. *Journal of Palaeontology* **28(2)**: 132 - 152.

Basou, I. A. 1976. Benthic foraminferans in shelf sediments of the Gulf of Guinea. *Biologiya Morya* **1**: 22 - 29.

Blow, W. H. 1959. Age, correlation and biostratigraphy of the Upper Tocuyo (San Lorenzo) and Pozon Formations, Eastern Venezuela. *Bulletin of American Palaeontology* **39**: 67 - 251.

Cushman, J. A. and Renz, H. H. 1941. New Oligocene - Miocene foraminifera from Venezuela. *Contributions from the Cushman Laboratory for Foraminiferal Research* **17**: 1 - 27.

Kaminski, M. A., Berggren, W. A. and Preece, R. C. In Press. The Agua Salada Fauna: A Neogene deep-sea agglutinated foraminiferal fauna adapted to dysaerobic conditions of the low latitude upwelling zones.

Moreno-Vaquez, J. 1995. Neogene biofacies in eastern Venezuela and their calibration with seismic data. *Marine Micropalaeontology* **26**: 287 - 302.

Preece, R. C., *et. al.* In Prep. Miocene benthic foraminiferal morphogroups in an oxygen minimum zone offshore Cabinda.

Renz, H. H. 1948. Stratigraphy and fauna of the Agua Salada Group, State of Falcon, Venezuela. *Geological Society of America, Memoir* **32** pp. 219.

Renz, H. H. 1959. San Lorenzo Formation (Agua Salada Group) of Eastern Falcon, Venezuela, a valid lithostratigraphic name. *American Association of Petroleum Geologists Bulletin* **43 (10)**: 2500 - 2502.

Emendation of the genus *Trochammina* Parker and Jones

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CANADA

Since the original description of the genus *Trochammina* in 1859 many new species that are trochospiral and agglutinated have been attributed to this genus. Subsequently, however, many new genera have come into existence based solely on small changes in the aperture. Examples of these are *Arenoparrella* Andersen, *Tiphotrocha* Saunders, *Jadammina* Bartenstein and Brand, *Siphotrochammina* Saunders and several others that were originally described as *Trochammina.* We have used these names but we have also observed flexibility in most of these species, especially *Trochammina macrescens* Brady which also has a form that was put into the genus *Jadammina* but we have shown repeatedly with intergradational series that the *polystoma* and *macrescens* forms are simply ecophenotypes. However because *macrescens* is not the type species of *Trochammina* we could not emend the genus and technically the genus name for the *macrescens-polystoma* complex should be *Jadammina.* However in recent work from mangrove-marsh regions in Brazil, South Carolina, and Japan we have been able to to show that species belonging to the genus *Siphotrochammina* are conspecific with *Trochammina inflata* (Montagu) thus demonstrating within the genotype the flexibility of apertural characteristics that we have observed in other trochamminids. Hence we are emending the genus *Trochammina* to include variations in apertural types such as supplementary apertures(*Jadammina, Arenoparrella)* and umbilical tubes(*Siphotrochammina, Tiphotrocha)* , thus making all these genera junior synomyns of the older genus *Trochammina*. We feel this will make it much easier to work with this important group which has suffered a proliferation of generic names in recent times that has confused many students new to the field. We can demonstrate once again that taxonomy should be done on large contiguous populations where the full range of variability can be observed before new taxa are created. It is interesting to note that many of the type species for these genera were originally placed in the genus *Trochammina* and will now return to their original designation.

Orbitolinids from the Middle East - A revision of the F.R.S. Henson Collection

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Orbitolinids (here taken to mean *Orbitolina sensu lato*) are agglutinating larger foraminifera and are one of the most important groups of microfossils for biostratigraphic studies of carbonate platform sediments in the Tethyan realm. Modern studies by Rolf Schroeder (1960 onwards) have shown that the structure of the embryonic apparatus (initial chambers seen in thin-section) of this group is the most important feature for taxonomic subdivision. Difference in the structure of the embryonic apparatus allow for several evolutionary lineages to be recognised, with each lineage typically containing a number of stratigraphically restricted species.

