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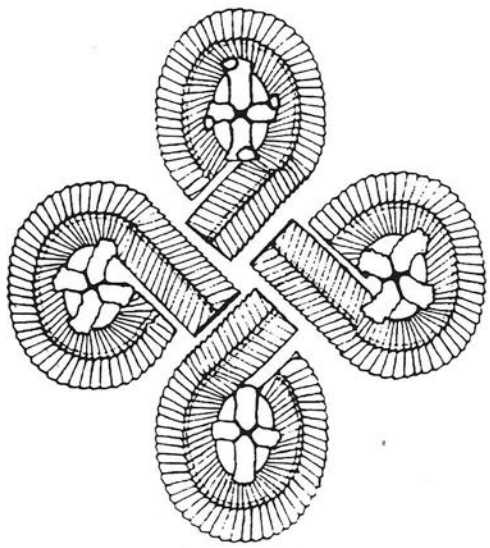

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CONTENTS

EDITORIAL NOTE

The 6th International Nannoplankton Association conference was held in Copenhagen from September 3 to September 6, 1995. More than 80 participants from 22 countries presented 29 talks and about 40 posters. The abstracts of all contributions were presented in an Abstract Volume, edited by Niels. E. POULSEN which was given to all conference attendants. But we felt that also the other INA members, who were not able to come to Copenhagen, might be interested in topics that had been discussed there.

With the permission of the organizing committee, this special JNR number brings the re-edition of the abstracts. We did not make any changes in the text, except a few autograph corrections, so a couple of abstracts for the contributions that were not actually presented at the conference are included. The only change we made concerns the headings fonts etc. according the JNR custom.

In this place, we would like to express our thanks to the Organizing Committee, namely to David JUTSON, Hanne SØRENSEN and Niels. E. POULSEN for their collaboration during preparation of this volume and their enormous organizing work and to the DGU for the permission to publish the abstracts in the Journal of Nannoplankton Research.

Editors

ABSTRACTS

NEOSPHAERA COCCOLITHOMORPHA AND *CERATOLITHUS CRISTATUS* : ARE THEY THE SAME SPECIES ?

J. Alcober and R.W. Jordan

Poster session

In current classification schemes there are almost 200 species of living coccolithophorids, however, only a few of their life cycles are known. This is largely due to the difficulties of establishing them in unialgal cultures. At present, maybe only 10 species have been successfully isolated and maintained, and of these most are either coastal or common oceanic taxa. Another problem lies in their relative inaccessibility. Many coccolithophorids live in subtropical waters, away from the continental shelf, and so an ocean-going research vessel is often needed. Common on-board collecting methods normally involve filtrations or preservation, as single cell isolation is extremely difficult to perform at sea, and maintaining wild populations normally selects the 'weeds'. Therefore, there is a need to document observations made from filtered or preserved material, and recently, a number of potential life cycles have been reported in this way. However, these findings will need verification from culture observations when cultures become available.

In this presentation we show a possible relationship between two well known type species, *Neosphaera coccolithomorpha* and *Ceratolithus cristatus*. In the coccolithophorid life cycles reported so far, one phase emerges from inside the other, causing the displacement of the older phase coccoliths. In one of our specimens of *N. coccolithomorpha* an emerging *C. cristatus* coccosphere, composed of hoop-like coccoliths, can be seen. The *N. coccolithomorpha* coccoliths are still tightly bound in an almost complete coccosphere, and so the likelihood of it representing agglutination is negligible. There are also other specimens in possible transitional states showing *Neosphaera* coccoliths on a *Ceratolithus* coccosphere or hoop-like coccoliths on a *Neosphaera* coccosphere, however, these are less convincing. If in the future this relationship is confirmed, *N. coccolithomorpha* has priority over *C. cristatus*, and so *Ceratolithus* would become a junior synonym of *Neosphaera*.

NANNOFOSSILS OF THE MAASTRICHTIAN-PALEOCENE GERMAV FORMATION, SOUTHEAST ANATOLIA, TURKEY

Seving Özkan and D. Altiner

Topics: Maastrichtian-Paleocene, SE Turkey, Biostratigraphy

A great number of samples from the Germav Formation in the SE Anatolia, Turkey, were examined for biostratigraphic purpose. The Germav Formation, spanning Early Maastrichtian-Paleocene interval, mainly consists of greenish to yellowish grey shales, marls with intercalations of argillaceous limestones, siltstones and sandstones.

This investigation is based on an analysis of samples collected from 4 stratigraphic sections: GER-A and GER-C sections from the Gercüs area, SW Siirt; GA and GB sections from the Kahta area, NE Adiyaman. Nannofossils are rare to abundant, generally well-diversified and moderately preserved. The recorded nannofossil events are calibrated with equivalent planktonic foraminiferal zones already recognized in the same samples (Özkan and Altiner, 1987; Özkan and Özcan, in preparation) and high resolution biostratigraphic zonation will be presented and discussed.

Preliminary data on the calcareous nannofossil assemblages in the Germav Formation indicate a "transition zone" at the K/T boundary interval.

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CALCAREOUS NANNOFOSSILS FROM CALVELLO BASIN (SOUTHERN APENNINES, ITALY)

Filomena Ornella Amore

Poster session

The Plio-Pleistocene sediments of the Calvello basin (Lucania, South Italy) have been investigated. They represent part of wider basins whose remnants discontinuously outcrop within Campano-lucano segment of the Apennines chain. A biostratigraphic analysis for these terrigenous sediments, by means of calcareous nannofossils, planktonic foraminifera and ostracods has been performed (Amore et al.,1994). The zonal schemes proposed for

Mediterranean Sea by Rio et al.,('90) and Rio et al.,('94) modified have been adopted in this study. The integrate biostratigraphic and field study of the basin fill allowed to recognize for the first time three cycles: I) Lower Pliocene in age (MNN 16a; MPl 4a Zones): *Globorotalia puncticulata* and *Sphaeroidinellopsis sp.* occur; II) Middle - Late Pliocene in age (MNN 16b, MNN 17; MNN 18; MPl 5a, b Zones p.p.): *Discoaster pentaradiatus, D. surculus* among calcareous nannofossils and *Globorotalia bononiensis, G.crassaformis* among planktonic foraminifera occur; III) The occurrence of *Globorotalia inflata* and *G. oscitans* among foraminifera in the basal part of the sequence allowed to refer it to Late Pliocene (MNN 18, MNN19a p.p.; MPl 6 Zones). The P-P boundary has been recognized at about 75m from the bottom of the last sequence by the FO of *Gephyrocapsa caribbeanica* s.l. and an increase of *Neogloboquadrina pachyderma* left coiled; in the topmost samples *G. oceanica* s.l. (MNN 19b p.p) occurs. Nannoflora assemblages are generally abundant and well preserved. Quantitative analysis carried out on nannoflora assemblages allowed to recognize, according to the Mediterranean biozonal schemes, some events also in the near-shore sediments of the Calvello basin. In particular: LO of *Discoaster pentaradiatus*, shortly before the LO of *Globorotalia bononiensis;* FO of medium sized (4,0-5,5 μm) *Gephyrocapsa*, FO of *G. caribbeanica* s.l. and FO of *G. oceanica s.l.* (sensu Raffi et al.,1993) were recognized. Changes in surface water temperature have also been recorded by means of the variation in the abundance of the cool-water *Coccolithus pelagicus* (McIntyre and Be,1967).

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PRODUCTION, SEDIMENTATION AND PRESERVATION OF COCCOLITHOPHORES IN THE NORTHERN NORTH ATLANTIC

Harald Andruleit

Monday, 10.45

Coccolithophores form a main part of the modern phytoplankton in the northern North Atlantic. Their remains in the sediments are frequently used for paleoceanographic reconstructions. In this study the occurrence of coccolithophores in the photic zone, in the watercolumn, and in the surface sediments were investigated to evaluate alteration processes.

About 200 watersamples from 80 stations were collected since 1988 in the entire area. Additionally, two annual sediment trap moorings from the Greenland Sea (1990-1992) and one mooring from the Norwegian Sea (1991-1992) with traps at 500 m, 1000 m, and 3000 m water depth were investigated. Samples of the surface sediments, underlying the sediment traps, were also examined.

The sites of the sediment traps are located in the distinct oceanographic regimes of the Arctic domain (Greenland Sea, to the west) and the Atlantic domain (Norwegian Sea, to the east) and are separated by oceanographic frontal systems.

Regional species groups can be defined according to species temperature-tolerances (Samtleben et al. 1995). The distribution of these groups coincide with the main surface water masses. However, the coccolithophore communities exhibit a high variability linked to seasonality. The variation in species composition and cell densities is most impressively illustrated by the enormous blooms of *Emiliania huxleyi*.

The examination of sinking assemblages from the sediment traps reveals that inspite of alteration by sedimentation processes, a distinct seasonal pattern can still be seen. The coccolithophore flux in the Norwegian Sea is about 10 to 20 times higher than in the Greenland Sea. From east to west the diversity diminishes and a change of the dominant species from *E. huxleyi* to *Coccolithus pelagicus* occurs.

To compare the living communities and sinking assemblages on a joint basis, the coccolithophore counts of the watersamples were grouped according to the regional distribution. This resulted in an averaged community for a specific area which can be compared with the annual averaged assemblages of the sediment traps and with the long term record of the fossil assemblages in the surface sediments.

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SEDIMENT TRAP STUDIES OF COCCOLITH AND PLANKTONIC FORAMINIFERAL FLUXES IN THE BENGUELA UPWELLING SYSTEM

Jacques Giraudeau and Geoffrey W. Bailey

Monday, 16.50

Coccoliths and planktonic foraminifera collected by a sediment trap deployed on the upper slope off Walvis Bay, Namibia, were investigated in order (1) to assess their contribution to the total particulate flux, (2) to evaluate their response to seasonal changes in the dynamics of the Benguela upwelling process, and (3) to use them as tracers of particle transfer process on the slope. The trap, located at 545 m depth, 50 m above the sea floor, provided high resolution (8 days) times series samples from late winter to early summer. This 4-month period is marked by a drastic change in hydrological processes, from active to quiescent upwelling conditions. The total mass flux ranged from 3 to 1,1g/m^2/day. The lithogenic fraction was the main contributor to the total mass flux (64% of average contribution), followed by carbonate (22%), organic matter (8%), and biogenic opal (5%). The relative contributions of the four components to the total mass flux were relatively stable throughout the period of the experiment, thereby suggesting that seasonal changes in hydrological/upwelling process, from late winter to early summer, did not induce sharp modifications in the composition of the particles sedimenting on the slope. The bulk of lithogenic particles sedimenting on the continental margin originates from aerosol sand plumes due to katabatic wind events. Considering the low frequency and short duration of such events, we suggest that resuspension of shelf material and continuous horizontal advection to the slope were necessary to account for the high contribution of lithogenic particles recovered by our trap throughout its 4-month deployement.

The free-coccolith mass flux closely followed total mass flux variations, and ranged from 90 to 10 mg/m^2/day, thereby accounting for less than 10% (on an average) of the total biogenic carbonate mass flux. Coccolith number fluxes varied from 4200 106/m2/day to 400 106/m^2/day, *Emiliania huxleyi* being the dominant form (relative abundance: 60 to 75%). On the contrary to coccolith fluxes, the coccosphere fluxes did not show any significant covariations with total mass fluxes. This, coupled, with dissimilarities in species assemblages, suggest that the bulk coccolith fraction and the coccospheres were affected by distinct transfer process: lateral transport of coccoliths resuspended from the shelf, vertical advection of coccospheres from the overlying surface waters.

Planktonic foraminiferal number fluxes, dominated by juvenile specimens, ranged from 600 to 50 103/m^2/day, and roughly followed the total mass flux variations. The three size classes (juvenile, neanic, adult) presented distinct patterns in flux variations, which can be related to distinct transfer process, as well as mass mortality events in the case of the adult populations.

OCEANIC FRONTS IN THE MESOZOIC

William W. Hay

Poster session

The modern ocean is characterized by four regions, three of which are mirrored in each hemisphere: an equatorial belt (28% of the ocean surface area) characterized by divergence and shared by the two hemispheres, stratified tropical-subtropical anticyclonic gyres (46%), temperate mid-latitude belts of water characterized by convergence and steep meridional temperature gradients (11%), and deeply convecting polar oceans characterized by cyclonic gyres (13%). Convergence and divergence of the ocean waters are forced beneath zonal winds. Convergences or fronts form sharp boundaries between water masses and introduce surface water into the ocean interior. The fronts can be recognized by abrupt changes in nannoplankton assemblages. The sites of divergence are more diffuse; they separate water masses and return water from the ocean interior to the surface. Surface waters of the equatorial belt flow westward, driven by the easterly trade winds. Eastward subsurface flow returns some of the water, but much of the westward flow becomes incorporated into the western boundary currents of the tropical subtropical gyres. Increasing zonal velocities of the trade winds away from the atmospheric Intertropical Convergence Zone (ITCZ) induce divergence and upwelling in the waters of the equatorial belt. The most stable features of the modern ocean are the stratified tropical-subtropical gyres between 15° and 45° N and S. Low-latitude easterly trade winds and mid-latitude westerly winds drive the gyres. They also force convergence in the gyre centres. The sinking waters spread beneath the gyre as central waters. The maximum of the zonal component of the westerly winds occurs at about 45° N and S. The zonal winds induce meridional flow of the surface waters toward the equator, forcing sinking along the subtropical and polar fronts and forming barriers to poleward heat transport. The subtropical front is the source of thermocline water. Intermediate water forms by sinking along the polar front. The alternate, competing, source for intermediate water is outflow from saline marginal seas. Decreasing zonal wind velocities poleward of the polar fronts induce divergence, cause cyclonic circulation, and promote deep convection and deep water formation.

The Jurassic and Early Cretaceous ocean may have been similar to that of the present, but the late Cretaceous ocean was significantly different, with polar temperatures well above 5° C. The tropical-subtropical gyres in the

THE TURNOVER OF CALCAREOUS PHYTOPLANKTON FROM THE BARREMIAN - APTIAN BOUNDARY INTERVAL IN NW EUROPE

Gregor Bischoff and Jörg Mutterlose

Poster session

In NW Europe and elsewhere the Barremian-Aptian boundary interval is marked by a major change of the paleoceanographic setting. Due to a widespread transgression in the earliest Aptian paleoceanographic and sedimentary patterns changed both in NW Germany and in S England. A major floral and faunal turnover occurs at the Barremian-Aptian boundary interval. Restricted conditions prevailing in the latest Barremian and earliest Aptian, which are expressed by anoxic sediments, changed to a pelagic setting in the late early Aptian. The composition of calcareous nannofossil assemblages, however, does not change abruptly. The main results of an integrated multidisciplinary study may be summarised as follows:

1. Nineteen nannofossil events (first occurrences, last occurrences, acmes) characterize the late Barremian to early Aptian sediments of NW Europe. Most of these events can be recognized throughout NW Europe (NW Germany, North Sea) and allow a correlation throughout the North Sea.

2. There is a general shift from endemic assemblages dominating in the Barremian towards cosmopolitan ones in the Aptian.

3. The extinction and the onset of new floras is spread throughout the earliest Aptian. The biological turnover is gradually.

4. The first new cosmopolitan species (*C. litterarius, R. irregularis, E. floralis, F. oblongata, R. angustus*) occur well below the significant sedimentological change (Fischschiefer).

5. The calcareous phytoplankton of the early Aptian Fischschiefer suggests deposition under warm water conditions during a regressive phase.

6. The Fischschiefer, an organic-rich sediment deposited under anoxic conditions, is considered to be a regional phenomenon. Data from organic geochemistry suggest rather preservation than productivity as the cause for the black shale sedimentation.

It has been suggested, that increased spreading rates and abnormal intraplate volcanism in the Aptian may have caused the onset of the mid-Cretaceous greenhouse. This would have caused global warming, high humidity and sluggish oceanic circulation, resulting in an accelerated carbon cycling and increased availability of nutrients. Our data, however, do not support the idea of higher productivity. Thus it seems more likely to explain the floral and faunal turnover by changes of the sea level and changes in the circulation pattern of the epeiric NW-European sea.

JURASSIC - EARLY CRETACEOUS CALCAREOUS NANNOFOSSILS FROM THE NEUQUÉN BASIN, ARGENTINA

P.R. Bown and C. Ellison

Wednesday, 12.25

A preliminary summary of calcareous nannofossil results from Jurassic and Cretaceous sediments of the Neuquén Basin (Neuquén and Mendoza Provinces), Argentina, is presented. Ninety five samples were collected from formations ranging in age from Pliensbachian to Hauterivian. Seventy samples yielded calcareous nannofossils. The assemblages are generally of low abundance and moderately-well to poorly preserved. All assemblages are dominated by *Watznaueria*, although *Micrantholithus* is common in Lower Cretaceous sediments. Biostratigraphic dating of the assemblages is problematical due to the absence of most marker species although higher diversity in the Toarcian-Bajocian and Tithonian-Hauterivian have provided broad dates. Biogeographical observations are also limited due to the low diversity, however, a significant result is the absence of *Nannoconus* in Tithonian to Lower Hauterivian sediments and only rare nannoconids in the Upper Hauterivian. This contrasts with high nannoconid abundances in the western Tethys-Caribbean region at this time and provides tenuous support for the existence of an Austral nannofloral realm through the late Jurassic-early Cretaceous interval.

COCCOLITH BUILDING BLOCKS: HIGH RESOLUTION ANALYSES OF HETEROCOCCOLITH MORPHOLOGY AND CRYSTALLOGRAPHY

P.R. Bown, J.R. Young, T.E. Ehrendorfer, S.A. Davies, J.M. Didymus and S. Mann

Poster session

High resolution analysis of coccolith structure has been achieved using a number of different but complimentary analytical techniques, namely, light microscopy (LM), scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM), and selected area electron diffraction (SAED). This study is the first where single coccoliths (and single crystals within coccolith structures) have been examined using each of the techniques in turn. Since each method contributes information of a different nature and accuracy, and is limited by different factors, their combined use allows a high degree of confidence where the same results were achieved. Furthermore, additional data beyond the limitations of individual methods were obtained.

We present detailed results from the analysis of *Emiliania huxleyi* and *Biscutum magnum* and more general results from a range of heterococcolith families. We conclude that: (i) The marginal area (rim) of heterococcoliths consist of only two discrete crystallographic units, despite the gross morphological appearance of a complicated multi-cyclic architecture. These findings support the V/R hypothesis of Young et al. (1992) which predicts that only two crystallographic units constitute the entire coccolith - these units originating from a common nucleation site in the proto-coccolith ring. (ii) The two crystallographic units have considerably different c-axis orientations but the c-axes in neither unit are truly vertical or radial. In Biscutum magnum, for example, one of the units has a c-axis inclination of about 60°-70° and an azimuth ~45° anticlockwise. In the second unit the c-axis has an inclination of 0°-10° and deviates from the radial direction by ~20° clockwise. These orientations are very approximately vertical and radial but are still significantly different from the orientations predicted in the original model. One interesting result of this is that the chirality of complete coccoliths can now be seen to be determined by nucleation processes. (iii) The analysis of other coccolith species in different phylogenetic groups reinforces these conclusions; two crystallographic units are consistently present but that the values of the c-axis inclination and azimuth are more variable than initially predicted. The consistency of the basic pattern provides strong support for the interpretation of heterococcolithophorids as a monophyletic group. The variability of orientations makes identification of homologous units less straightforward but increases the significant phylogenetic characters that can be determined.