Although there are some exceptions, the use of orbitolinids in biostratigraphic studies in the Middle East has been hampered by a reliance on archaic taxonomic nomenclature, which has prevented the stratigraphic value of these microfossils from being fully utilised. Therefore, in order to review the stratigraphic distribution of orbitolinids in the Middle East, it has proved necessary to carry out a complete taxonomic review of previously described orbitolinid occurrences in the region.

The starting point for such a review must be the seminal work of F.R.S. Henson. Although orbitolinids had been described from the Middle East before Henson's publications, Henson was the first micropalaeontologist to realise the significance of the internal structure of orbitolinids in taxonomy. In 1948 he published his monograph "Larger Imperforate Foraminifera from South-Western Asia" in which he completely reviewed the occurrence of orbitolinids in the Middle East, describing 10 species and varieties within the genus *Orbitolina*: *Orbitolina kurdica* Henson, *Orbitolina cf. O. discoidea* Gras, *Orbitolina discoidea* var. *delicata* Henson, *Orbitolina discoidea* var. *libanica* Henson, *Orbitolina* cf. *O. bulgarica* (Deshayes), *Orbitolina* cf. *O. lenticularis* (Blumenbach), *Orbitolina* cf. *O. trochus* (Fritsch), *Orbitolina* cf. *O. concava* (Lamarck), *Orbitolina concava* var. *sefini* Henson, *Orbitolina concava* var. *qatarica* Henson. However, the nomenclature he used cannot readily be compared with the widely accepted nomenclature of Schroeder.

The type and figured material of Henson is held in the collections of The Natural History Museum and has been reviewed to place the taxa of Henson within current taxonomic nomenclature. In addition, the museum holds supplementary unillustrated material in the F.R.S Henson & Associates Collection, which has been of great assistance in redescribing Henson's taxa.

Of Henson's taxa, only one species is retained - *Orbitolina sefini*. In the Henson material we recognise 8 species in total - *Conicorbitolina conica* (d'Archiac), *Eopalorbitolina charollaisi* Schroeder & Conrad, *Mesorbitolina aperta* (Erman), *Mesorbitolina parva* (Douglass), *Mesorbitolina texana* (Roemer), *Orbitolina sefini* Henson, *Palorbitolina lenticularis* (Blumenbach) *and Praeorbitolina cormyi* Schroeder. Each of Henson's taxa can include more than one of these species, and these species sometimes also occur under more than one name in the Henson collection. For example, the syntypic thin-sections of Henson's *Orbitolina kurdica* contain both *Mesorbitolina texana* and *Palorbitolina lenticularis* (two species that are stratigraphically distinct). *Palorbitolina lenticularis* occurs under the names *Orbitolina kurdica, Orbitolina* cf. *discoidea*, *Orbitolina discoidea* var. *delicata* and *Orbitolina* cf. *bulgarica.*

By revising the Henson Collection we now have a better idea of the stratigraphic and palaeogeographic distribution of orbitolinids in the Middle East and can so improve their utility in correlation studies. Work is ongoing to assess the use of auxiliary features for identification such as chamberlet shape, chamber layer thickness and style of the marginal zone. In non-axial thin-sections where the embryonic apparatus is absent, these features may prove a useful aid to identification, if consistency can be found within a species.

Post-impact assessment of Restronguet Creek, south-west Cornwall and investigations into the absence of agglutinating foraminifera

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Following a major discharge in January 1992 of acid mine drainage (AMD) from Wheal Jane tin mine in south-west Cornwall, a post-impact study using benthic foraminifera as bio-indicators has been carried out on Restronguet Creek, which is receiving the contamination.

Benthic foraminiferal response to heavy metal contamination include: low standing crops; high proportions of deformed tests; low diversity; temporal and spatial shifts in species dominance; high metal concentrations within the tests of deformed specimens relative to undeformed and acid alteration of the test. Due to the lack of pre-discharge foraminiferal data for this area, other estuaries draining abandoned metal mining areas have been sampled to determine background levels of foraminiferal test condition and living abundance. These estuaries are the Fowey (Cornwall), Avon and Erme (south-west Devon) and provide the main control sites. In addition to the systematic sampling of these estuaries, reconnaissance sampling of several other south-west estuaries has also been undertaken. These estuaries are the Axe (east Devon), Looe (east Cornwall) and the associated creeks and tributaries entering Carrick Roads, the estuary of the Fal.

The results of the past five years monitoring of Restronguet Creek, have documented improvements in the abundance of living individuals, reduced proportions of deformed tests, less severe acid dissolution of the test walls and a seasonal species distribution which is similar to that of the Fowey estuary. Low diversity is unchanged and the agglutinated foraminifera, which form assemblage zones in the control estuaries, remain absent in Restronguet Creek (despite improved water quality but which still remains above Environmetal Quality Standards).

This absence may result from the deleterious effects of acid mine drainage. As a consequence of the continued absence and to test this assumption, research has now concentrated on alternative controls which may account for the variation in the distribution of the agglutinating species. Research has now focused on comparisons of the foraminiferal and sedimentological data from the polluted, control and reconnaissance locations. The relationship between presence/absence of agglutinated foraminifera and associated sediment geochemistry, sediment grain size distribution and mineralogy, in relation to the test wall construction of *Miliammina fusca*, *Jadammina macrescens* and *Trochammina inflata* has shown that these parameters, do not appear to account for the absence of these species. It is evident from the data that the high metal loadings in the sediment and metals in solution are the cause of the persistant absence of the agglutinating foraminifera.

Modern Agglutinated Foraminifera from the Indopakistanic Continental Slope (NW Indian Ocean): Influence of the Oxygen Minimum Zone to the Faunal Assemblages

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The NW-Indian Ocean is characterized by high pelagic productivity and a well developed oxygen minimum zone (OMZ) with a thickness of about 1000m. Three transects were examined for benthic foraminifera. Along the transects the assemblages show significant shifts, especially within the OMZ.

All transects show a significant increase in faunal density and a decrease in diversity within the OMZ. The species composition reflects different environmental preferences. Above the OMZ calcareous surface dwellers, mostly suspensionfeeders, are common reflecting a typical shallow water HPR-fauna. Within the OMZ the assemblage is charecterized by infaunal detritus feeders preferring HPR-conditions as well as tolerating low oxygen contents; the percentage of agglutinated forms increases. Below the OMZ a typical DWAF-fauna is established.

Three zones of agglutinated foraminifers can be distinguished: 1) Shelf Assemblage, down to 200m (above the OMZ) - a variety of some textulariid species. 2) Slope Assemblage, 200-1200m (OMZ) - *Labrospira sp.A1*, *Recurvoides laevigatum*, *Orectostomina sp.Z23*, *Eggerelloides parkerae*, *Nouria polymorphinoides*, *Reophax rostratum*, *Reophax sp.Z10*, *Ammodiscus cretaceus.* 3) Lower Slope and Rise Assemblage, down to 3000m (below the OMZ)- *Rhizammina algaeformis*, *Haplophragmoides aff. bulloides* and a variety of reophaxinid species.

Observations on habitat preferences of small Ammodiscids

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We observed in several surface samples from the South China Sea and the Indopakistanic Continental Slope small Ammodiscids with an atypical test morphology. Very often the final part of the test is uncoiled and erected in different directions. The tubes show different degrees of uncoiling.

Some individuals could be identified as hard ground dwellers. We found them attached to large Gaudryiinids. This kind of life position is also known from suspension feeders like Tolypamminids. The same morphotype occurs also in soft substrates, but here the uncoiled part of the test is extremely long. In this case it can be assumed that the coiled part has the function of an anchor in the sediment. This strategy is also known from the suspension feeder *Saccorhiza ramosa*.