ALBIAN/CENOMANIAN TO K/T STAGE BOUNDARIES AND NANNOFOSSIL EVENTS: INCREASED PRECISION IN UPPER CRETACEOUS NANNOFOSSIL BIOSTRATIGRAPHY AND CORRELATION

Jackie Burnett

Poster session

In Brussels this September, Cretaceous stage boundary stratotypes will be designated for the Cretaceous. The boundaries themselves will be defined by an event, probably biostratigraphical but probably not based on nannofossils (since nannofossils cannot be seen in the field). Nevertheless, these decisions will provide a more precise framework within which correlation between nannofossil (sub-) zones and (sub-)stages can be improved.

At present, the assignment of stage names to nannofossil zones is imprecise, particularly at/around stage boundaries, because stage boundaries have not previously been strictly defined. Confusion abounds in the literature: investigators of onshore sections tend to use macrofossil biostratigraphy, which has been correlated to stages at least on a regional level, to provide a time-frame for their nannofossil zones, whilst investigators of oceanic cores, in the absence of macrofossil biostratigraphy, use nannofossil events to define, rather than approximate, the stage boundaries.

Study of numerous sequences, both onshore and oceanic, and including a number of proposed stage boundary stratotypes, has provided integrated sequences of fossil (macrofossil, microfossil and nannofossil) and geochemical events across the Albian/Cenomanian to K/T boundary intervals. Primarily, the study set out to more rigorously define the stage boundaries and the ages of Sissingh's/Perch-Nielsen's nannofossil (sub-)zones, following the original stage boundary conference (Copenhagen, 1983). The geographical and biostratigraphical extent of the study, however, also indicated previously unused nannofossil events, and provided an increased resolution between events previously believed to have been contemporaneous. Thus, the CC zones have been refined and revised.

These results will enhance precision in correlation between nannofossil zones and other stratigraphies, and provide a higher resolution in nannofossil biostratigraphy for the Upper Cretaceous.

SOME CALCAREOUS NANNOFOSSILS MISINTERPRETED IN LITERATURE AS *TETRALITHUS, TRIQUETRORHABDULUS, FUSELLINUS* SP. ARE ACTUALLY SPICULES OF *DIDEMNUM* SSP. (TUNICATA, ASCIDIAN). EVIDENCE FROM UPPER JURASSIC SEDIMENTS OF CHARENTES (W. FRANCE)

Georges Busson, Denise Noël, Françoise Monniot and Annie Cornee

Poster session

In the Upper Jurassic of Charentes (S. W. of France), in a limestone-marl rhythmic sedimentation system, the fine carbonate fraction of the marly interbeds is largely constituted of some micron-sized nannoliths either fusiform or composed of several conical points. We regard them as spicules of *Didemnum* ssp. for the following reasons.

1- By their wide morphological variety, the spicules are quite similar to the tunic spicules extracted from the type of the living species *Didemnum fusiferum* VAN NAME 1921 that we have studied in SEM. They also look like the spicules of *D. minutum* BONET et BENVENISTE-VELASQUEZ 1971, described from Callovian sediments in

Mexico. The nomenclatural problem of the spicules is discussed.

2- Indeed, aragonitic crystallisations resembling Didemnidae spicules can be obtained *in vitro* but, in experimental conditions, which try to duplicate the physico-chemical conditions prevailing in the tunic of the living animal. In the contrary, by some examples, we show that in recent and ancient sediments from various aquatic environments, the observed aragonitic - and sometimes calcitic - chemical or biochemical precipitations are different from Didemnidae spicules.

3- We emphasize the necessity to take into account the whole association of spicules present in a given sediment to state their Didemnidae origin. Only some isolated spicules are not enough to state such origin.

Didemnidae spicules are rarely recorded in sediments. We show that some of them could have been misinterpreted as calcareous nannofossils attributed to the following genera : *Tetralithus* (Gardet, 1955), *Triquetrorhabdulus* (Martini, 1965), *Fusellinus* (Noël 1956).

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COCCOLITHUS PELAGICUS, A SORT OF PRODUCTIVITY PROXY ?

Mário Cachão and M.T. Moita

Monday, 11.10

Data on the development dynamics and distribution patterns of *Coccolithus pelagicus* the water column on the Portuguese upwelling system and in sediments (coccolith present day and Quaternary taphocoenosis) from the Portuguese continental margin and Western Mediterranean (ODP 653 Pliocene section) may be questioning the traditional interpretation of *C. pelagicus* as a cold water proxy. Our results suggest instead an opportunistic behaviour of *Coccolithus pelagicus* to newly nutrient enriched waters (by upwelling or other processes), but outside areas of strong turbulence.

Coccolithus pelagicus is one of the few extant Nannoplankton species which are easy to identify from both a biological (coccospheres from water column samples) and a paleontological (coccoliths from surface sediment samples) point of view. For this reason it should be possible to understand the ecological behaviour of this species (or at least its heterococcolith-bearing phase) from available laboratory and biogeographic data together with its sedimentary record on continental shelf and abyssal planes. In addition its stratigraphic record covers practically all the Cenozoic (~60 Ma), which means that, in theory, its present day ecological/oceanographic meaning could be traced back till the Paleocene.

Based upon its present day biogeography, mainly restricted to North Atlantic subpolar water masses (in oceanic domain, MCINTYRE and BÉ 1967), there seems to be a general agreement that *C. pelagicus*, characterises cold water masses (living interval -1,7° to 15°C, OKADA and MCINTYRE 1979, WINTER et al. 1994; optimum interval 2° to 12°C, OKADA and MCINTYRE 1979). Since then it has been used as a qualitative/semiquantitative parameter (RAFFI and RIO 1981), in transfer functions (GIRAUDEAU and PUJOS 1990) and/or in Factorial Analysis (HAQ 1980) interpretations as a paleotemperature proxy. Nevertheless some authors have also recognised on it a signal of nutrient rich surface oceanic waters (MCINTYRE and BÉ 1967, RAHMAN and ROTH 1990). In surface waters temperature and nutrient concentrations are strongly covariant and it is not clear which of the two properties may influence the most the development *C. pelagicus*.

Along the Portuguese continental margin, from 42°N (Caminha) to 37°N (Algarve), *C. pelagicus* is almost always present in water column samples, although in low concentrations (normally below 1000 cell/l). Its distribution can be better described as being related to the area influenced by a water body of subtropical characteristics ($ENAW_T$ in RIOS et al. 1992) which is modified in upper layers. The abundance of *C. pelagicus* decreases northward, along the western coast, apparently in accordance with a progressive change of $ENAW_T$ characteristics. In fact its minimum values were observed in coastal waters to the north of Nazar canyon (39,5°N), an area which during Spring and Summer tends to be occupied by a shallow lens of reduced salinity, resulting from NE Atlantic and Bay of Biscay waters combined with local river runoff (JORGE DA SILVA and MOITA 1993).

On an upwelling coastal region such as the Portuguese margin, phytoplankton assemblages can be positioned along an axis relating its different groups and species to decaying turbulence and nutrient availability (MARGALEF 1978). On the core of upwelling, species with maximum growth rates, such as Diatoms, take advantage, contrasting with assemblages from offshore nutrient-poor and stratified waters, such as Dinoflagelates with lower growth rates. In these regions Coccolithophores appear to occupy an intermediate ecological position between those two groups (ESTRADA and BLASCO 1985). In this context our data (from two areas of distinct upwelling patterns: August 1985 at the S. Vicent Cape - 37°N - ; August 1987 at North-western coast - 41° 05'N) show that in both cases *C. pelagicus* occupies a confined band, at the immediate border (upwelling thermal front) of the turbulent fertile core, between Diatoms which clearly dominate the upwelling center, and an outer area occupied by other Coccolithophore species (e.g. *Calcidiscus leptoporus, Helicosphaera carteri*). The development dynamics of *C. pelagicus* during an upwelling event at North-western coast (41°05'N), revealed an increase of cells in response to nutrient enrichment, with maximum values being observed in the picnocline- nutricline, below the wind-driven layer.

When present in waters with subtropical characteristics

C. pelagicus reveals some affinity for relatively low temperature conditions, the maximum numbers being obtained for the interval 13° to 15°C, during the upwelling season. Our results also show that this species occupies an ecological niche between diatoms and other Coccolithophores. It reveals an opportunistic behaviour for nutrients and moderate turbulence (and not simply "cold water") which also may explain its present day North Atlantic biogeography, between K-assemblages on stratified water masses brought northwards by Golf Stream, and turbulent polar waters characterised by E. huxleyi and diatoms (BRAND 1994, OKADA and MCINTYRE 1979).

Another interesting pattern could be disclosed after the analyses of 70 surface samples collected from North-western section of Portuguese occidental continental margin. These results showed that significant increases in the percentage of *C. pelagicus* on the total nannolith present day taphocoenosis were directly related to the presence of three river mouths. We interpreted this as a consequence of "fresh" input of nutrients from river runoff which seems to favour ("opportunistically") this species.

The results from the Atlantic coast of Iberian Peninsula allow us to conclude that *C. pelagicus* is somehow related to nutrient availability and productivity. Consequently it is useful to test this conclusion with other productivity proxies, in other regional context. When we compared *C. pelagicus* with $\delta^{13}C_{G.elongatus + G.obliquus}$ Western Mediterranean Pliocene (4.85 to 1.95 Ma) time series several match (same trend) and unmatch (opposite trend) intervals were recognised. Unmatch intervals (with 600 to 200 Ky) occur just before particular moments (when significative changes in planktonic Foraminifera assemblages take place) after which a predominantly match interval is registered. It seems that when long-standing ("mature and stratified ?") pelagic Mediterranean paleocommunities persisted, preferential development of *C. pelagicus* was related with episodes of low general productivity. After particular moments, when renewing of the pelagic paleocommunities occurred in the Tyrrhenean Sea, *C. pelagicus* started to contribute (preferentially, as an opportunistic species) directly to the general productivity, for a certain period of time, before returning to the earlier pattern of development.

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AN EXAMINATION OF THE GLOBAL RELATIONSHIP BETWEEN THE LAST TWO "SPECIES" OF DISCOASTERS AT THE END OF THE PLIOCENE

Alex Chepstow-Lusty and Mark Chapman

Monday, 12.00

Discoasters are the enigmatic calcareous remains of a group of phytoplankton spanning 55 Myr of the oceanic record from the Upper Paleocene to the Upper Pliocene, disappearing at approximately the base of the Olduvai subchron, 1.95 Ma. In the 200 kyrs prior to extinction, a three-armed form called *Discoaster triradiatus* is produced. This taxon occurs globally and in significant abundances relative to the dominant surviving species *Discoaster brouweri*. Here, we examine the extent of the co-variation between these two morpho-species, and assess if this relationship is merely the response of a single biological species to the accentuation of glacial-interglacial climatic variability during the late Pliocene. We have produced high resolution records of *Discoaster* abundances using 8 sites (Fig. 1) from the Atlantic (DSDP 552, DSDP 607, ODP 658, ODP 659 and ODP 662), the Pacific (ODP 677 and ODP 806), and the Indian Oceans (ODP 709).

A uniform chronology, based on the orbitally-tuned oxygen isotope stratigraphy from ODP Site 677, is employed for each site. High resolution records of *Coccolithus pelagicus* are also examined at ODP sites 677, 709 and 806 to provide an independent assessment of the effects of variable dissolution on *Discoaster* abundances. In spite of the observed marked temporal and spatial fluctuations in abundance, it appears that there is generally a consistent relationship between these two "species" which cannot be

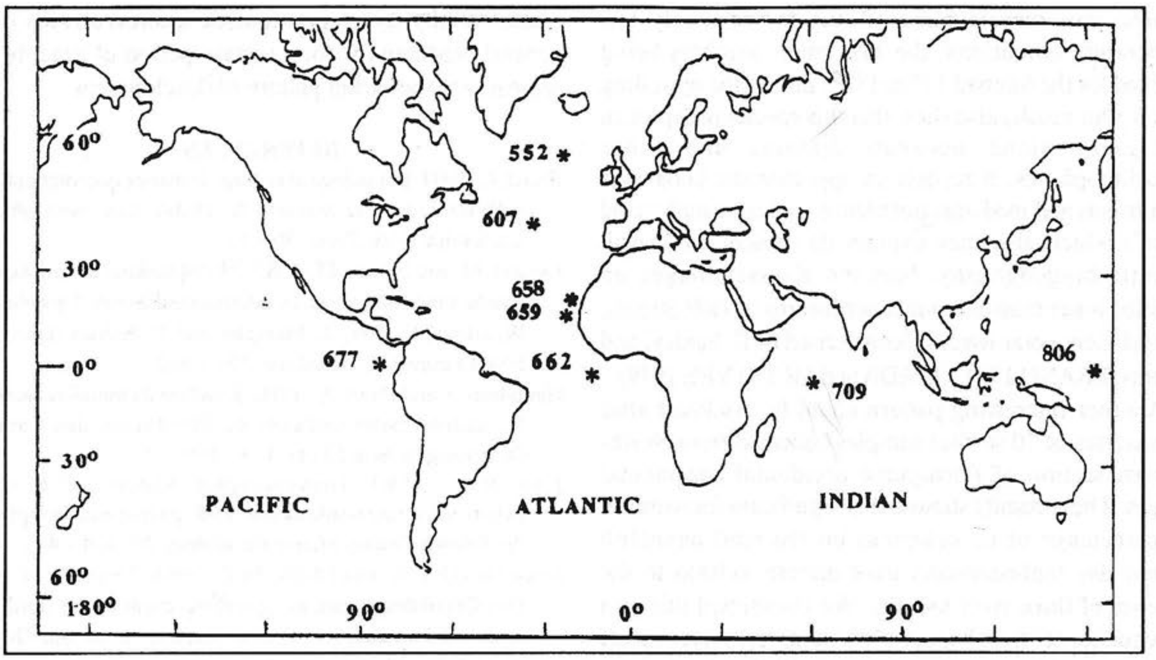

Figure 1: Location of sites investigated in this work.

attributable to differential preservation. This suggests that the ecological preference of discoasters for warm, low-nutrient waters is the major factor controlling their distribution. The detailed analysis of *D. brouweri* and *D. triradiatus* records in this study, as shown for ODP Site 709 (Fig. 2), clearly demonstrates that the *D. triradiatus* acme is a useful biostratigraphic datum which can be applied globally.

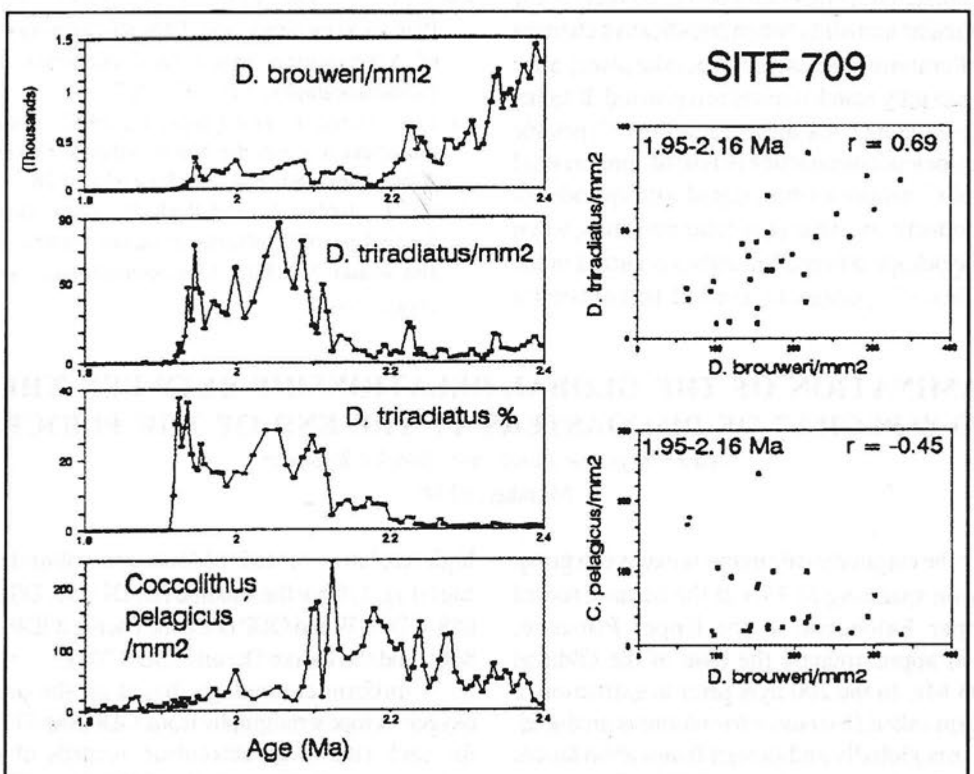

Figure 2: Abundance variations and correlation of *Discoaster brouweri*, *Discoaster triradiatus* and *Coccolithus pelagicus* at ODP Site 709.

COCCOLITHOPHORID DISTRIBUTION ACROSS A TRANSECT BETWEEN THE IBERIAN PENINSULA AND THE BALEARIC ISLANDS (NORTHWESTERN MEDITERRANEAN SEA)

Lluïsa Cros

Monday, 11.35

To study the coccolithophorid distribution in the Catalano-Balearic Sea and its relationship with the different water masses and hydrographic structures, samples at surface and at 40 m. depth have been taken along a transect between Barcelona and the threshold between Mallorca and Menorca. The water samples were collected aboard the Oceanographic Ship Garcia del Cid (May 31th - June 16th) and hydrographic parameters were measured in the same stations. This report presents a preliminary study of the coccolithophorid assemblages found as well as the comparison of some results between different sample preparation methodologies.

The samples were fixed aboard the ship with formaldehyde neutralized with hexamethyl-enetetramine and then filtered at the laboratory. In three stations of the transect, parallel samples were filtered on board. The samples treated with this last method showed the best preservation of coccolithophorid specimens.

Three different surface water masses separated by two fronts, can be recognised between the Iberian Peninsula and the Balearic Islands. Near the Iberian Peninsula there are a low salinity coastal water influenced by continental discharges. At the Balearic Islands side there are a warmer and well-stratified water mass of Atlantic influence. In the middle, a high salinity Mediterranean Sea water is present.

Emiliania huxleyi was the most abundant and ubiquitous species found. *Syracosphaera pulchra* as well as the majority of *Syracosphaera* species were more abundant in the continentally influenced coastal water masses, near the Iberian Peninsula. *Gephyrocapsa ericsonii* increased towards the Balearic Islands. *Gephyrocapsa mullerae,* the other species of *Gephyrocapsa* found, appeared in the water mass of Atlantic influence where *G. ericsonii* had the maximum. *Rhabdosphaera clavigera, Rhabdosphaera xifos, Polycrater galapagensis* and *Umbellosphaera tenuis* increased towards the Balearic Islands too. All the specimens of *Rhabdosphaera clavigera* belonged to the form *R. clavigera* var. *stylifera.* It is interesting to point out that the only form of *Calcidiscus leptoporus* found was *C. leptoporus* f. *rigidus,* which occurred in the vicinity of the Balearic Islands. The greatest number of holococcolithophorid species as well as the maximum coccolithophorid species diversity were found in the station nearest to the Balearic Islands.

CALCAREOUS PLANKTON BIOSTRATIGRAPHY AND ^{40}AR/^{39}AR DATING OF VOLCANIC ASH LAYERS FROM MONFERRATO (NW ITALY)

A. d'Atri, A. Novaretti, R. Ruffini, M.A. Cosca and J.C. Hunziker

Poster session

In the last years many volcano-sedimentary beds have been discovered in the Oligo-Miocene succession of the Monferrato (NW Italy). They are made up of vitric tuffs and contain minerals suitable of radiometric age determination.

Petrographically, they show vitroclastic texture with well preserved glass shards and phenocrystic assemblage including plagioclase, quartz, sanidine, biotite, minor amphiboles and pyroxenes.

Two volcaniclastic layers (Villadeati and Varengo), bearing well preserved biotite and amphibole, have been chosen for biostratigraphic studies and 40Ar/39Ar dating.

A quantitative analysis of calcareous nannofossil associations present in the volcaniclastic layers and in the under- and overlying sediments has been carried out. The Villadeati layer can be attributed to the lower part of Zone CN2 (Okada and Bukry, 1980) and/or to Zone MNN3a (*S. belemnos*) of Fornaciari and Rio (1995), Late Burdigalian in age. The Varengo layer falls within the upper part of Zone CN3 (Okada and Bukry, 1980) and/or the upper part of Zone MNN4a (*H. ampliaperta - S. heteromorphus*) of Fornaciari and Rio (1995), correspondent to Early Langhian. The foraminiferal data confirm this attribution; in fact the Villadeati and Varengo layers are respectively referable to the lower part of Zone N7 (Late Burdigalian) and to the lower part of Zone N8 (Early Langhian) of Blow (1969).

40Ar/39Ar analyses performed with the step heating technique at the University of Lausanne have been carried out on amphibole and biotite from the two ash layers. Villadeati sample gives a plateau age of 18.7 ±0.1 Ma, whereas Varengo sample gives a plateau age of 16.4 ±0.2 Ma.

This radiometric data are in good agreement with the biostratigraphic ones and will be very useful to calibrate nannofossil and foraminiferal bioevents in the Mediterranean region.

PALEOCENE TO EARLY EOCENE CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE EL KEF SECTION (TUNISIA)

Eric de Kaenel

Tuesday, 11.10

A light microscopy study of 60 samples collected by Amoco Paleontologists from a composite of two sections near El Kef, Tunisia was completed in the summer of 1992. This composite section of 430 meters spans the K/T boundary (in its type region) in shales of the El Haria Formation into overlying lower Eocene limestones. The main objectives of this study were a revision of Paleocene to early Eocene nannofossil taxonomy and an improved biostratigraphic framework. Perch- Nielsen (1981a) had demonstrated that a relatively complete Paleocene section is present near El Kef, recognizing Zones NP1 through NP9 of Martini (1971). Perch-Nielsen (1981b) also subdivided Zone NP1 into four subzones based on the Tunisian material. The abundance and diversity of nannofossil assemblages recovered by centrifugation from the El Haria shales were high. The excellent preservation and the continuity of section provided further incentive to restudy sections from this region in reference to more recent advances within the past one and one-half decade.

Martini (1971) published the first global nannofossil biozonation of the Cenozoic (NP/NN Zones), whose Paleocene to early Eocene zones were defined in various outcrop sections in NW Europe and the circum-Caribbean, as well as references to Tunisia and New Zealand. Romein (1979) studied individual lineages in coeval section (Spain, Denmark, Sweden, Israel), reproducing the biostratigraphic framework of Martini (1971) and enhancing resolution within Zone NP1. Okada and Bukry (1980) subsequently published a Cenozoic nannofossil biozonation (CP/CN Zones) based on deep-sea material. Interest in hydrocarbon exploration in the North Sea resulted in enhanced biostratigraphic resolution within the Paleocene (Perch-Nielsen, 1979; van Heck and Prins, 1987; and Varol, 1989). Varol (1989) extended this enhanced resolution into low to mid latitude regions based largely on material from the Kokaksu Section in Turkey, for which he defined 20 Paleocene nannofossil zones (NTp1-20). Bybell and Self-Trail (1995) improved understanding of the taxonomy and evolution of late Paleocene and early Eocene nannofossils based on material from southern New Jersey (U.S.A.).

Many of the nannofossil bioevents and lineages recently described from the New Jersey sections (Self-Trail and Bybell, 1995) were independently observed in the El Kef region and indicate the their potential utility in global correlations. In addition, nearly all the calcareous nannofossils bioevents described in the aforementioned papers (including the North Sea) have been observed in the composite El Kef section and integrated into a unified biostratigraphic scheme. More than 290 nannofossil species have been identified in the composite section, including several new species recognized within evolutionary lineages. A table summarizing the nannofossil biostratigraphic framework is presented, as well as fifteen related tables showing the distribution of species within individual 50 genera and their major morphologic characteristics. The main lineages considered include: *Bomolithus-Heliolithus, Chiamolithus, Cruciplacolithus-Clausiccocus, Ellipsolithus, Neobiscutum-Futyania-Prinsius-Towieus, Chiastozygus-Neochiastozygus, Fasciculithus, Neocrepidolithus, Markalius-Discoaster, Palaeopontosphaera-Hornibrookina,* and *Sphenolithus.*

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CALCAREOUS NANNOFOSSILS BIOSTRATGRAPHY OF THE PLIO-PLEISTOCENE DEPOSISTS OF THE PELORITANI MOUNTAINS (NE SICILY)

Agata di Stefano

Poster session

Topics: Plio-Pleistocene, Southern Italy, Biostratigraphy

Plio-Pleistocene sediments crop out largely along the north-eastern coast of Sicily, facing the Tyrrhenian Sea. A quantitative analysis of calcareous nannofossils carried out on 9 sections sampled in the easternmost sector of the Peloritani Mountains led to recognize four different sedimentary units forming distinct cycles bounded by unconformities.

The first one is represented by "Trubi" Formation, consisting of marls and marly limestones, which range from zone MNN12 (Rio et al., 1990) to zone MNN14/15 (Early Pliocene).

The second one consists of clays, sands and calcarenites ranging from the upper part of zone MNN14/15 to MNN16a/17 (Early-Middle Pliocene).

The third is made up by sands and calcarenites assigned to the zones MNN19a and MNN19b (Late Pliocene-Early Pleistocene).

The fourth represented mostly by clays, belongs to the zones MNN19e and MNN19f (Early-Middle Pleistocene).

Deposition of the Plio-Pleistocene sequences by eustatic fluctuations and the tectonic history of the Tyrrhenian Sea opening.

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PALEOECOLOGY OF THE PALEOCENE NANNOPLANKTON

Olga B. Dmitrenko

Topics: Cenozoic Atlantic/Indian oceans, Paleoecology

In the basis of this paper lays the vast quantity of data about calcareous nannofossils presence, distribution and abundance in the bottom sediments of the Atlantic and the Indian oceans. These sediments were sampled during deep-sea drilling by "Glomar Challenger" and "Djoides Resolution". The paleoecology study includes: the analysis of the distribution of different species and groups of species by area; the change of common nannoplankton abundance with time; the change of the individual species abundance; the perculiorities of the most numerous species variations. All of this gave the opportunity to make more precise the paleoecology of different species and to distinguish the nannofossil's groups of the different paleogeographic environments. The data about more than 300 species was used. More than 500 areal-ranges were constructed for 9 moments from 65 to 25 Ma ago during 5 Ma. On the basis of these areal-ranges the profiles of the different species' distribution and the abundant changes after changes of the latitudes were constructed.

The partly-quantity data from the volumes of the DSDP and ODP was used. The common nannoplankton abundance and the changes of the common coccolith's masses were taken into account for the construction of the meridional profiles, and were traced along the time. The analysis of all of these materials allowed to distinguish all the paleogene species in the few paleoecologic groups:

1. Equatorial-tropic species, with no markable concentration;
2. The narrow-tropical species, those that form and that do not form the high concentrations;
3. The species of the broad geographic distribution with increasing of the concentrations in the tropical environments;
4. Subtropical species of the general and bipolar distributions;
5. The species of the cold subtropics and moderate areas. There have high concentrations, and their distribution can be wide or bipolar.

CALCAREOUS NANNOFOSSILS AS PALEOPRODUCTIVITY INDICATORS IN CAMPANIAN - MAASTRICHTIAN UPWELLING SYSTEMS

Yoram Eshet and Ahuva Almogi-Labin

Tuesday, 12.25

During Santonian to Maastrichtian times, enhanced upwelling conditions prevailed along the southern margin of the Tethys, resulting in the accumulation of thick sections of organic-rich carbonates, phosphates and cherts. In order to contribute to the understanding of the ecological and oceanographic conditions in this system, the calcareous nannofossil assemblages from Campanian-Maastrichtian organic-rich cored sections in the subsurface of Israel were analyzed. Previous micropaleontological studies (foraminifera, dinoflagellates) and geochemical studies showed that the sedimentation of these sequences was controlled by the interplay between surface water productivity and bottom conditions. Calcareous nannofossils from 150 samples in these sections were analyzed in the present study in order to identify taxa that can be used as indicators of productivity, and taxa whose degree of preservation reflects bottom conditions. The following results were obtained:

1. Nannofossil assemblages abundance and species diversity decrease in high productivity conditions. On the other hand, in lower productivity and open marine conditions, assemblages reach the highest abundance and diversity. Similar trends are reported from peridinioid dinoflagellates that become abundant in high productivity, and from gonyaulacoid dinoflagellates that increase in lower productivity conditions (P/G ratio).

2. *Micula decussata* was found to be a good indicator of preservation; in badly- preserved samples, its abundance increases drastically. This result is supported by previous experiments that showed the dissolution-resistance of this taxon. On the other hand, the distribution of *Watznaeueria barnesae*, another reported-to-be dissolution-resistant taxon doesn't always match well with the preservation curve obtained for the studied sections: in some intervals its distribution seems to be affected by productivity.

3. Based on matching their distribution curves with productivity reconstruction curves offered by planktic foraminifera and dinoflagellates, higher amounts of some taxa were found to reflect lower productivity conditions: *Thorachosphaera operculata*, *Lithraphidites carniolensis*, *Vekshinella* spp., *Prediscosphaera* spp. and *Eiffelithus turriseiffelii*. The highest productivity intervals are represented by higher abundance of *Glaukolithus* spp., *Biscutum* spp. and *Thorachosphaera saxea*.

4. The nannofossil index of productivity, as suggested in this study, is useful in reconstructing paleoproductivity history, and matches well with reconstructions made by other micropaleontological disciplines.

CALCAREOUS NANNOFOSSIL DATUM LEVELS: A KEY FOR THE UNDERSTANDING OF THE GENESIS OF UPPER CRETACEOUS OIL SHALE SECTIONS IN ISRAEL

Eshet, Y., Minster, T., Moshkovitz, S.

Poster session

Chalks and marly chalks enriched in organic matter (oil shales) are abundant in the Maastrichtian sequence of Israel, especially in synclinal structures. In order to contribute to the understanding of oil shale basin development, Maastrichtian calcareous nannofossil datum levels were determined in selected boreholes that penetrated the oil shale 'facies' of the Ghareb Formation in the Rotem Syncline, northern Negev. The studied boreholes form longitudinal and latitudinal sections across the Rotem syncline.

The following calcareous nannofossil datum lines were determined (absolute ages are quoted from the literature):

- Last occurrence of *Quadrum trifidum* (73 MA).
- Last occurrence of *Reinhardtites levis* (71.5 MA).
- First occurrence of *Lithraphidites quadratus* (70 MA).

The results shed new light on some aspects of the development of the basin during the oil shale formation and may be used for better understanding of the sedimentary and tectonic evolution of the basin during the time period represented by the oil shale sequence:

1. The top of the oil shale unit demonstrates a sharp diachronic nature - in the southern part of the basin it appears close to and below the first occurrence of *L. quadratus*, whereas in the north it is found in much older layers, below the last occurrence of *Q. trifidum*.

2. Based on the absolute ages of the determined datum lines and on the assumption that the base of the oil shale unit (base of the Ghareb Fm.) is almost of equal time, it appears that the oil shale unit does not represent equal time-spans all over the syncline; in its northern part, it represents a period of about 1-1.5 MA, whereas in the south it represents a much longer time interval, up to 4-4.5 MA.

3. The sedimentation rates which were computed for the oil shale sequence in the Rotem syncline vary between 15-40 m/MA. The highest rates were attained in the central and southern parts of the basin, whereas towards the north, lower rates were recorded.

4. The nannofossil datum lines indicate the existence of a major depo-centre, that developed mainly after the last occurrence of *Q. trifidum*, in the central to southern part of the oil shale body. A NNW-SSE trending hinge line, passing through the joining point of the Havarbar-Ef'e valleys was developed during that period and generated two subbasins: a northern, smaller, and a southern, a larger one. A gentle, differential uplifting of the eastern flank of the basin during the same period is also indicated by the nannofossil datum levels.

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY IN SANTONIAN-MAASTRICHTIAN ORGANIC - RICH CARBONATE SECTIONS IN ISRAEL

Y. Eshet, and S. Moshkovitz

Poster session

A calcareous nannofossil zonation scheme is presented for Santonian-Maastrichtian organic-rich carbonate sequences in southern and central Israel, that were deposited in a strong upwelling system along the southeastern Tethys. The zonation is correlated with foraminifera and organic-walled dinoflagellate cyst zonal schemes for the same sequences. The following zones are recognized:

- *Lucianorhabdus cayeuxii* Zone, Sissingh, 1977 (Late Santonian) - NC 16
- *Aspidolithus parcus* Zone, Verbeek, 1976 (Early Campanian) - NC 18
- *Ceratolithoides aculeus* Zone, (Cepek and Hay, 1969) Martini, 1976 (late Early Campanian) - NC 19a
- *Quadrum sissinghii* Zone (Sissingh, 1977) Perch-Nielsen, 1985 (early Late Campanian) - NC 19b
- *Quadrum trifidum* Zone, Bukry and Bramlette, 1970 (Late Campanian-Early Maastrichtian) - NC 20
- *Arkhangelskiella cymbiformis* Zone, (Perch-Nielsen, 1972) Martini, 1976 (Early-Middle Maastrichtian)
  - subzone A - NC 21a
  - subzone B - NC 21b
- *Lithraphidites quadratus* Zone, (Cepek and Hay, 1969) Bukry and Bramlette, 1970 (Middle Maastrichtian to early Late Maastrichtian) - NC 22

In this study we suggest that the NC21 Zone (according to Monechi and Thierstein, 1985) is subdivided into two subzones: NC21a and NC21b. We also note that some taxa that are commonly used as markers elsewhere, have a different range in the studied area.

The proposed zonal scheme indicates the occurrence of unconformities at the Santonian-Campanian boundary and within the upper part of the Middle Maastrichtian.

Calculations of sedimentation rates indicate an increasing rate towards the north, and that there is a general trend of rate increase through time from the Santonian to the Maastrichtian. A significant rate increase is found in sections from the outer shelf and continental slope at the first occurrence of *Quadrum sissinghii* and *Quadrum trifidum*.

CALCAREOUS NANNOPLANKTON FROM THE AUSTRALIAN SECTOR OF THE SOUTHERN OCEAN

Claire Findlay

Poster session

Calcareous nannoplankton assemblages were recorded from water column samples between 10m and 200m water depth, from the Australian Sector of the Southern Ocean. Samples were taken during the summer months from December 1993 to January 1994, between 48°19'S and 64°09'S, and 143°52'E (WOCE-V7 cruise), and from January to February, 1995, between 41°00'26"S and 49°04'S, and between 142°31'E and 151°22'E (Australian Geological Survey Organisation cruise 147).

Particular attention was given to *Emiliania huxleyi*, and various measurements were recorded and compared to previous studies (Young and Westbroek, 1991). The results show the most dominant morphotype of *E. huxleyi* from the WOCE-V7 samples compares to Type C of Young and Westbroek, the 'cold water' form (though the morphotypes are not necessarily influenced solely by temperature) described by previous workers (McIntyre and Bé, 1967; Okada and Honjo, 1973). The 'polar form' described by Verbeek (1989) was also present. Biogeographic plots of *E. huxleyi* from these samples show a change in abundance and diversity at depth (90 to 100m), and latitude. *Calcidiscus leptoporus*, the second major component in the WOCE-V7 transect, is absent south of 49°45'S, indicating the position of the Subtropical Convergence (Subantarctic Front), and the absence of *E. huxleyi* south of 61°20'S indicates the position of the Polar Front (Antarctic Divergence). *Gephyrocapsa* species were not found in the WOCE-V7 samples

Initial investigations of the AGSO samples indicate a very different assemblage between the two transects. The dominant form in the north of this transect is *Umbellosphaera tenuis*, not the expected 'warm water' form of *E. huxleyi*. This indicates a different water mass compared to the west of Tasmania and possibly reflects the presence of southward-flowing, warm-water, near-coastal currents, such as the Leeuwin and Zeehan Currents. Although *Gephyrocapsa oceanica* is present, it is not a significant component of the assemblage.

Comparison with temperature and salinity data for this region should determine the different water masses and how they affect the composition of calcareous nannoplankton assemblages in this section of the Southern Ocean. This information will be compared with downcore assemblages to determine the changes in the Southern Ocean through the Quaternary.

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MAASTRICHTIAN NANNOFOSSIL BIOGEOGRAPHY IN THE SOUTHERN TETHYS

Andrea Fiorentino

Wednesday, 11.10

Nannofossil assemblages from Southern Tethys sections were analyzed in order to identify patterns of geographic distribution and their causes. The general biogeographic scheme for this period of time was difficult to apply, due to the changes in the composition of the assemblages observed locally. The geographic distribution of selected nannofossil species was therefore interpreted in another perspective, considering the influence of the environment of deposition, the lithology, the effects of preservation and the geologic history of the sections examined. The absences of *Micula decussata* and *Braarudosphaera bigelowii* from assemblages, of which they should be typical representatives, are reported and a tentative explanation is given, suggesting that geographic distribution of a species is strongly affected by factors other than only temperature and latitude.

AN EXAMPLE OF EUTROPHIC - OLIGOTROPHIC ALTERNATES IN THE LOWER MESSINIAN: THE SORBAS BASIN (WESTERN MEDITERRANEAN)

J.A. Flores, F.J. Sierro, I. Zamarreno, A. Vazquez, R. Utrilla and G. Frances

Poster session

In the Sorbas section (Lower Messinian, SE Spain), the calcareous plankton microfossils assemblages show a cyclicity interpreted as precessional orbital forcing, as effect of changes in the surficial water characteristics. Here, a detailed analysis of the calcareous nannofossils (CN) assemblages in three cycles is carry out, using quantitative techniques. The lithology of these cycles consist of hard (partially silicified and calcareous nannofossil sterile) levels, separating two meters marly levels very rich in calcareous plankton. The proportions of the Planktic Foraminifera (PF) warm assemblages show the same distribution that Asteroliths and Sphenoliths, richest in the lower part of the marls levels. However, the Sphenolith peak preceeds the Asterolith peak. The frequencies of the Very Small Reticulofenestrids (VSR; most important group in the CN assemblages) are opposite to those of Asteroliths and Sphenoliths, increasing towards the top of each marly cycle. Using the Scanning Electro Microscope in not disturbed samples, is observed that the VSR richest intervals are the less diluted and richest in complete coccospheres. It is discussed the possibility that these VSR dominant levels correspond to maximum eutrophic episodes. On the contrary, the Asterolith-Sphenolith rich assemblages should correspond to oligotrophic episodes in the basin. This dinamic is related to variations between the Sorbas and the Mediterranean connection during the Messinian.