From these observations it can be supposed that Ammodiscids not only live as epifaunal detritus feeders, but also as suspension feeders. They are able to adapt their feeding habits to suit different environmental conditions.

Wall structure of agglutinated foraminifera within oxygen minima

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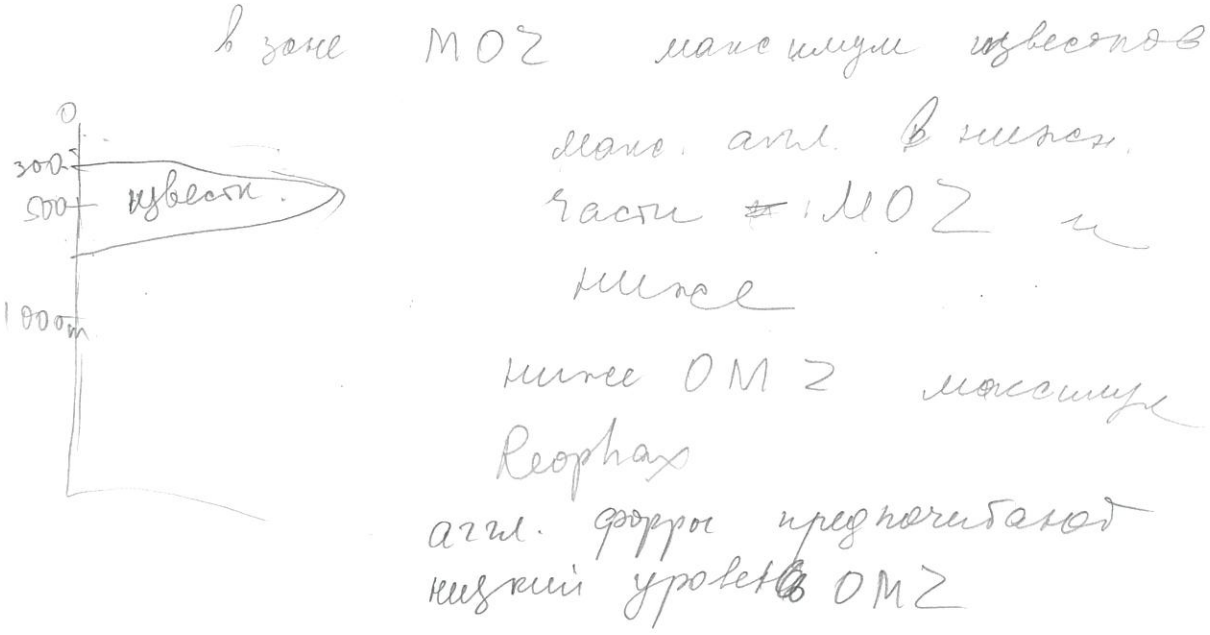
Scanning electron microscope studies of the wall ultrastructure of living ammodiscids and recurvoids within an intense oxygen minimum zone along the Indo-Pacific continental margin revealed the following features:

1. Individuals living within the oxygen minimum zone are generally thinner walled, more loosely agglutinated and use less organic cement.
2. Small holes are commonly observed in the walls of these forms
3. Organic linings are often reduced

These observations may be interpreted in terms of functional morphology as features for facilitating gas exchange through the test wall. A second possible interpretation would be an adaption for fast growth by minimizing the amount of construction material (grains and cement) thus enabling the maintainance of large populations. We speculate, that the cementation by organic strands in ammodiscids may be an advantage in poorly oxygenated environments.

Similar features (thin walls, loosely agglutinated walls with small amounts of organic cements) were observed in agglutinated foraminifera of organic rich deep sea sediments at the Cenomanian/Turonian boundary. If these still random observations reveal a general trend, it may be possible to estimate oxygen concentrations and/or population dynamics of (well-preserved) fossil communities by systematic studies of the wall ultrastructures.



Palaeoecology of *Spiroplectinata* and its palaeoceanographic application (Albian, Lower Saxony Basin)

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The Lower Saxony Basin serves as a good example of "Boreal" epicontinental basin, best suited for palaeoceanographic and palaeoclimatic studies within the ALBICORE Project. This study is focused on Albian *Spiroplectinata annectens* (Parker & Jones, 1863) and *S. complanata* (Reuss, 1860) morphologically unique, benthic, agglutinated foraminifera, and their application for reconstructing water mass changes within the basin. New interpretation of microhabitat preferences and feeding strategy for *Spiroplectinata* is proposed and discussed. The functional morphology, composition of the test, and relationships between adherent foraminifera suggest that at least adult individuals of *Spiroplectinata* employed suspension feeding strategy. This organism constructed triserial, biserial and elongated uniserial parts of the test which facilitated an erect position to spread the protoplasmic fan above the sediment/water interface.

Tests of *S. annectens* are mainly composed of coccoliths, single small parts of planktonic foraminifera, their microfossil remains, such as fragments of microshells, single spicules, everything glued by the calcareous matrix. Two types of grain arrangements can be recognised: the first type shows similar grains in the whole test, i.e., coccoliths with irregularly distributed larger particles; the second one reveals a distinct difference between the initial triangular, then the biserial part and the final uniserial part of the test. This distinct difference is expressed in nearly exclusive occurrence of coccoliths within the initial part; the middle part consists of coccoliths mixed with other not well-sorted bioclastic particles; the final (uniserial) part contains relatively very large, poorly-sorted particles stuck with others, much smaller ones. Co-occurrence of these two patterns in the same samples indicates that *S. annectens* did not arrange grains in a constant manner. Its test construction material was probably controlled by grain availability and/or by bottom current activity. The latter agent may have been decisive when *S. annectens* was growing during periods of increasing hydrodynamic energy. It is surprising that most of its test particles while being probably selectively bioclastic, were not selectively collected by the foraminifera. It seems that this taxon was not able to separate relatively large particles of planktonic foraminifera from other, smaller ones. These larger grains are, as a rule, often distributed randomly but more often within the younger parts of the test.

Distribution of *Spiroplectinata* (its maxima) can be applied as a sensitive indicator of bottom currents activities. These repeated phases of stronger current activity as well facilitated colonisation by other suspension feeders, *Nodobacularia nodulosa* among the benthic foraminifera and inoceramids among the bivalves. Four periods of intensified bottom water circulation around the Early/Middle Albian boundary (S-1), Middle (S-2 and S-3) and early Late Albian (S-4) are reconstructed and well marked by abundance maxima of *S. annectens* and *S. complanata*. The first appearance of *S. annectens* followed by the first maximum occurs just below the Early/Middle Albian boundary and probably represents the main immigration event into the Lower Saxony Basin. *S. annectens* is known from older strata in the Western Tethys (i.e. in the Late Aptian and Early Albian) than in the "Boreal" realm. The direction of this immigration also indicates deep water currents of possible Tethyan origin. This supports the idea that the deep water in the Middle Albian "Boreal" epicontinental sea derived from the Tethys and not from the polar regions. If one interprets the plankton/benthos foraminiferal ratio as reflecting sea-level changes, it implies that sea-level rises may have been responsible for opening and/or deepening "Boreal"/Tethyan gateways that activated an extensive water mass exchange and more open marine conditions. This late Early Albian and Middle Albian "invasion" of the Tethyan water can be correlated to a global general warming trend, and shifting of climatic zones.