BIOSTRATIGRAPHY USING SILICOFLAGELLATES AND CALCAREOUS NANNOFOSSILS OF NEOGENE - PLEISTOCENE DEPOSITS OF GREECE

Patras Dimitris Frydas

Monday, 16.00

An intensive research using calcareous and siliceous nannofossils has been carried out in the South Aegean Sea, Greece. New subzones of the siliceous nannofossils were identified and correlated with stratigraphically equivalent planktonic foraminiferal and calcareous nannoplankton zones.

A continuous sedimentation from Tortonian to Lower Piacenzian is observed in the Neogene deposits of Crete island, with a thickness of more than 500m. During the Upper Miocene a rhythmic alternation of thick evaporite beds with gypsum (Selenit), sandstones and laminated diatomite layers was deposited. The Pliocene succession mainly consists of grey silty clays, yellow marls and light grey to white diatomites or diatomaceous marls.

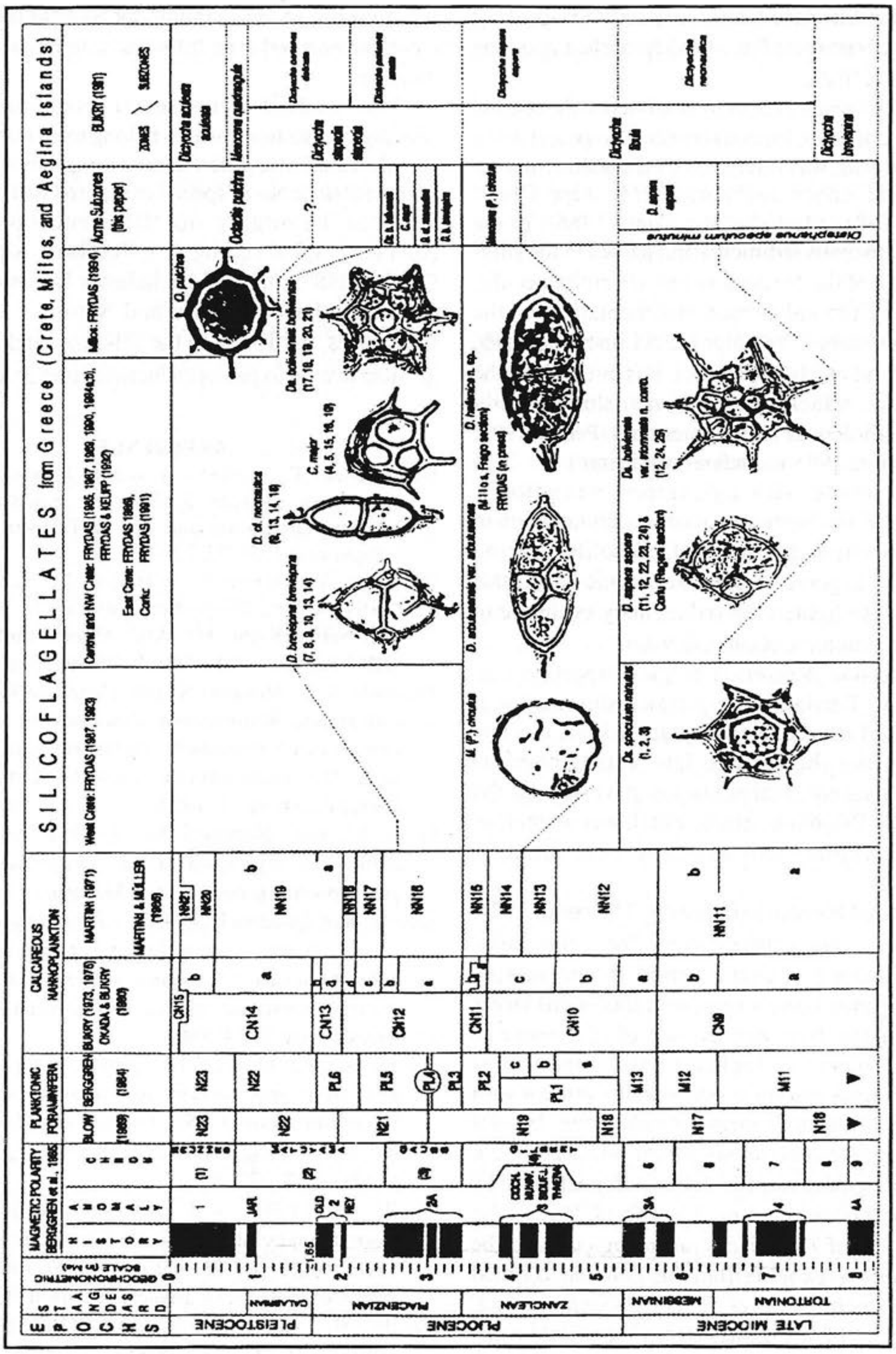
From a total of nine formations which have been recognized from the East to the West of Crete island, three were deposited during the Upper Miocene and the rest during the Pliocene.

The silicoflagellates of the Kavoussi section, W. Crete are placed to the interval-Zone *Distephanus speculum minutus*. The latter is equivalent to the CN9 (*Discoaster quinqueramus*) characterized by the *Discoaster berggrenii* and the *D. quinqueramus* first occurrences (Upper Miocene).

The Pyrgos, Dafnes, Tsagaraki and Makria Rachi sections situated at the central part of Heraklion district, Crete, can be assigned to the *Dictyocha aspera aspera* Acme-subzone, which is considered stratigraphically equivalent to the CN9b (*Amaurolithus primus*) subzone of the Messinian. Similarly, the Ragani section association, NW Corfu, belongs to the same subzone (*D. aspera aspera*), which is also equivalent to the *Globorotalia conomiozea* Zone of planktonic foraminifera.

Using the silicoflagellate percentage distribution, the Lower Piacenzian has been subdivided into four new subzones, listed below (from older to younger): the *Dictyocha brevispina brevispina* Acme-subzone, the *Dictyocha neonautica* Acme-subzone, the *Cannopilus major* Acme-subzone, and the *Distephanus boliviensis* Acme-subzone. These subzones are coeval to the CN12a (*Discoaster tamalis*) subzone as well to the *Globorotalia bononiensis* Zone.

The silicoflagellates associations from the section Frago (Milos island) as well Aghios Thomas (Aegine island) were placed in the Acme-Zone *Mesocena circulus* (Upper Zanclean). The calcareous nannofossils from both sections indicate the biozone CN11b (*Discoaster asymmetricus*) through the coexistence of *Discoaster tamalis* and *Reticulofenestra pseudoumbilicus*. This biozone corresponds to the zone of *Globorotalia puncticulata* from planktonic foraminifera. Further the silicoflagellate association of the section SE-Adamas (Milos island) belongs to the Acme-subzone *Octactis pulchra* (Lower Pleistocene) which corresponds to the zone CN13a (*Emiliania annula*) from calcareous nannoplankton.



EARLY CRETACEOUS CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE INTERNAL LIGURIDS (NORTHERN APENNINES, ITALY) AND THE ONSET OF COCCOLITH - BEARING SEDIMENTS IN THE LIGURIAN - PIEDMONT OCEANIC DOMAIN

Silvia Gardin and Nicola Perilli

Poster session

Topics: Biostratigraphy, Early Cretaceous, Western Tethys, Northern Apennines, Italy.

The internal ligurid succession of the Northern Apennines (Italy) consists of Early to Middle Jurassic ophiolite sequences, interpreted as slabs of the Western Tethys oceanic lithosphere, and their pelagic sedimentary cover (Principi et alii, 1992 and reference therein). The Middle Jurassic-Early Cretaceous pelagic cover includes radiolaritic sediments, as the Mt. Alpe Chert, and coccolith-bearing formations as the Nisportino Fm., the Calpionella Limestone and the Palombini Shale.

During the Callovian-Tithonian time interval the oceanic Ligurian-Piedmont basin, located between Europe and Adria continental margins, was interested by the sedimentation of well-stratified ribbon radiolarites (Mt. Alpe Chert: Baumgartner, 1984; Marcucci and Conti, 1986). In the Berriasian the siliceous sedimentation passed to the silty-marly deposition of the Nisportino Fm. (Bortolotti et alii, 1994) and/or to the calcareous sedimentation of the Calpionella Limestone. The Calpionella Limestone, made up of siliceous and marly limestones, it is overlain by the Palombini Shale, which consist of marlstones, marly claystones and siliceous or marly limestones (Perilli, 1995; Perilli and Nannini, 1995 and references therein).

This work deals with calcareous nannofossil biostratigraphy of the Early Cretaceous sedimentation of Western Tethys and the onset of coccolith-bearing sediments in the Ligurian-Piedmont oceanic basin; this study contribute to lighten the sedimentary evolution of the Ligurian-Piedmontese oceanic domain.

The hemipelagic deposition of the Nisportino Fm. started in the early Berriasian; the pelagic sedimentation of the Calpionella Limestone took place within the late Berriasian. During the early to late Valanginian the Calpionella Limestone sedimentation gave way to the deposition of the Palombini Shale, which was ubiquitous in the whole Ligurian-Piedmont basin until the early Barremian.

The recognized biozones (following Thierstein 1971, 1973, 1976) are: *Nannoconus colomi* Zone: this easily recognizable biozone is characterised by the sharply increase of the genus *Nannoconus* with specimens larger than 8μm and the first occurrence of *Nannoconus steinmannii steinmannii* togheter with *Nannoconus kamptneri*; the zonal marker is occasionally present with rare specimens. *Retecapsa angustiforata* Zone: besides the zonal marker *Retecapsa angustiforata*, which is present even if with rare specimens, this Zone is characterised by the FO of *Rucinolithus wisei*, the FO of *Percivalia fenestrata*, the FO of *Tubodiscus jurapelagicus*, and the FO of *Tubodiscus verenae*. Within this Zone we recorded the presence of *Rucinolithus* cf. *R. terebrodentarius* and, in the upper part of the Zone, of *Calcicalathina* aff. *Calcicalathina oblongata*, a precursory form of *Calcicalathina oblongata*. *Calcicalathina oblongata* Zone: as reported by many authors, this is an interval in which there are few appearances or extinctions of common species and therefore, it is difficult to finely subdivide it. *Rucinolithus wisei* and *Tubodiscus verenae* sporadically occur and get extinct in this biozone, although their LO's is not clearly detectable. Within this biozone it is also recorded the FO of *Nannoconus bucheri* (and wide canal related forms), but this event needs to be further tested. *Litraphidites bollii* Zone: The difficulty in characterising this Zone is the lack of the zonal marker *Litraphidites bollii* in the studied deep-sea lithofacies; however, within this biozone the LO of *Cruciellipsis cuvillieri* is easily well detectable; on the contrary the FO of *Rucinolithus terebrodentarius* is questionable due to, as above reported, the presence of very similar forms (*Rucinolithus* cf. *R. terebrodentarius*) even from the *Retecapsa angustiforata* biozone.

The studied nannofossil assemblages of the investigated sections, which belong to an oceanic domain, reveals remarkable differences in composition and total and relative abundance of species compared with other of same age but belonging to different epicontinental paleogeographic setting (e.g Southern Alps: Erba and Quadrio, 1987; Umbria-Marche basin: Bralower et al., 1989; Vocontian basin: Gardin and Manivit, 1993). These differences, partly due to the lithology and preservation, are also related to paleoproductivity and paleogeography.

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SEDIMENT TRAP STUDIES OF COCCOLITH AND PLANKTONIC FORAMINIFERAL FLUXES IN THE BENGUELA UPWELLING SYSTEM

Jacques Giraudeau and Geoffrey W. Bailey

Monday, 16.50

Coccoliths and planktonic foraminifera collected by a sediment trap deployed on the upper slope off Walvis Bay, Namibia, were investigated in order (1) to assess their contribution to the total particulate flux, (2) to evaluate their response to seasonal changes in the dynamics of the Benguela upwelling process, and (3) to use them as tracers of particle transfer process on the slope. The trap, located at 545 m depth, 50 m above the sea floor, provided high resolution (8 days) times series samples from late winter to early summer. This 4-month period is marked by a drastic change in hydrological processes, from active to quiescent upwelling conditions. The total mass flux ranged from 3 to 1,1g/m^2/day. The lithogenic fraction was the main contributor to the total mass flux (64% of average contribution), followed by carbonate (22%), organic matter (8%), and biogenic opal (5%). The relative contributions of the four components to the total mass flux were relatively stable throughout the period of the experiment, thereby suggesting that seasonal changes in hydrological/upwelling process, from late winter to early summer, did not induce sharp modifications in the composition of the particles sedimenting on the slope. The bulk of lithogenic particles sedimenting on the continental margin originates from aerosol sand plumes due to katabatic wind events. Considering the low frequency and short duration of such events, we suggest that resuspension of shelf material and continuous horizontal advection to the slope were necessary to account for the high contribution of lithogenic particles recovered by our trap throughout its 4-month deployement.

The free-coccolith mass flux closely followed total mass flux variations, and ranged from 90 to 10 mg/m^2/day, thereby accounting for less than 10% (on an average) of the total biogenic carbonate mass flux. Coccolith number fluxes varied from 4200 106/m2/day to 400 106/m^2/day, *Emiliania huxleyi* being the dominant form (relative abundance: 60 to 75%). On the contrary to coccolith fluxes, the coccosphere fluxes did not show any significant covariations with total mass fluxes. This, coupled, with dissimilarities in species assemblages, suggest that the bulk coccolith fraction and the coccospheres were affected by distinct transfer process: lateral transport of coccoliths resuspended from the shelf, vertical advection of coccospheres from the overlying surface waters.

Planktonic foraminiferal number fluxes, dominated by juvenile specimens, ranged from 600 to 50 103/m^2/day, and roughly followed the total mass flux variations. The three size classes (juvenile, neanic, adult) presented distinct patterns in flux variations, which can be related to distinct transfer process, as well as mass mortality events in the case of the adult populations.

OCEANIC FRONTS IN THE MESOZOIC

William W. Hay

Poster session

The modern ocean is characterized by four regions, three of which are mirrored in each hemisphere: an equatorial belt (28% of the ocean surface area) characterized by divergence and shared by the two hemispheres, stratified tropical-subtropical anticyclonic gyres (46%), temperate mid-latitude belts of water characterized by convergence and steep meridional temperature gradients (11%), and deeply convecting polar oceans characterized by cyclonic gyres (13%). Convergence and divergence of the ocean waters are forced beneath zonal winds. Convergences or fronts form sharp boundaries between water masses and introduce surface water into the ocean interior. The fronts can be recognized by abrupt changes in nannoplankton assemblages. The sites of divergence are more diffuse; they separate water masses and return water from the ocean interior to the surface. Surface waters of the equatorial belt flow westward, driven by the easterly trade winds. Eastward subsurface flow returns some of the water, but much of the westward flow becomes incorporated into the western boundary currents of the tropical subtropical gyres. Increasing zonal velocities of the trade winds away from the atmospheric Intertropical Convergence Zone (ITCZ) induce divergence and upwelling in the waters of the equatorial belt. The most stable features of the modern ocean are the stratified tropical-subtropical gyres between 15° and 45° N and S. Low-latitude easterly trade winds and mid-latitude westerly winds drive the gyres. They also force convergence in the gyre centres. The sinking waters spread beneath the gyre as central waters. The maximum of the zonal component of the westerly winds occurs at about 45° N and S. The zonal winds induce meridional flow of the surface waters toward the equator, forcing sinking along the subtropical and polar fronts and forming barriers to poleward heat transport. The subtropical front is the source of thermocline water. Intermediate water forms by sinking along the polar front. The alternate, competing, source for intermediate water is outflow from saline marginal seas. Decreasing zonal wind velocities poleward of the polar fronts induce divergence, cause cyclonic circulation, and promote deep convection and deep water formation.

The Jurassic and Early Cretaceous ocean may have been similar to that of the present, but the late Cretaceous ocean was significantly different, with polar temperatures well above 5° C. The tropical-subtropical gyres in the

Panthalassic Ocean had high salinities, though not as high as in the early Atlantic. Central waters would have formed as they do today. The subtropical and polar fronts, driven by the winds, must have existed, and would have been located in the mid latitudes even if the poles were warmer than today. Between the subtropical and polar fronts both the temperature and salinity of the water must have decreased, representing the outcrop of the lower part of the tropical-subtropical pycnocline. Nannoplankton assemblages indicate that the subtropical fronts in the Cretaceous were at the same latitude as they are today. The Cretaceous term for the region equatorward of the subtropical fronts is "Tethyan," the regions poleward are "Boreal" and "Austral."

CALCDINOCYSTS FROM THE MIDDLE CONIACIAN TO UPPER SANTONIAN CHALKS AT LAEGERDORF (N GERMANY)

Tania Hildebrand-Habel and Helmuth Willems

Poster session

Calcareous dinoflagellate cysts are a very common, often even rock-forming nannofossil group in the pelagic chalk facies of northern Europe. According to the systematic concept of KEUPP (1987) and KOHRING (1993), four morphological groups of cysts within the Calciodinellaceae DEFLANDRE 1947 can be distinguished on the level of subfamilies. The striking feature is the orientation of the crystallographic c-axis of the calcite crystals in the outer cyst wall relative to the cyst surface. The Orthopithonelloideae are characterized by an orthogonal (radial), the Obliquipithonelloideae by an irregularly oblique, the Pithonelloideae by an uniquely oblique, and the Fuettererelloideae by a tangential orientation of the crystals. From the 400 m thick Upper Cretaceous white chalk standard section of Laegerdorf - Kronsmoor (N Germany), a first survey of calcareous dinocyst assemblage is given for the time period of middle Coniacian to upper Santonian. 24 samples have been studied from the 85 m thick series from the koeneni Zone to the *Uintacrinus/granulata* Zone. The spectrum of forms comprises 27 taxa, three of them are described newly. In addition to the systematic description, the flora has been interpreted paleoecologically using quantitative evaluations. Summarizing representations of the distribution of the subfamilies and further morphological groups, of the diversity, and of the frequency have been established on the basis of vertical cyst distributions. The tendencies to be derived from these patterns allow a rough division of the section into three stratigraphic ranges. Considering the studies of other authors, the distributions seem to be related to transgressive/regressive trends. Possibly, the lower range of the section (koeneni Zone) indicates a regressive trend, the middle range (upper middle Coniacian to lower middle Santonian) a transgressive trend, and the upper range (middle Santonian to upper Santonian) a regressive trend.

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UPWELLING RELATED DINOFLAGELLATE CYST ASSOCIATIONS OF THE BENGUELA CURRENT SYSTEM

Ramses P. Hoek and Karin A.F. Zonneveld

Poster session

Dinoflagellate cysts are recorded from most marine environments and are susceptible to changes in temperature, nutrients and salinity. Little is known, however, of the environmental affinity of dinoflagellate cysts from subtropical regions of the Atlantic Ocean.

The Benguela Current System, the eastern boundary current of the South Atlantic subtropical gyre, can be subdivided into a northward-directed, relatively cold, near-coastal upwelling part and a relatively warmer north to northwest flowing oceanic part.

Surface sediments of both multicores and boxcores from the Benguela Current System are studied for their palynologic content, with emphasis on organic-walled dinoflagellate cysts (dinocysts). Preliminary results, related to known oceanographic parameters, will be presented here.

Dinoflagellates producing organic walled cysts may have heterotrophic and/or autotrophic (photosynthetic) feeding strategies. The associations recorded in the samples from the main upwelling cell (Walvis Bay) are dominated by heterotrophic, dinoflagellate cysts (representatives of the family Peridiniacea) with a total of 12000 dinoflagellate cysts per cm^3. Several of these species seem to be endemic for upwelling areas and are only recorded in large concentrations in studies offshore Somalia and Peru. Concentrations are relatively lower in and close to the freshwater plume of the Orange river. An increase in the amount of terrestrial derived material (pollen, spores and fresh water algae) is observed here.

Concentrations of dinocysts decrease oceanward (28-9000 dinocysts per cm^3), and are primarily concomitant with an increase in the relative amount of autotrophic dinoflagellate cysts (representatives of the family Gonyaulacaceae).

CORRELATION OF CALCAREOUS AND ORGANIC-WALLED DINOFLAGELLATE CYST ASSOCIATIONS IN GLACIAL/INTERGLACIAL CYCLES, AN EXAMPLE OF THE EQUATORIAL ATLANTIC

Christine Hoell

Poster session

Organic-walled dinoflagellate cysts (organic dinocysts) have been described from sediments of almost all marine environments, whereas calcareous dinocysts often have been neglected. The occurrence of organic dinocysts is mostly restricted to neritic regions only a few species live in the oceanic realm. On the contrary, calcareous dinocysts occur mostly in oceanic regions and less in neritic. One sediment core (from the Guinea Basin, Equatorial Divergence Zone of the South Equatorial Current, Core GeoB 1105-4) was used for the investigation for both, calcareous and organic dinocysts. Most of the organic dinocysts are formed by gonyaulacoid, autotrophic dinoflagellates or protoperidinoid, heterotrophic dinoflagellates. Among the calcareous dinoflagellates, it has to be differentiated between calcareous dinoflagellate cysts (calcareous dinocysts) and the vegetative coccoid form *Thoracosphaera heimii*. The analysis of the dinocysts assemblage shows a much greater amount of calcareous forms, which are mainly dominated by the vegetative coccoid form of *T. heimii*. The total cyst flux of organic dinocysts increases during glacial periods together with a predominance of protoperidinoid cysts. The predominance of these cysts can be related to higher nutrient levels and/ or a decrease in temperature. The amount of calcareous dinoflagellates including *T. heimii* is especially high at the beginning of glacial periods. Assemblages of organic dinocysts and calcareous forms both show striking changes in composition and flux from glacial to interglacial. The vegetative form *T. heimii* seems to be a valuable direct indicator for paleoproductivity.

MID-CRETACEOUS CALCAREOUS NANNOPLANKTON IN AN ORGANIC-RICH FACIES OF THE SUBBETIC AND PENIBETIC (BETIC CORDILLERA, SOUTHERN SPAIN)

Glen Homeier

Poster session

Calcareous nannoplankton and Rock-Eval analyses of C_{org}-rich intervals are used as tools to provide a better understanding of the mid-Cretaceous paleoceanographic conditions around the Alboran-microcontinent in southern Spain. Ten sections and ten high-resolution profiles (sampled in cm intervals) are being investigated along the axis (Median-Subbetic) and at the margin (Penibetic/ Internal-Subbetic) of the "Betic Seaway". Nannofossil and organic carbon data are compared with "Oceanic Anoxic Events" (OAEs) within deep sea drilling sites (DSDP/ODP) of the North Atlantic Ocean.

Pelagic (Barremian)-Aptian-Albian (OAE-1) dark marlstones/claystones, marly lime-stones and black shales (>1% TOC) were mainly investigated in the Sierra de las Cabras in the western Subbetic and the Sierra de los Canutos (Manilva) in the Penibetic. Calcareous Nannofloras are poorly preserved but are common in black shales with Total Organic Carbon (TOC) contents up to 3% during the Aptian. The Albian deep-marine sediments of the Median-Subbetic consist of alternating dark green, bioturbated claystones, grey claystones and black shales. Benthic foraminiferal assemblages indicate deposition below the calcite composition depth (CCD) in the Rio Fardes area (Central-Subbetic) (Homeier, 1993; Reicerter et al., 1994). Calcareous nannoplankton and planktonic foraminifera are absent and C_{org}-values reach up to 2,6% TOC. The kerogen is of type-III according to the Rock-Eval data and contains terrestrial macerals (fusinite, sporenite, vitrinite). Further to the Northeast, in the Sierra de Ponce area (East-Subbetic) calcareous nannoplankton is relatively abundant in the dark claystones (0,7% TOC). This implies that this Subbasin of the Median-Subbetic was located above the CCD in contrast to the sub-CCD conditions in the Rio Fardes-Basin.

Black shales at the Cenomanian/ Turonian boundary (OAE-2) reach 16,7% TOC in the Rio Fardes area (Homeier, 1993; Section Olivares). They are intercalated with fine-grained calciturbidites, grey marlstones and calcilutites with black banded chert, rich in radiolarians. This is a typical facies association of the Cenomanian-Turonian Boundary Event (CTBE) in the entire Subbetic. Calcareous nannoplankton is rare and occurs mainly in the interstratified horizons between the black shale layers. They show low diversity and poor preservation. Most of the species are intensively overgrown and dissolution is present. The dissolution resistant species *Watznaueria barnesae* and, to a lesser extent, *Ephrolithus floralis* occur in some of the black shale layers with C_{org}-values reaching 3% TOC, which contain marine macerales (algenite, bituminite) of type-II kerogen and lesser amounts of terrestrial type-III kerogen.

Anoxia occurred only sporadically at the Cenomanian/ Turonian boundary, whereas most of the Albian dark sediments were deposited in a dysaerobic to aerobic environment. Turbidites are most probably responsible for transportation and preservation of calcareous nanno-plankton into deeper parts of the basin in the Rio Fardes area during the Cenomanian/Turonian Boundary Event.

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MID - LATE CRETACEOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE PAPUAN BASIN, PAPUA, NEW GUINEA

Richard Howe

Poster session

Situated on the north-eastern margin of the Australian Plate, the Papuan Basin of Papua New Guinea has undergone a highly complex Mesozoic and Cenozoic tectonic and depositional history. Following early rifting in the Late Triassic and Early Jurassic, the basin developed on a passive margin in the Late Jurassic, Cretaceous and Palaeogene. Changes in relative plate motion in the late Palaeogene, as the Australian Plate began to move north, resulted in the basin developing as a foreland basin on a convergent margin from the late Oligocene to the present day. Exposures of mid- and upper Cretaceous sediments of the Basin are concentrated in the Papuan Fold Belt, where they have been uplifted and deformed during the Neogene. Nannofossil assemblages in the Basin have very rarely been comprehensively described (e.g. Shafik, 1990) for the mid-late Cretaceous interval, and have never been well illustrated by published photographs.

In the western part of the Basin, around the Ok Tedi area, mid-Cretaceous siliciclastics of the Ieru Formation contain low to moderate diversities and abundances of late Aptian-Turonian nannofossils. Preservation and abundance become progressively better up-section, as the paleobathymetry increased. These assemblages show cool-water Austral affinities, with the presence of such species as *Seribiscutum primitivum*, *Sollasites falklandensis* and the generally low abundance of warmer water species such as *Flabellites biforaminis* and *Rhagodiscus asper*. The Austral affinities decrease up-section into the Turonian. In the northern part of the Basin, around the Mendi area, upper Cretaceous calcareous siliciclastics of the Chim formation contain moderate to well preserved Santonian to Maastrichtian nannofossils, including some very well preserved *Micula prinsii* zone material from Mendi. These assemblages show temperate to warm-water extra-tropical affinities, with the absence of species such as *Seribiscutum primitivum*, and higher diversities than in the mid-Cretaceous section. These assemblages confirm that the Papuan Basin was in the Austral province of Shafik (1993) during mid-Cretaceous times, and that it had a northerly component of motion during this time which progressively carried it into the warmer-water extra-tropical province of Shafik (1993).

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BIOSTRATIGRAPHY IN THE OIL INDUSTRY

Martin Jakubowski

Wednesday, 15.15

Biostratigraphy is a geotechnology which has been at the foundation of geology for many years and is an essential discipline in hydrocarbon exploration. There are many different biostratigraphic (and non-biostratigraphic) disciplines available to the industry for the purpose of chronostratigraphic and paleoenvironmental interpretation and well correlation, which are reviewed. A thorough understanding of the advantages and disadvantages of these techniques are required to ensure that a biostratigraphic study meets its objectives. The correct combination of these techniques allows for the construction of a sound stratigraphic framework which is essential in predicting lateral and vertical facies changes.

The impact biostratigraphy can have on hydrocarbon exploration can only be fully realised through integration with other geological disciplines. In recent years the concept of sequence stratigraphy has provided the vehicle to ensure that this integration procedure is followed to develop geological models at reservoir, basin and regional scale. This has led to a change in the skills profile and the function of biostratigraphers in the oil industry.

Some examples of the application of bistratigraphy in an exploration and production context are documented.

CALCAREOUS DINOFLAGELLATE CYSTS: ULTRASTRUCTURE TYPES AND SYSTEMATIC APPLICATION

Dorothea Janofske, Helmut Keupp and Helmut Willems

Monday, 10.20 and poster session

About 20 % of living dinoflagellate species are known to produce cysts during their life cycle but for most of the known dinocysts the cyst-theca relationship is not yet established. Two different taxonomic systems exist for dinoflagellates: one based on the vegetative stage and one based on the cyst stage. As fossil dinoflagellates are normally known only by their cyst stage, paleontologists have to use the latter. Fossil dinocysts consist of acid-resistant sporopollenin-like material (organic-walled) and/or of calcite (calciodinelloid). Dinoflagellates are known to have various cyst morphotypes for one vegetative species. One clone of calciodinelloid dinoflagellates can produce up to four morphotypes simultaneously. Assemblages of fossil and recent calcareous dinocysts show different morphotypes, caused by variation of crystal morphology. Thin sections (2-3 μm) of selected calcareous dinocysts were used for the analysis of crystallographic patterns, and four ultrastructure types were confirmed, on the basis of the crystallographic orientation of the calcite crystals forming the cyst wall:

1. Radial: calcite crystals arranged with the c-axis perpendicular to cyst surface, optic sign: negative, symmetric extinction cross.

2. Tangential: calcite crystals arranged with the c-axis horizontal to cyst surface, optic sign: positive, symmetric extinction cross.

3. Oblique: calcite crystals arranged with the c-axis inclined at various angles and directions even in one specimen, optic sign: vague due to overlapping of interference colours.

4. Pithonelloid: calcite crystals arranged in rows, their c-axes inclined, angle and direction consistent to cyst surface. In sections perpendicular to the longitudinal axis, optic sign is a symmetric extinction cross.

Sections parallel to the longitudinal axis show an asymmetric extinction cross. Interference colours depend on the specific angle of the c-axis. The different morphotypes of one single calcareous cyst species occurring in fossil and recent assemblages as well as in clones are characterized by variation in crystal morphology. But, the calcite crystals forming the cyst wall always have the same crystallographic orientation. These crystallographic regularities are the result of biologically-induced and biologically-controlled biomineralization processes. Crystallographic orientation patterns are regarded as a genetically fixed and primary character in taxonomy. The four different ultrastructure types based on crystallographic orientation correspond to the subfamilies Orthopithonelloideae (radial, Triassic - Recent), Fuettererelloideae (tangential, Tertiary - Recent), Obliquipithonelloideae (oblique, Triassic - Recent) and Pithonelloideae (pithonelloid, Triassic - Cretaceous) in calciodinelloid dinoflagellates.

COMPARATIVE VARIATION OF CALCAREOUS NANNOFOSSILS (ESPECIALLY ELLIPSAGELOSPHAERACEAE), FORAMINIFERS AND ORGANIC MATTER CONCENTRATION IN THE KIMMERIDGIAN SEQUENCE FROM LA BRIÈRE (NORMANDY, FRANCE)

Marie-Christine Janin, Yann Samson, Maria Saint-Germés, François Baudin and Gérard Bignot

Wednesday, 12.00

Among the highly polymorphic group of Ellipsagelosphaeraceae, the circular forms (particularly Cyclagelosphaera margerelii Noël, 1965) are often considered as indicative of confined paleoenvironments. In order to obtain more precise information about the biological and paleoecological significance of the variability of Ellipsagelosphaeraceae, a detailed investigation of calcareous nannofossil assemblages (Fig. 1, next page) has been carried out on 35 samples from the Octeville Clay Formation (Late Kimmeridgian sensu gallico = ammonite zones Mutabilis and Eudoxus) outcropping in La Brière cliffs near Le Havre (northwestern Paris Basin: Bignot et al., 1994). The nannofloral variability is compared with the variation of foraminiferal assemblages on one hand (Y.S.), and of clay composition and carbonate and organic matter content on the other (M.St.G and F.B.; preliminary results in Baudin, 1993 and Saint-Germès, 1994).

The uniform lithology (dark clay succession only interrupted by a few more calcareous beds), the unchanging composition of the clay fraction, and the moderate amplitude of the bathymetrical variation indicated by the foraminiferal assemblages suggest that no drastic paleogeographic modification occurred in the basin during the time interval considered. However, the calcareous nannofloral abundance and composition seem highly variable, with a striking correlation between the dominance of coccoliths of Ellipsagelosphaeraceae and the high values of organic matter concentration. Different hypotheses are proposed and discussed to explain this paradoxical situation.

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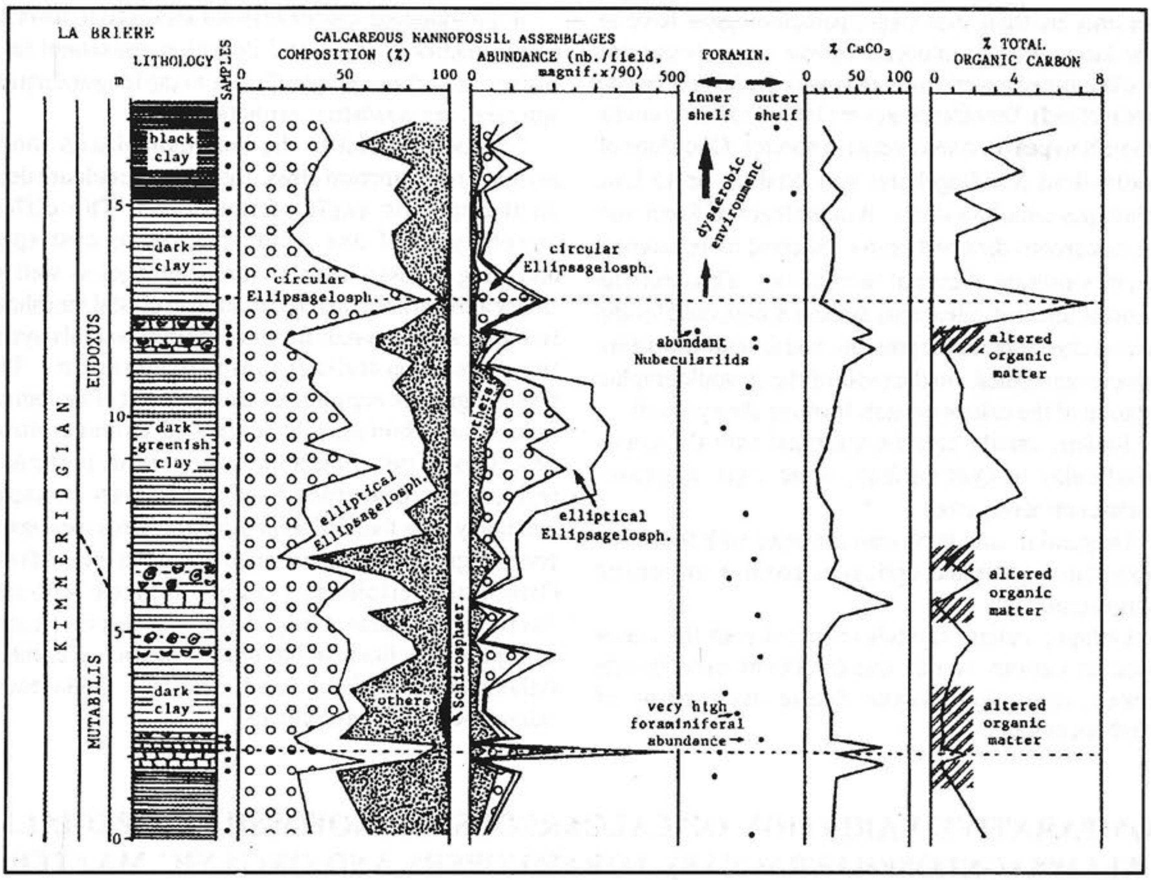

Figure 1. La Brière section, lithology, composition and abundance of nannoplankton assemblages, foraminifers, content of $CaCO_3$, and total organic carbon.

THE CASE OF THE MISSING NANNOFOSSIL OR "NOW YOU SEE IT, NOW YOU DON'T"

David Jutson

Wednesday, 16.00

The field of nannoplankton research, both of living and fossil forms has expanded greatly in the last twenty years. The uses of nannofossils for paleoenvironmental reconstructions and stratigraphy, often with very high resolution, are well-known.

Observations of nannofossil assemblages over time from almost any source reveals that nannofossils are disappearing at significant rates from raw material and from prepared slides. In an industrial setting, this process can be observed taking place within a few minutes of the sample from a drilling well reaching the surface. In an academic setting, within the time frame of three years, samples which have been stored as dry, raw reference samples have been seen to contain significantly impoverished nannofloras compared to material from the same sample processed soon after collection.

For any nannofossil worker interested in her/his discipline, consideration of this loss of data should be of primary interest as the conclusion must be that however hard we try, we are all working with fundamentally corrupt data sets. Unless a solution can be found to avoid the loss, then we must accept that comparisons of qualitative and especially quantitative analyses must be highly suspect. This talk does not to offer a solution, but attempts to make nannofossil workers aware of the problem and to stimulate interest in finding ways of solving it.