Lower Tertiary marine microfossils from the Qiong Dong Nan Basin, South China Sea

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Microfossil age control developed for the Qiong Dong Nan Basin in the South China Sea has improved stratigraphic correlations by providing bracketing ages for subsurface formations and for distinct regional hiatuses. Dating the formations and unconformities shows a clear relationship of transgressions and regressions to published global sealevel curves. Hydrocarbon exploration wells in the basins penetrate a thick Upper Tertiary clastic interval to test Upper Oligocene shallow marine clastics.

Biostratigraphic ages for Lower Tertiary exploration units were determined from intermittent occurrences of calcareous nannofossils, very rare planktonic foraminifera, and the restricted occurrences of two distinctive shallow marine arenaceous foraminifera. The Lower Miocene Lingshui I Formation is characterized by *Gaudryina pseudohayasakai* Chang (1960) whereas the Upper Oligocene Lingshui II Formation is characterized by *Gaudryina hayasakai* Chang (1954). The Lingshui III and Yacheng Formations underlying the reservoir target have rare occurrences of Lower Oligocene to Upper Eocene nannofossils and marginal marine foraminifera.

Miliammina gerochi n. sp. - a middle Jurassic rzehakinid from quasi-anaerobic biofacies.

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Miliammina gerochi n. sp. is so far the first reported representative of the superfamily Rzehakinacea from Jurassic sediments. This species is characterised by a very small, elongated spindle-shaped test, triangular to trapezoidal cross-section and rounded periphery. Its occurrence is confined to the lower part of Harcygrund Shale Formation in the Pieniny Klippen Belt (Western Carpathians, Poland). The early Bajocian age of the formation, from the *Sonninia sowerbyi* Zone, through *Otoites sauzei* Zone, to the lowest part of *Stephanoceras humphriesianum* Zone, is based on ammonites (Myczyński, 1973). This formation is represented by a "black shale" facies developed during the late phase of the Aalenian/Bajocian "regional anoxic/dysoxic event".

Relatively high proportions of *Miliammina gerochi* (18-54%; mean 39.4%) are associated with other agglutinated foraminifera limited to rare astrorhizids (*Rhabdammina/Hyperammina*) and single specimens of *Ammobaculites, Recurvoides, Trochammina*. Calcareous foraminifera are represented by nodosariids dominated by *Lenticulina* spp. and *Laevidentalina* spp., associated with a lower number of *Astacolus, Frondicularia, Nodosaria* (including *N. regularis*), and *Vaginulinopsis*.; additionally, by variable proportions of poorly preserved epistominids (2-25%) and low proportions of ophthalminids, polymorphinids, and ramulinids. Epistominids resemble smooth-test *Reinholdella* spp. and ornamented *Epistomina* spp., and include single specimens of *Epistomina arcana* Antonova and *E. semiornata* (Schwager).

Overall biofacies relationships indicate that *M. gerochi* n. sp., as a benthic agglutinated foraminifer, inhabited normal saline, middle to outer neritic palaeoenvironments under extremely dysoxic or even suboxic, food-rich conditions, and gradually disappeared with improving bottom water oxygenation, enhanced density of macrofaunal bioturbation, increasing sedimentation rate, and probably deepening of the basin. The *Miliammina gerochi* Assemblage marks a very productive phase in the Klippen Basin history. Based on functional morphology and studies of modern *Miliammina* species, it can be speculated that this Jurassic species preferred an endobenthic microhabitat and probably thrived within benthic bacterial mats associated with suboxic conditions. Comparison between different habitats successfully colonised by rzehakinids suggests that since the Jurassic till the present, this group preferred eutrophic conditions and was able to live within stress environments. Evolutionary relationships remain uncertain due to the lack of reported ancestors and a gap in the record of rzehakinids until the Early Cretaceous.

Mid Cretaceous micropalaeontology, Agat Region, offshore Norway.