LATE PLIOCENE NANNOFOSSIL BIOEVENTS AND THEIR BIOSTRATIGRAPHIC AND PALEOCEANOGRAPHIC MEANINGS

Koji Kameo, Tokiyuki Sato, and Toshiaki Takayama

Tuesday, 9.15

Since many authors have been studied sequential changes of nannofossil assemblages, they have established nannofossil datums in the Quaternary sediments (Takayama and Sato, 1987; Raffi et al., 1993; Wei, 1993, etc.). Quaternary nannofossil datums defined by them are mainly composed of the first and the last occurrences of some taxa, especially included into the family Prinsiaceae. Some authors have also investigated sequential biometrical changes of their taxa and shown gradual changes of their size (Matsuoka and Okada, 1989, etc.). As a result of them, it has been clarified the datums of *Gephyrocapsa* and *Reticulofenestra* specimens are apparently represented by some appearances and disappearances of their larger specimens. Sato et al. (1991) and Kameo et al. (1995) indicated new late Pliocene biohorizons, may be composed of similar patterns of *Reticulofenestra* size variations observed in the Quaternary, and possibility of their global correlation. However, detailed size variations of them have not been shown yet.

In this study, detailed size variations of the reticulofenestrids coccoliths in the upper Pliocene sediments were studied in the North Atlantic DSDP cores, Holes 606, 607 and 610A. As a result of this study, a characteristic size fluctuation of *Reticulofenestra* specimens and remarkable occurrences of other reticulofenestrids coccoliths were found in the upper Pliocene sediments. The size variation of *Reticulofenestra* specimens during the late Pliocene is characterized by four cycles of a size fluctuation which becomes gradually larger upward and abruptly smaller at each biohorizon. Small *Gephyrocapsa* and *Dictyococcites* specimens were found in the limited intervals in the upper Pliocene sediments. It is clear that the *Reticulofenestra* size variation and the abundant occurrence of small *Gephyrocapsa* are almost synchronous. Furthermore, they can be almost traceable into the upper Pliocene sediments not only in the North Atlantic but also in other Oceans.

The biohorizons which were made clear by the biometrical study of the reticulofenestrids coccoliths, the correlation with other areas and their paleoceanographic meanings will be discussed.

CALCAREOUS DINOFLAGELLATES OF THE EQUATORIAL ATLANTIC OCEAN

Beate Kerntopf

Monday, 14.25 and poster session

In the equatorial Atlantic Ocean, about 25-55% of the shelled phytoplankton organisms are armoured dinoflagellates. Data from the tropical fully oceanic plankton communities confirmed that only 8-9% of the thecate dinoflagellate species produce cysts. The cyst assemblages are heavily dominated by calcareous forms. Few species are found in great abundances.

Calcareous dinoflagellate resting cysts (calcareous dinocysts) add up to 2-15% of the shelled phytoplankton. Data from several plankton surveys (pers. comm. Janofske and Hoell), including the present study, suggest a strong temperature dependence of some calcareous dinocysts. *"Sphaerodinella" albatrosiana* (Kamptner) and *"S." tuberosa* (Kamptner) can be regarded as "warm water cysts". Their planktonic distribution is restricted to low-latitude waters and the geographical areas defined by the 24°C SST isotherm. In waters colder than 24°C no such calcareous warm water cysts were recorded.

The vegetative, coccoid *Thoracosphaera heimii* (Lohmann) Kamptner is a more or less cosmopolitan species which is found frequently to abundantly in the plankton within a wide temperature and salinity range. In the waters around the Canary Isles the relative amount of *T. heimii*-shells reached a maximum of 12% of the phytoplankton.

The calcareous dinocysts and *T. heimii*-shells are readily preserved in the sediments. Sub-Recent multi-corer sediment samples of the tropical East Atlantic were investigated for calcareous dinoflagellates. The presence or absence of the calcareous warm water cysts in the sediments can be used as an indicator for glacial SST shifts below the "critical" 24°C-limit. And, the relative abundances of *T. heimii*-shells can give further information on dinoflagellate paleoproductivity. The distribution of species and assemblages in the sediment, compared with conditions in the directly overlying water column, give evidence of lateral transport.

The species association in the sediments offshore NW Africa is overwhelmingly dominated by *T. heimii*-shells (relative amount 80-90%); the calcareous dinocysts are present but only in small amounts (max. 15%). In the sediments of the Guinea Basin, however, the species association is dominated by the warm water cysts *"S." albatrosiana* (50-55%) and *"S." tuberosa* (12-20%). *T. heimii*-shells amount to 20-40%. Offshore NW Africa the specimen densities of *T. heimii*-shells are approximately three times as high as in the Guinea Basin, suggesting a productivity three times as high. And, there are only minor shifts in the species association downcore to the LGM, suggesting higher SST values than most foraminiferal SST estimates.

Thus, the distribution pattern of calcareous dinocysts can be used as a further paleoclimatic indicator, whereas the fossil vegetative, coccoid *T. heimii*-shells potentially offer a direct record of dinophyceae primary productivity. Furthermore, the dinoflagellate fossil record could be re-evaluated on the basis of calcareous dinocysts and *T. heimii*-shell remains, at least from the Tertiary onward.

CALCAREOUS DINOFLAGELLATE CYSTS OF THE LATE ALBIAN AND THEIR ENVIRONMENTAL DEDUCTIONS (BOREHOLE KIRCHRODE 1/91, GERMANY)

Helmut Keupp
Poster session

The Late Albian flora of calcareous dinoflagellates recorded from the 240 m long borehole Kirchrode 1/91 (Hannover, Lower Saxonia) contains 37 morphotaxa (cf. Keupp 1995). There are following structural basic types represented:

I. With consequente radial orientation of wall-crystals (Orthopithonelloideae Keupp 1987): 8 Morphospecies

II. With uniquely oblique orientation of wall-crystals (Pithonelloideae (Keupp 1987): 3 Morphospecies (cf. Keupp and Kienel 1994)

III. With irregularly orientated wall-crystals (Obliquipithonelloideae Keupp 1987): 26 Morphospecies

Two species are dominant: *Pithonella sphaerica* and *Obliquipithonella patriciagreeleyae* type A indicative of warmwater conditions (greenhouse climate) of a rather distal sedimentation area (open shelf situation: Villain 1981).

The assemblages react in its percentage composition to phases which are characterized by increasing water movements particularly during transgressions. These factor enabled also Mediterranean taxa to reach the Lower Saxonian Basin via the Wessex Basin from the west. Therefore, the transgressive periods of the borehole (240-150 m, 90-70 m, and 25-5 m) are characterized by:

- A relatively high diversity (up to 18 morphospecies/ sample) due to taphonomical mixture of the more-or-less autochthonous neritic cysts (benthic cysts with thick, douple-layered calcareous walls) and rather pelagic cysts (normally with thin, single-layered calcareous walls) including also few Tethyan elements (e.g.: *Bicarinellum cristatum*).

- Acmes, particularly of the small (23-30 μm) cysts of *Obliquipithonella albiensis* Keupp and Kowalski 1992. Its morphology resembles closely the Modern vegetative coccoid bodies of *Thoracosphaera heimii*. *Obliquipithonella albiensis* is interpreted here to represent rather planktonic cysts of a pelagic environment than vegetative stages.

The interval of the borehole between 165 and 40 m exhibits probable orbital forced cyclicity based on geochemical, geophysical and lithological data (cf. BCCP-Group 1994). The prominent 12 m cycles correspond possibly to eccentricity (100 000 years). The additional subordinate periodic cycles of 8 m, 4,2 m, 3,4 m and 1,7 m corresponds roughly to the Milankowitch frequency band. Some species of calcareous dinoflagellate cysts react significantly to the 12 m-cyclicity (a more detailed view is not possible due to every 5 m distance of investigated samples) by changing of sizes (smaller during carbonate rich phases, larger during phases of pure carbonate content) suggest a cyclicity controlled by productivity.

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DEVELOPMENT OF CALCAREOUS DINOFLAGELLATE CYSTS (CALCIODINELLACEAE DEFLANDRE, 1947) AT THE CRETACEOUS - TERTIARY BOUNDARY (NE GERMANY, DENMARK)

Ulrike Kienel
Poster session

Topics: calcareous nannofossils, calcareous dinoflagellate cysts, K/T boundary, Germany, Denmark

Samples originating from core Nennhausen 2/63 (Westbrandenburg, East Germany) have been investigated for their content in calcareous nannofossils and calcareous dinoflagellate cysts. The profile includes late early Maastrichtian (CC24) sensu Sissingh, 1977) to lowermost Danian (NP2 sensu Martini, 1971) sediments with an uncommonly complete record of the K/T boundary interval for the near shore environment of this area, caused by its location in the rim syncline of a salt diapir. The hiatus at the K/T boundary comprises the uppermost part of CC26 (Sissingh, 1977) and the lower part of the *Biantholithus sparsus* zone (van Heck and Prins, 1987).

The missing interval is, according to the correlation of the nannofossil data, completely covered by the Danish profiles (Stevns Klint, Nye Kløv, Kjølby Gaard, Bulbjerg and Vokslev). This fact allows characterization of the development of calcareous dinoflagellate cysts around the K/T boundary.

The taxonomical study of the latter results in the description of numerous new genera and species. The morphospecies *Obliquipithonella operculata*, *Operculodinella hydria* and *Od. costata* are recognized as belonging to one "form-group" sensu Keupp et al. (1991) with gradual transition. By including *Obliquipithonella operculata*, known by nannofossil workers as "*Thoracosphaera" operculata*, within a "form-group" of increasing paratabulation its long debated cyst nature can be confirmed.

Within the development of the calcareous dinoflagellate cysts 4 more or less artificial stages can be recognized following the ecological stress at the K/T boundary. This stages allow to infer a similar development within the calcareous dinoflagellate cyst assemblages to that known from the calcareous nannofossils. It is characterized (besides the persisting forms without any reactions) by the "surviving" of "stress"-forms, showing bloom like abundances (*Lentodinella danica* and *Obliquipithonella operculata*), from which later the new morphospecies seem to have derived.

A 300 KYRS CALCAREOUS PLANKTON RECORD OF THE EQUATORIAL SOUTH ATLANTIC: RECONSTRUCTIONS OF SURFACE WATER PRODUCTIVITY AND BOTTOM WATER DISSOLUTION CYCLES

H. Kinkel, N. Dittert, K.H. Baumann

Poster session

Pelagic carbonate fluxes from surface waters to the sediment and carbonate dissolution in the water column and at the sediment water interface play an important role in the carbon cycle of the oceans and the atmosphere. In the Late Quaternary fundamental changes occured in the carbon cycle, which are documented in alternating sedimentation of calcium carbonate in the deep sea; they are explained as cycles of productivity, dilution, dissolution, and diagenesis. While productivity responds directly to changing climates via the wind driven equatorial upwelling system in the precessional band (23 kyr) the preservation/dissolution is more indirectly controlled by the production rate of North Atlantic Deep Water (NADW) in the eccentricity band (100kyr).

The synoptic and quantitative record of planktonic foraminifera and coccolith assemblages in glacial/interglacial sediment sequences of the Late Quaternary South Atlantic follows an synecological analysis and interpretation.

The investigation of carbonate tests according to the partial respectively the complete dissolution refers to the surrounding water masses. Methods are the conventional fragment index, dissolution indices (REM), and the comparison between heavy dissoluted foraminifera and the poor preservated coccoliths.

The changes in the surface water masses are well documented in the species composition of planktonic foraminifera and coccolith assemblages. The changing bottom water distribution is documented by changing carbonate contents and accumulation rates, and conventional fragmentation and dissolution indices of planktonic foraminifera. Dissolution indices for coccoliths, however, are difficult to establish, but, the general trend in the preservation of the whole coccolith assemblage can be correlated to the dissolution indices of planktonic foraminifera.

THE MIOCENE BLUE CLAY FORMATION OF THE MALTESE ISLANDS: SEQUENCE - STRATIGRAPHIC AND PALEOCEANOGRAPHIC IMPLICATIONS BASED ON CALCAREOUS NANNOFOSSIL STRATIGRAPHY AND CALCAREOUS DINOFLAGELLATE CYSTS

U. Kienel, U. Rehfeld, S. Bellas and R. Kohring

Poster session

Topics: Calcareous nannofossils, calcareous dinoflagellate cysts, paleooceanography, sequence stratigraphy, Miocene, Blue Clay, Maltese Islands

Samples from the Middle to Upper Miocene strata of the Maltese Islands have been investigated for their content in calcareous nannofossils and calcareous dinoflagellate cysts. The sediments under consideration have been deposited on a submerged carbonate platform; they comprise the upper part of the Upper Globigerina Limestone, the Blue Clay and the lowermost Greensand Formation. They cover the time interval between the NN5 zone (Langhian) to NN11b subzone (Messinian), with two conspicuous biostratigraphical hiatuses in between.

The *Catinaster coalitus* zone (NN8 sensu Martini and Worsley, 1970) has been proved for the first time on the Maltese Islands. The occurrence of undifferentiated *Catinaster*-like individuals interpreted as early forms of *Catinaster calyculus* and small *Catinaster* sp., are considered as indicators of the upper part of the *C. coalitus* zone appearing below the FO of *Discoaster hamatus* NN9 zone). The nannofossil assemblage from the Greensand Formation exhibits strong reworking reflected by the occurrence of *C. floridanus* and *C. nitescens*. The presence of *Discoaster icarus, D. pansus, D. surculus* as well as *A. primus* provides strong evidence that the base of the Greensand belongs into the NN11b subzone.

Few calcareous dinoflagellate cysts have been recorded. The dominating species, *Orthopithonella granifera* exhibits a great variability in crystal size and overgrowth pattern. Additionally, the stratigraphic range of the obliquipithonelloid species *Bicarinellum tricarinelloides* (up to now known from Pleistocene to Recent), can be traced back to the Serravallian.

In general, the recorded calcareous dinoflagellate cysts are mainly dominated by orthopithonelloid and fuettererelloid species, indicating open marine, pelagic conditions.

The first hiatus, within the upper part of the Blue Clay Formation, comprises about 100 ky (top NN7 to upper part NN8 - uppermost Serravallian). It corresponds to the second order Sequence Boundary at the transition from supercycles TB2 to TB3 according to the global sea level chart of Haq et al. (1988). It comprises the time of the NH4 deep sea-hiatus related to increased ice build-up in the Antarctic region. After a very short time of reestablished sedimentation (about 100 ky) a second hiatus follows immediately on top of the NN8 zone (Serravallian/Tortonian boundary). It lasted as long as 3.7-3.9 my to the NN11b subzone; thus the whole time of the Tortonian and probably the lower part of the Messinian elapsed between the deposition of the Blue Clay and Greensand Formation. This time span comprises the narrowly spaced deep sea-hiatuses NH4 to NH6. A cooling of surface waters on the Maltese Platform is partially substantiated by the calcareous nannofossil assemblages. An earlier cooling event may be sketched by the gradual transition from the Globigerina Limestone carbonate deposits to the siliciclastic sediments of the Blue Clay Formation.

CALCAREOUS NANNOPLANKTON RESPONSE TO TERMINATION II AND HEINRICH EVENT (140-110 KA BP) IN THE NE ATLANTIC

Anna Lotoskaya and Patrizia Ziveri

Poster session

First results on carbonate fluxes in the NE Atlantic during the last interglacial have been obtained from the pelagic piston-core T90-9P (45°17.5' N; 25°41.3' W) raised from the Mid-Atlantic Ridge. The last interglacial (Termination II, oxygen isotope stage 5e) covers the time interval between 140 and 110 ka BP, and is considered to be the strongest warming during the Quaternary. Quantitative analyses of calcareous nannofossils have been carried out in order to know coccolith-paleo-fluxe during the previous deglaciation. Each sample was first wet sieved over 32 µm mesh using 2 liters of tap water; then the finer fraction has been processed with solutions of $Na_4P_2O_7$ and H_2O_2 to get equal distribution of the material on the filter. Afterwards 0.15 ml of obtained solution has been filtered with a Millipore filter (47 mm diameter, 0.45 µm pore size). Proportions of the filter have been used for quantitative polarised microscope and SEM study. Fraction >32 µm in size has been checked semiquantitatively with a binocular microscope.

A count of 350-400 specimens of coccoliths were identified and quantified (plus about 100 specimens of rare species) in the fine fraction using a polarized light microscope by analyzing a defined area of each filter. Terrigenous material, detrital carbonate and foram fragments were taken into account. The counted particles have been extrapolated for the entire sample in order to calculate the number of coccoliths per gram of fine fraction, relative abundances of different species in the coccolith assemblage and the role of non-coccolith material in the sediments. Total and fine fraction carbonate content, and oxygen isotope stratigraphy are also investigated.

The results show that calcareous nannoplankton appear to be the main carbonate producers in the NE Atlantic deep sea. Fluctuations in carbonate content (total and fine fraction), percentage of mineral particles (mostly quartz) and detrital carbonate in both fractions, coccolith flux and distribution of different nannoplankton species show the presence of a Heinrich layer composed of debris, probably released during the melting of massive influxes of icebergs into the North Atlantic. This event coincides with the period of the strongest temperature changes in the sediment record. Distribution patterns of *Florisphaera profunda* increasing in abundance during the Heinrich event, support the idea of this species being an indicator of sea-water turbidity, as it was recently shown for the Quaternary of the Pacific (Ahagon et al., 1993). It is known that *F. profunda* lives exclusively in the lower euphotic zone (Okada and Honjo, 1973), so reductions in light caused by iceberg discharges didn't influence its abundance, whereas the production of all other species was diminished.

The middle part of the studied interval corresponding to the Termination itself, is characterised by appearance of the tropical water species *Umbellosphaera tenuis* and *U. irregularis* (McIntyre and Be, 1967), and significant decrease in subarctic species *Coccolithus pelagicus* (McIntyre and Bé, 1967) and *Helicosphaera carteri* which had been described as a species preferring cold waters (Bartolini, 1970). *Calcidiscus leptoporus* and *Gephyrocapsa oceanica* distribution don't show any fluctuations directly related to studied parameters. The "small placoliths", including small-medium size *Gephyrocapsa* and subordinated *Emiliania huxleyi*, make up to 94% of the coccolith assemblage. The taxonomic identification of this group will be studied separately with the SEM.

Estimated absolute numbers of coccoliths per gram of sediment vary from 7x10 8 in the Heinrich layer to 15x10 9 liths/g sediment in the coccolith ooze. These results don't show good correlation with carbonate content variations due to different methods of sample preparation in the early stages. But it's possible to state that decreases in coccolith and planktonic foraminifera remains are not high, and are caused mostly by dilution, rapid debris accumulation, and partly by reduction in plankton productivity (as a result of light obstruction due to spread of icebergs).

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CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHIC ANALYSIS AS A TOOL FOR THE STUDY OF DISCONTINUITY SURFACES IN THE CRETACEOUS OF THE TRENTO PLATEAU (SOUTHERN ALPINE, ITALY)

Francesca Lozar

Wednesday, 11.35

Several discontinuity surfaces recognized in the Cretaceous sequence of the Southern Alps are in study at the Dipartimento di Scienze della Terra in Torino.

During the Cretaceous the Trento Plateau experienced a mainly pelagic carbonatic sedimentation, apparently very continuous and without major gaps. The Cretaceous sediments are represented by Biancone, Scaglia Variegata and Scaglia Rossa Formations.

In the pelagic environment represented by the formations listed above, the tectonic and/or paleoceanographic events caused several discontinuity surfaces (at the Cretaceous/Tertiary boundary, during the Campanian, during the Aptian-Albian). This preliminary study deals with the discontinuity located in the Aptian-Albian time interval, marked by sharp lithologic change and underlined by a hard ground surface, and/or by burrowings or sometimes without sedimentological evidence.

In the Monte Altissimo and Molveno areas this discontinuity surface occurs at the boundary between Biancone and Scaglia Variegata Formations p. From the lithologic point of view, this surface is, in general, characterized by: 1) a flat surface on which lays a thin chaotic layer (debris flow), with rounded lithoclasts belonging to the underlying Biancone; 2) deep burrowing of the underlying limestones; the burrows infill is a red micritic limestone containing planktonic foraminifera; 3) a glauconitic mineralization wrapping the clasts and the chert nodules in the chaotic level, sometimes (Lenzima) covering the entire surface.

The detailed biostratigraphic analysis, performed with calcareous nannofossils and planktonic foraminifera, allowed to infer the age of the topmost Biancone strata, of the burrow infills and of the overlying Scaglia Variegata. These are: Early Aptian for the top of the Biancone, Late Aptian for the burrow infills and Late Albian for the overlying Scaglia Variegata. This clearly shows that different sedimentological evidences (hard ground, debris flow and burrowing at Monte Altissimo, debris flow at Molveno and hard ground at Lenzim), in fact represent the same time gap in the sedimentary record, thus confirming that major discontinuity can have the same genetic significance.

PLEISTOCENE CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF SITE 577 LEG 86, NORTHWESTERN PACIFIC OCEAN

Patrizia Maiorano, Maria Marino and Simonetta Monechi

Poster session

A detailed biostratigraphic study has been performed on Pleistocene sediments of Site 577 of the Shatsky Rise. Previous studies (Monechi, 1985; Monechi et al., 1985) evidenced the good recovery by hydraulic-piston cores and the fairly complete sedimentary sequence in both holes (Hole 577 and Hole 577A).

Semiquantitative analyses on abundant and well preserved calcareous nannofossil assemblages has allowed recognize a succession of events that improve the resolution of the Pleistocene interval (between the LO *Discoaster brouweri* and FO *Emiliania huxleyi*): LO *D. brouweri*, FO *Gephyrocapsa caribbeanica*, LO *Calcidiscus macintyrei*, FO *G. oceanica* s.l. (*sensu* Rio, 1982), FO large *Gephyrocapsa* (*sensu* Rio, 1982), LO large *Gephyrocapsa*, bottom temporary disappearance *G. oceanica* s.l., FO *Reticulofenestra asanoi*, FO *G. parallela* (*Gephyrocapsa* sp.3, sensu Rio, 1982), re-occurrence *G. oceanica* s.l., bottom temporary disappearance *G. parallela*, FO *Helicosphaera inversa*, re-occurrence *G. parallela*, LO *H. inversa*, FO *E. huxleyi*.

Many of the recognized events have a world-wide distribution and have been used to define the Zones of

Okada and Bukry (1980), Rio et al. (1990) for the Mediterranean and Sato et al. (1991) for the Arabian Sea. Few supplementary events such as the *G. caribbeanica* and *Dictyococccites productus* acme in the upper part of MNN 19f have been observed.

The succession of the nannofossil events and their correlation with magnetostratigraphy (Bleil, 1985) is mostly in agreement with the literature data. A major problem regards the LO of *H. sellii*; in both the holes, this event is recorded in the latest Pliocene shortly below the Olduvai subchron, confirming the already known diachroneity of the LO of the species, although the event has been generally recorded above the Olduvai subchrone. The FO of *R. asanoi* occurs below the Jaramillo subchrone, according to Sato et al. (1991), Matzuoka and Okada (1989); the LO of *R. asanoi* occurs at the top of Jaramillo subchrone and this is not in agreement with the calibration of Matzuoka and Okada (1989). The FO of *G. parallela* occurs at the top of Jaramillo, according to Takayama and Sato (1987), Sato et al. (1991) and Castradori (1993).

Quantitative nannofossil biostratigraphic investigations are in progress in order to define more precisely the succession of all the recognized events and to give further details about the beginning and the end of acme of *G. caribbeanica* and *Dictyococcites productus*.

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CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF EARLY - MIDDLE PLEISTOCENE TERRIGENOUS SEDIMENTS (SOUTHERN ITALY)

Maria Marino

Poster session

An early-middle Pleistocene succession of terrigenous sediments, 400 metres thick, outcrops west of Montalbano Ionico (Southern Apennine Foredeep, Italy). The reconstructed section is mainly made up of marine silty clays interbedded by nine thin volcaniclastic layers showing undersatured alkaline chemistry (Ciaranfi et al., 1994; Ciaranfi et al., in prep.). Preliminary paleomagnetic investigations pointed out the bottom and the top of Jaramillo subchrone and the Matuyama-Brunhes boundary (Channell, pers. com., in Ciaranfi et al., 1994).

The calcareous nannofossils quantitative biostratigraphy led to the recognition the large *Gephyrocapsa*, small *Gephyrocapsa* and *Pseudoemiliania lacunosa* Zone, according to the scheme of Rio et al. (1990). Particulary, despite of "diluted" nannofossil assemblages and the rarity of meaningful markers, several events were recognized: last occurrence of large *Gephyrocapsa*, botton acme of *Reticulofenestra asanoi*, top acme of *R. asanoi*, end acme of small *Gephyrocapsa*, first occurrence of *Gephyrocapsa parallela (Gephyrocapsa* sp.3, sensu Rio, 1982), temporary disappearance of *G. parallela* and re-entry of this species. The biostratigaphic data are in agreement with preliminary paleomagnetic results, according to biochronology by Castradori (1992; 1993): the top of Jaramillo occurs just below the FO of *G. parallela* (top of small *Gephyrocapsa* Zone) and the Matuyama-Brunhes boundary occurs close to the re-entry of *G. parallela*.

Moreover, biostratigraphic work in progress seems to show peculiar abundance patterns of some "minor" species (*Syracosphaera* spp., *Rhabdosphaera* spp.) with respect to sapropelitic (?) interval characterizing the upper part of Montalbano Ionico succession.

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CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE LATE CRETACEOUS - EARLY TERTIARY OF WADI FEIRAN AND GEBEL QABELIAT, SOUTH WESTERN SINAI, EGYPT

Akhmal M. Marzouk and Mohamed K. Abou-El-Enein

Tuesday, 12.00

The biostratigraphic study of the Late Cretaceous - Early Tertiary rocks of Wadi Feiran and Gebel Qabeliat, South western Sinai has revealed the presence of several calcareous nannofossils biozones. A Cretaceous/Tertiary faunal break is present in the two studied sections, but the magnitude of the hiatus is greater to the south at Gebel Qabeliat. This boundary here occurs somewhere at the top of the Sudr Chalk at W. Feiran section and in the lowermost part of the Esna Shale at G. Qabeliat section. No faunal break was observed within the Esna Shale of the Paleocene/ Eocene boundary in the studied sections.

CALCAREOUS NANNOFOSSILS BIOSTRATIGRAPHY OF THE FUENTELSAZ (SPAIN) AND FIUMINATA (ITALY) SECTIONS: LATE TOARCIAN - EARLY AALENIAN

Emanuela Mattioli and Nicola Perilli

Poster session

Topics: late Toarcian-early Aalenian, Spain, Italy, Biostratigraphy

Semiquantitative and quantitative analyses have been carried out on late Toarcian- early Aalenian fairly regular alternation of limestone and marlstone deposits of the Castilian Branch (Iberian Range) and of the Umbria-Marche basin (Central Apennine). The Fuentelsaz section is an exceptionally thick and uniform succession which has been recently proposed as a possible stratotype for the base of the Aalenian stage, since it is characterized by a very rich, well-preserved and complete succession of ammonite assemblages. In this section, detailed biostratigraphical (brachiopods, foraminifers and ostracods) and sedimentological studies have been also performed (1 and references therein). Likewise, the Fiuminata section is a continuous thick and superbly exposed late Toarcian-early Aalenian succession characterized by well-preserved microfossil assemblages. Here also, detailed biostratigraphical (foraminifers), sedimentological and magnetostratigraphical studies have been carried out (2, 3 and references therein). At present, in the Tethyan areas several data on the Domerian-Toarcian and on the Aalenian-Bajocian time intervals are available in the literature and the nanno-biostratigraphy resolution is quite high. On the other hand, published works on the Toarcian-Aalenian boundary are few and further investigations are required to detect a good and reliable sequence of events. Aim of this work is to investigate the late Toarcian-early Aalenian interval in order to recognize the sequence of major and minor calcareous nannofossil events, and to compare the composition of the assemblages of the two sections. The Fuentelsaz section is located 170 km NE of Madrid (NE of the Guadalajara province). It is 32 m thick and encompasses the Turmiel (4) and the Chelva Fms (5). The Turmiel Fm. consists of a rhythmic alternance between marlstones and limestones, which are represented by mudstones and, subordinately, bioclastic wackestones, sedimented on a platform or external ramp environment (6, 7). The lower part of the Chelva Fm. is made up of limestones, mainly represented by wackestones and rare packstones, with intercalations of marlstones, and it is sedimented on an external platform with very little influx of fine clastic material (6). Fine shelled bivalves, fragments of echinoderms and gastropods have been found in some levels, whereas bioturbation is frequent.

The Fiuminata section outcrops 190 km NE of Roma (Eastern Umbria) and it consists of 30 m thick of the Calcari e Marne a Posidonia Unit (2 and references therein). At Fiuminata, a regular alternation of light brown marly limestones and marlstones crops out and represents a good example of a dm-scale pelagic rhythmic sedimentation. The marly limestones are locally bioturbated and nodular limestones are present. Posidonia shells are very common, both in the marly and in the carbonate lithotypes (2, 3). The succession, referable to an active subsiding furrow (8), is characterized by a considerable amount of clay, if compared to other Umbria-Marche sections. This study is focused on more than 200 samples, closely collected from different lithotypes. A total of 250-350 specimens were counted in each smear slide, under a polarizing light microscope at about 1000X magnification. Six classes of total and specific abundance and four classes of preservation have been distinguished. Preliminary data from the studied sections reveal an overall similar assemblage composition. In the late Toarcian, radiating placoliths, *Biscutum* spp. and *Discorhabdus* spp. are very common; in particular, the genus *Biscutum* shows a great diversity. *Calyculaceae* are common and mainly represented by *Carinolithus superbus;* however, *Calyculus* spp. shows a decreasing trend, which is a prelude to the disappearance of the smaller form. *Watznaueriaceae* are common, well-diversified and mainly represented by species of the genus *Lotharingius; Watznaueria* sp. 1 is the first species of the genus to appear, and it is already present from the base of the sections. The Toarcian-Aalenian transition is characterized by the first occurrence of *Watznaueria contracta* and *Hexalithus magharensis,* and by a light decrease of the genera *Lotharingius* and *Carinolithus.* Some Early Liassic specimens are still present: protoliths (*Mitrolithus* spp.) whith sporadic occurrences, whereas loxoliths (*Crepidolithus* spp., *Tubirhabdus patulus*) with a background noise. *Schizosphaerella* spp. is constantly present in great abundance.

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CALCAREOUS NANNOFOSSIL ASSEMBLAGES IN THE CENOMANIAN AND TURONIAN DEPOSITS IN LITHUANIA

Romualda Mertiniene

The deposits of the Cenomanian and Turonian are widely spread in Lithuania. They are represented by the terrigene sandy sediments in the western part and by the carbonaceous - the marl and the chalk - in the east side of the basin. The intercalations of the sand are frequent in their lower part.

The nannoplankton from the deposits was investigated. Rare and badly preserved nannofossils *Watznaueria* sp., *Prediscosphaera* sp., *Manivitella* sp. were found in green carbonaceous sands (Lower-Middle Cenomanian). The growth of the nannoplankton is observed when the quantity of the carbonate increases in the deposits. The nannoplankton is abundant and well preserved in the green porous limestone (Upper Cenomanian): *Microrhabdulus decoratus, Gartnerago oliquum, Watznaueria barnesae, Eiffellithus turriseiffeli, Prediscosphaera cretacea, Broinsonia enormis, Zygodiscus bussoni, Z. diplogrammus, Cretorhabdus conicus* etc. (there are 22 species in all).

The taxonomical composition of the assemblage does not change in the argillaceous chalk, which superpose over the limestone. There only the increase of the quantity of nannofossils is observed. The chalk of the Upper Cenomanian pass to the Lower Turonian light grey chalk without any visible change. The assemblage of the nannofossils is rich. The bed is marked by the first appearance of *Quadrum pyramidum*. There is a lot of *Watznaueria barnesae, Prediscosphaera cretacea, Zygodiscus diplogrammes, Z. variatus, Gartnerago obliquum, Microrhabdulus decoratus, Biscutum* sp., *Lithraphidites carniolensis, Cretorhabdus conicus, Eiffellithus turriseiffeli* etc. (there are 26 species in all).

Kamptnerius magnificus appears in the middle of the Lower Turonian. The nannoplankton assemblage is similar to that from the lower part of the grey chalk (there are 34 species in all).

The top of the Upper Turonian is indicated by the first appearance of *Lucianorhabdus maleformis*. The assemblage is composed by *Kamptnerius magnificus, Cretarhabdus surrirelus, Lithastrinus floralis, Eiffellithus turriseiffeli, Quadrum pyramidum, Watznaueria barnesae* etc. (there are 35 species in all).

The analysis of the assemblages of the nannoplankton shows that there was a close connection between the flora of the Late Cenomanian and the Turonian.

NANNOPLANKTON ZONES IN THE VOLCANIC TUFFS OF THE TRANSYLVANIAN BASIN (MIOCENE)

Nicolae Mészáros

Tuesday, 9.40

The Transylvanian Basin constitutes a Tertiary intra-mountain basin lying within the internal zone of the Carpathian Mountains. The complex basin history commenced with the emplacement of internal nappes of the Carpathians during the Albian continental collision. The nappes contain allochtonous metamorphic basement and Late Jurassic calc-alkaline volcanics overlain by late Jurassic-Early Cretaceous platform carbonates and deeper marine clastics. The overlying sediment, in an overall "piggy-back" setting reflects the complex interaction of the Tethyan sea level variations with the active compressional regime of the evolving Carpathian Mountain chain.

Four major tectonic phases subdivide the Transylvanian basin fill into distinct tectonic stratigraphic units: Late Cretaceous-Paleocene (Laramian), Eocene (Laramian reactivation), Early Miocene (Old Styrian) and Mid-Miocene (New Styrian). Following the Albian continental collision, post-tectonic Senonian clastics were deposited in a subsiding north-south trending basin, subsequently deformed and up-crusted during the Laramian phase. The overlying Early Eocene red bed sequence was also deposit in a subsiding north-south trending basin, and locally inverted in the Lutetian. This inversion created an emerged north-south ridge controlling the paleogeography and lateral extent of two subsequent Late Eocene marine transgressive events. In the Early Oligocene a regional drowning of the basin occurred and Rupelian black organic rich shales were deposit as a draping unit. In the overlying sequence, clastic input from the north-west was deposited as shallow marine sandstones in marginal parts of the basin whereas outer self marls was deposit in central parts of the basin.

The major reorganization of the Transylvanian Basin occurred in the Mid-Miocene (New Styrian phase), when the basin acquired its present configuration. This reorganization is linked with the emplacement of the east Carpathian nappes. Transgressive clastics, marls and tuffs were deposited, followed by deep marine salt layers. The basin fill history ends with the deposition of a rapidly subsiding Mid-Late Miocene brackish clastic sequence with many tuffs intercalations (Fig. 1).

The nannoplankton assemblages recorded in the marls of the Dej Tuffs are assigned to the zone NN5 (i.e. the zone with *Sphenolothus heteromorphus*). The Ocna Dejului Beds, which comprises the evaporites with gypsum and salt, belongs to the zone NN5 too.

The next level of volcanic tuffs is the Borsa-Apahida Tuffs, which contain assemblages of nannoplankton assigned to zone NN6. This level is followed by the H d reni Tuffs, which are correlated to the NN7 zone, and by the Ghiris Tuffs, which correspond to the NN8 zone. This level is followed by the S rm sel, the Urca Tuffs, and the Sincai Tuffs, which all are correlated to NN9 zone. It should be noted, that a precise dating of the deposits overlying the salt has been possible by the study of nannoplankton within the volcanic tuffs. The nannoplankton assemblages between the tuff layers contain huge amount of reworked Late Cretaceous and Paleogene forms, but only few Miocene specimens.

AGE			STRATIGRAPHICAL UNITES	Nannoplankton zones		Enviro-ment	Age Ma
				E.Martini	Okada and Bukry		
MIOCENE	Pannonian s.s.		BAZNA TUFFS			Brakish	9,4
	SARMATIAN s.s.	BESSARABIAN INF.	FELEAC FORMATION: ŞINCAI TUFFS (Band Rîciu) +++	NN 9	CN 7,a,b		
			URCA TUFFS +++	NN 9	CN 7,a,b		
			SĂRMAŞEL TUFFS +++ (Colina, Zau)	NN 9	CN 7,a,b		
		VOLHYNIAN	GHIRIŞ TUFFS (Rotbav,Grînari) +++	NN 8	CN 6		11,8
			HĂDĂRENI TUFFS +++	NN 7	CN 5b	Deeper marine	
	BADENIAN	KOSSOVIAN	(Băiţa, Cara, Ocna Mureş) +++				
			ICLOD BEDS				
			BORŞA-APAHIDA TUFFS +++ (Iclod, Buneşti)	NN6	CN 5a		13,6
		WIELICIAN	OCNA DEJULUI BEDS (Salt, Gypsum)	NN5	CN 3,4	Lagonal evaporites	
		MORAVIAN	DEJ TUFFS +++ (Ciceu-Giurgeşti Formation, Podeni limestone)	NN5	CN 3,4	Outer shelf	16.6

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Nicolae Mészáros

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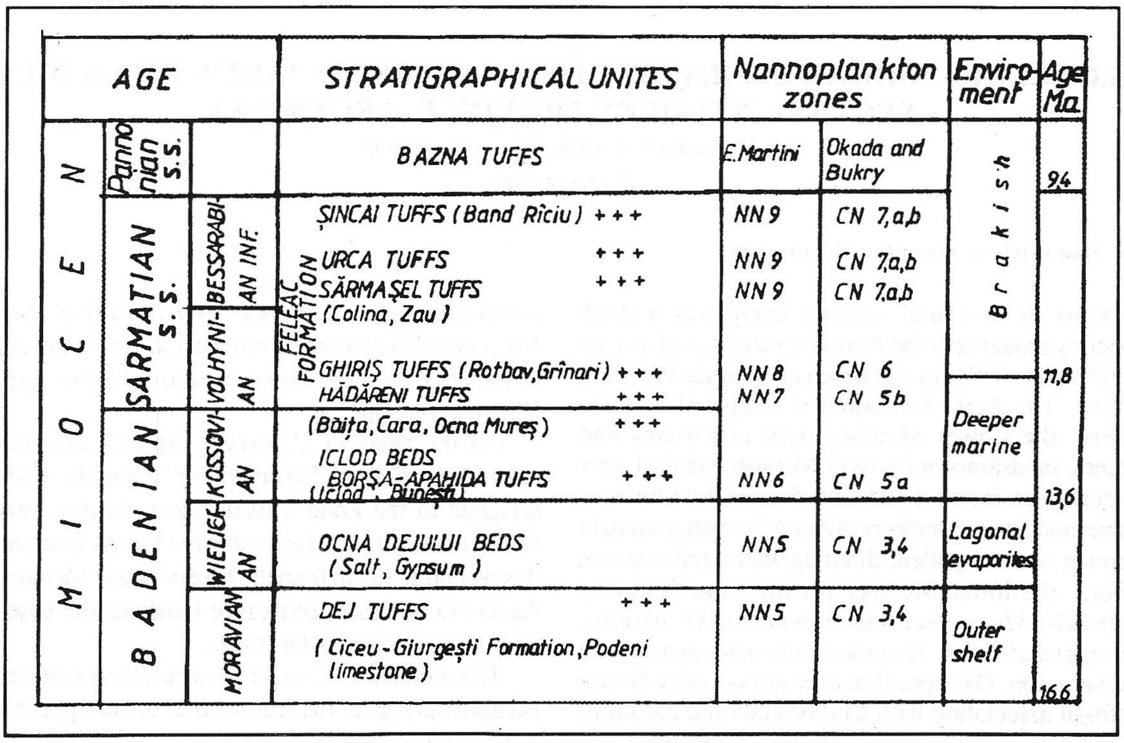
The Transylvanian Basin constitutes a Tertiary intra-mountain basin lying within the internal zone of the Carpathian Mountains. The complex basin history commenced with the emplacement of internal nappes of the Carpathians during the Albian continental collision. The nappes contain allochtonous metamorphic basement and Late Jurassic calc-alkaline volcanics overlain by late Jurassic-Early Cretaceous platform carbonates and deeper marine clastics. The overlying sediment, in an overall "piggy-back" setting reflects the complex interaction of the Tethyan sea level variations with the active compressional regime of the evolving Carpathian Mountain chain.