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This is a first attempt at a more systematic study of the Cretaceous micropalaeontology offshore Noway, using cores in the Agat Field, which is located on Block 35/3 50 Km west of the Norwegian coastline, immediately south of the 62*N. The block lies on a platform between the Fennoscandian Shield and Sogn Graben. At this locality the Lower Cretaceous is almost exclusively dominated by Aptian and Albian strata. The sediments containing the reservoir were probably transported down-slope from the east through submarine canyons and deposited as the slope flattened out. Various types of gravity flow deposits are represented. The shaly intervals are rich in foraminifera. The interval in well 35/3-4 is divided into 2 main zones, based on the different dominating suborders of foraminifera: I. Agglutinated and II. Planktonic. Total number of taxa observed is 83. Based on a quantitative analysis the interval is divided into 5 assemblages. They are named after the most common taxa in the assemblages. 1) *Rhizammina* sp.1, 2) *Rhizzammina* sp.3, 3) *Recurvoides imperfectus*, 4) *Recurvoides gerochi* and 5) *Gavelinella intermedia*. The Agglutinated zone consists exclusively of organic cemented foraminifera, which resembles the flysch type assemblages. It is characteristic for the bathyal realm, and is considered a response to reduced availability of dissolved CaCO3 in a restricted marine, dysaerobic basin. The Planktonic zone consists mainly of calcareous foraminifera, planktonic species and benthic species. The presence of plankton indicates influence from deep/open marine oceanic water with normal salinity. There is a correlation between the planktonic presence, the calcareous benthic forms and the CaCO3 in the sediment. The presence of the calcareous benthic forms in the upper part correlates to the high planktonic and the high CaCO3 content. This indicates a good availability of dissolved CaCO3 in the bottomwaters. The Albian/Cenomanian transition in SE England and in NW-Germany also have planktonic floods. Appearance of large hedbergellids and a flood of *Globigerinelloides bentonensis*. The same acme has been found in several wells throughout the North Sea and offshore Norway. This flood consists of the planktonic species *Hedbergella delrioensis*, *H. planispira* and *G. bentonensis*.

The application of foraminifera analysis to understanding relative sea-level changes: an example from SW Scotland

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Recent studies of relative sea-level changes have primarily concerned themselves with the identification of intercalating minerogenic (estuarine/marine) and biogenic (terrestrial peats) sedimentary sequences. Radiocarbon dating of facies transitions combined with altitudinal and biostratigraphical controls provides the detail for the construction of relative sea-level index points. Such index points can be plotted on age/altitude graphs which provide relative sea-level curves of particular areas. To date there has been limited application of foraminifera analysis to regional studies of relative sea-level changes in Scotland.

Study of modern estuarine foraminifera distributions in the Cree estuary (SW Scotland) combined with a detailed levelling programme of estuarine facies has enabled foraminifera assemblages to be related to both depositional environments and present tide levels. The most accurately defined of these is the *Jadammina macrescens*-dominated ecozone of the low intertidal saltmarsh (low saltings terrace). In this way a fossil assemblage which is dominated by *J. macrescens* is known (in the Cree estuary) to approximate to a former saltings level and a palaeo-tide level between M^1 and M^1 - 30cm [N.B. M^1 = (HAT + MHWST)/2]. Identification of this ecozone in fossil sedimentary sequences provides an indication of the rate of relative sea-level change through time.

In the valley of the Cree estuary detailed stratigraphic investigations show thick (>19m) sequences of Flandrian estuarine silty clays which are rarely interrupted by intercalated peats. A systematic analysis of the foraminifera throughout these apparently homogenous sediments at one location shows a pattern of changing estuarine depositional environments throughout the early to middle Flandrian. Constrained by ^{14}C dates the results show that the rate of relative sea-level rise during the Main Postglacial Transgression was non-uniform. Results from palynological analyses of the same sediments indicates that there was a distinctive increase in the rate of relative sea-level rise after *circa* 7,600 ^{14}C BP.

It is hoped that future relative sea-level studies will optimise the potential of foraminifera investigations and that the use of new dating techniques (e.g. AMS radiocarbon dating) can be used to provide detailed information on rates of sea-level change during the Flandrian.