Four major tectonic phases subdivide the Transylvanian basin fill into distinct tectonic stratigraphic units: Late Cretaceous-Paleocene (Laramian), Eocene (Laramian reactivation), Early Miocene (Old Styrian) and Mid-Miocene (New Styrian). Following the Albian continental collision, post-tectonic Senonian clastics were deposited in a subsiding north-south trending basin, subsequently deformed and up-crusted during the Laramian phase. The overlying Early Eocene red bed sequence was also deposit in a subsiding north-south trending basin, and locally inverted in the Lutetian. This inversion created an emerged north-south ridge controlling the paleogeography and lateral extent of two subsequent Late Eocene marine transgressive events. In the Early Oligocene a regional drowning of the basin occurred and Rupelian black organic rich shales were deposit as a draping unit. In the overlying sequence, clastic input from the north-west was deposited as shallow marine sandstones in marginal parts of the basin whereas outer self marls was deposit in central parts of the basin.

The major reorganization of the Transylvanian Basin occurred in the Mid-Miocene (New Styrian phase), when the basin acquired its present configuration. This reorganization is linked with the emplacement of the east Carpathian nappes. Transgressive clastics, marls and tuffs were deposited, followed by deep marine salt layers. The basin fill history ends with the deposition of a rapidly subsiding Mid-Late Miocene brackish clastic sequence with many tuffs intercalations (Fig. 1).

The nannoplankton assemblages recorded in the marls of the Dej Tuffs are assigned to the zone NN5 (i.e. the zone with *Sphenolothus heteromorphus*). The Ocna Dejului Beds, which comprises the evaporites with gypsum and salt, belongs to the zone NN5 too.

The next level of volcanic tuffs is the Borsa-Apahida Tuffs, which contain assemblages of nannoplankton assigned to zone NN6. This level is followed by the H d reni Tuffs, which are correlated to the NN7 zone, and by the Ghiris Tuffs, which correspond to the NN8 zone. This level is followed by the S rm sel, the Urca Tuffs, and the Sincai Tuffs, which all are correlated to NN9 zone. It should be noted, that a precise dating of the deposits overlying the salt has been possible by the study of nannoplankton within the volcanic tuffs. The nannoplankton assemblages between the tuff layers contain huge amount of reworked Late Cretaceous and Paleogene forms, but only few Miocene specimens.



HIGH RESOLUTION BIOSTRATIGRAPHY OF THE AMAZON FAN

Naja Mikkelsen

ODP Leg 155 drilled 17 sites on the Amazon deep-see fan, to study the evolution of the fan structure and to obtain high resolution paleoceanographic and paleoclimate records. The sites recorded not only glacial-interglacial climate cycles but also massive debris flows which is believed are triggered by changes in sea level. Biostratigraphy with additional evidence from magneto-, acoustic-, and stable isotope-stratigraphy have been used to reconstruct the stratigraphy of the Amazon Fan. Planktonic foraminifera and calcareous nannofossils provide useful age markers at approximately 6, 9, 11, 40, 85, 130, 260, and 460 ka. Despite drilling to depths of over 400 m no datable sediments were recovered older than 460 ka, this reflects the overall high Amazon Fan sedimentation rates. The sedimentation rates range from 5 cm/ka in the Holocene sections to over 250 cm/ka in parts of the last glacial. Sites 942 and 946 contain an exceptional Oxygen Isotope Stage 5 with an average sedimentation rate of 80 cm/ka. The Amazon Fan sediments thus provide the opportunity to obtain paleoceanographic records with the similar resolution to the ice cores.

The relative abundance of foraminifera and calcareous nannofossil have provided valuable information on surface water productivity and deep water corrositivity. All these records suggest that both the western equatorial Atlantic Ocean and the Amazon River were dramatically different during the last glacial compared with the late Holocene.

A STUDY OF THE FORAMINIFERAL AND CALCAREOUS NANNOPLANKTON ASSEMBLAGES OF CORE SAMPLES TAKEN FROM THE LAHAR-AFFECTED PORTIONS OF THE SOUTH CHINA SEA IN ZAMBALES PROVINCE, PHILIPPINES

Priscilla J. Militante-Matias and Marietta M. De Leon

Monday, 16.25

A two-year study of selected core samples collected from the South China Sea fronting the lahar-affected area of the Zambales province has been commenced. The purpose of the study is to determine the occurrence and distribution, and thus document the foraminiferal and calcareous nannoplankton assemblages present prior to, and during the Mount Pinatubo eruption in June 1991. Ten piston cores dredged by the Philippine Mines and Geosciences Bureau-Department of Environment and Natural Resources (MGB-DENR) during their 1992 expedition were initially investigated for calcareous nannoplankton while five were studied for foraminifera. Preliminary results reveal the presence of generally abundant, moderately- to well-preserved, low-diversity assemblages of calcareous nannoplankton and planktonic foraminifera in sediments of mostly volcanic materials. Benthonic foraminifera are likewise abundant but are more diverse.

CALCAREOUS NANNOFOSSILS (HAUTERIVIAN) FROM "AGUA DE LA MULA" SECTION, NEUQUÉN PROVINCE, ARGENTINA

E. Mostajo, A. Concheyro, F. Dzquez

Poster session

Topics: Hauterivian, Argentina, Stratigraphy

The "Agua de la Mula" section comprises a thick sedimentary sequence of the Agrio Formation, and it crops out at 38°S and 70°W, northern area of Neuquén Province, Argentina. The Agrio Formation is composed by three members: the Lower Member with claystones and limestones, sandstones of the Avilé Member and the Upper Member with grainstones and subordinated limestones.

Lower and Upper Members of Agrio Formation contain ammonites, spores, pollen, dinoflagellates and a scarce nanoflora; the lower Member provides the following nannofossils: *Micrantholithus hoschulzii, M. obtusus, Chiastozygus striatus, Zeugrhabdotus embergerii,* and *Watznaueria* spp. The Upper Member shows a more diverse nannofossil association with nannoconids and cocoliths, among them: *Nannoconus globulus, N. bucheri, M. hoschulzii, M. obtusus, Watznaueria biporta, Ellipsagelosphaera britannica, Z. embergerii, Cruciellipsis cuvillieri, Cretarhabdus* spp. and *Watznaueria* spp.

On the basis of *C. striatus* and *C. cuvillieri* the nannoflora of Agrio Formation in "Agua de la Mula" is assigned to the Zone *Chiastozygus striatus,* early-late Hauterivian. *Chiastozygus striatus* has its first record in this section at 397 m from the base of Lower Member of the Agrio Fm. It first appeareance indicates the base of the early Hauterivian (Taylor, 1982).

The presence of *Cruciellipsis cuvillieri* confirm a late Hauterivian age for the sedimentites of the Upper Member of Agrio Formation in this area.

CALCAREOUS NANNOFOSSIL PALEOCEANOGRAPHY OF THE LOWER CRETACEOUS OF NORTHWEST EUROPE

Jörg Mutterlose
Wednesday, 10.45

The paleobiogeographic distribution patterns of calcareous nannofloras are caused by the interaction of various autecological factors. Their long term and short term fluctuations in the boreal early Cretaceous are controlled by sea-level changes, temperature and nutrients.

Short term fluctuations (clay - marl rhythms) are controlled by surface water temperature and nutrients. The nannofossil associations of the pale, marly horizons are indicative of warm surface waters, probably poor in nutrients. These warm water assemblages, which have a high diversity, consist of *R. asper*, *Cretarhabdus* spp., *Nannoconus* spp, *Conusphaera* and *Micrantholithus* spp. The dark, clayey beds are considered to have been deposited under cool, nutrient-rich surface water conditions. *B. constans*, *S. horticus*, *Corollithion* are included in this assemblage. These fluctuations occur at the scale of Milankovitch cycles (precession and obliquity).

Superimposed on the short term cycles are longer term fluctuations (3rd and 2nd order cycles of Haq et al. 1987) which are controlled by sea-level changes. Regressive periods favour the evolution of boreal and endemic species under restricted conditions. These regressive periods are: the latest Berriasian, the late early Hauterivian, the mid late Hauterivian and the Barremian. Moderate sea-level highstands, on the other hand, allowed tethyan nannofloras to spread into NW Europe and boreal species to migrate southwards. High stands can be postulated for: the early late Valanginian, the early Hauterivian, the mid Hauterivian, the late Hauterivian and the late Earl Barremian.

A major shift towards a more open oceanic regime in NW Europe was marked by the early Aptian transgression. Endemic species disappeared and calcareous nannofloras became homogenised and cosmopolitan.

THE NANNOPLANKTON OF THE JASLO LIMESTONE HORIZONS

András Nagymarosy

Uhlig (1883) recognized thin limestone horizons in the Paleogene part of the monotonous flysch sequence of the Polish Outer Carpathians, which serve as important tools in the lithostratigraphic subdivision of the several km thick turbiditic sequences. The "Jaslo Limestones" (in Ukrainia "Holovetz Horizon") occur in several tectonic units of the Carpathians, as the Dukla, Silesian, Subsilesian, Skole, Boryslav-Pokuty nappes. Nowak (1965) observed, that these limestone horizons are products of intensive calcareous nannoplankton blooms. A further similar Paleogene nannochalk horizon (Krhovsky 1981), the Dynów Marl occurs in several structural units of the Outer Carpathians, as well. While most field geologists deny, that the single Jaslo Limestone horizons would be corelable between different outcrops, others, like Haczewski (1989) subdivide the Jaslo Limestones into discrete horizons with their own specific sedimentology, well-correlable along hundreds of km distances. The nannoplankton investigations show an *individual* character of the single nannochalk horizons.

Dynów Marl: This not-microlaminated horizon contains big masses of *Reticulofenestra ornata* MÜLLER, *R. tokodensis* BÁLDI-BEKE and somewhat less *Transversopontis latus* MÜLLER and *Transversopontis fibula* GHETA. The sporadic occurrence of *Sphenolithus distentus* MARTINI proves the NP 23 age of the Dynów Marl. All members of this nannoplankton bloom seem to be Paratethys-endemic. This is confirmed by the appearance of the endemic mollusc species *Cardium lipoldi* in the Dynów Marl.

Tylawa Limestone: The microlaminated Tylawa Limestone horizon contains *Reticulofenestra ornata* MÜLLER in big masses together with rare specimens of *Transversopontis fibula* GHETA. The age of this horizon is also NP 23.

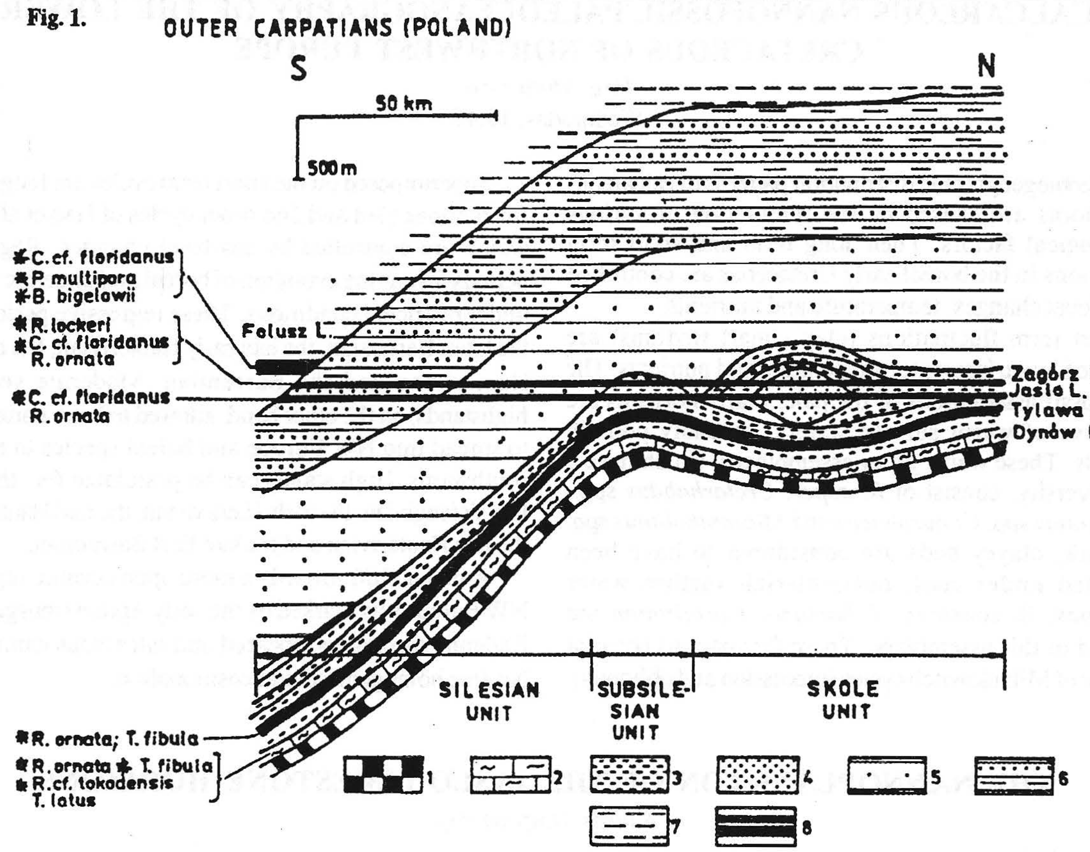
Jaslo Limestone (in a strict sense): Microlaminated nannochalk, its lower part consisting of blooms of *Cyclicargolithus* ex. aff. *floridanus* (ROTH et HAY) BUKRY with less *Reticulofenestra ornata* MÜLLER, in its upper part consisting entirely of *C.* ex. aff. *floridanus* (ROTH et HAY) BUKRY. This latter species is similar in many respects to *Cyclicargolithus abisectus* (MÜLLER) WISE. The age of this horizons can be near to the NP 23/24 boundary.

Zagórz Limestone: Slightly or not microlaminated horizon with blooms of *Cyclicargolithus* ex. aff. *floridanus* (ROTH et HAY) BUKRY and *Reticulofenestra ornata* MÜLLER. In its upper part (in one locality) also a *Reticulofenestra lockeri* MÜLLER bloom has been observed. Its age is NP 24.

Folusz Limestone: Slightly laminated horizon (only in the Silesian structural unit). It is built up of blooms of *Braarudosphaera bigelowii* (GRAN et BRAARUD) DEFLANDRE, *Pontosphaera multipora* (KAMPTNER) ROTH and *Cyclicargolithus* ex. aff. *floridanus* (ROTH et HAY) BUKRY. Its age is probably NP 24.

Detailed investigations helped to prove, that single horizons of the Jaslo Limestones contain consistently the same nannoplankton assemblages everywhere and these are differing from the assemblages of the other horizons. The nannofossil assemblages of the Dynów Marl and the Tylawa and Zagórz horizons show fluctuations in salinity.

Fig. 1.



Key to Fig. 1.: 1 - menilite chert, 2 - Dynów Marl, 3 - dysodile shale, 4 - Kliwa Sandstone, 5 - Lower Krosno Fm., 6 - Middle Krosno Fm., 7 - Upper Krosno Fm., 8 - "Jaslo Limestone" horizons, * - calcareous nannoplankton blooms (modified after Haczewski 1989)

Figure 1.: 1 - menilite chert, 2 - Dynów Marl, 3 - dysodile shale, 4 - Kliwa Sandstone, 5 - Lower Krosno Fm., 6 - Middle Krosno Fm., 7-Upper Krosno Fm., 8 - "Jaslo Limestone" horizons, * - calcareous nannoplankton blooms (modified after Haczewski 1989)

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CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE SALZGITTER-SALDER LIMESTONE QUARRY, LOWER SAXONY, GERMANY

F. Naji

Wednesday, 10.20

The Salzgitter-Salder Limestone Quarry was proposed by Wood et al. (1984) as an international standard section of the Turonian - Coniacian stage boundary. They studied the inoceramids and recommended that the base of Coniacian should be drawn at the level of the first occurrence of *Cremnoceramus? walterdorfensis hannovrensis*, coincident with the *Didymotis* ecoevent II.

Ammonites data of this section was reported by Kaplan et al. (1987). *Forresteria petrocoriensis* was not recovered. According to the ammonite stratigraphers the first appearance of *F. petrocoriensis* represent the base of Coniacian.

Rich and diverse nannoplankton assemblages were recovered including *Quadrum gartneri, Eiffellithus* *eximius, Lithastrinus septenarius, Lucianorhabdus maleformis* and *Marthasterites furcatus*. The first occurrence of *M. furcatus* lies at the base of the marl layer ME, which falls within the ammonite zone *Subprionocyclus neptuni* of Early Late Turonian age. ME lies about 100 m below the first occurrence of *Cremnoceramus? walterdorfensis hannovrensis* and *Didymotis* ecoevent II.

The discrepancies between the biostratigraphy by means of nannoplankton, ammonites and inoceramids are discussed.

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FLORISTIC AND ISOTOPIC CHANGES AT THE PALEOCENE - EOCENE BOUNDARY IN SLOVENIA

Jernej Pavšič and Tadej Dolenec

Poster session

A continuous transition between Paleocene and Eocene was established on the ground of changes in nannoplankton association in flysch at Nozno in Goricka Brda, SW Slovenia. Nannoplankton in marls is rather abundant but poorly preserved. Owing to high degree of reworking of nannoliths for stratigraphy only species that appearing in Eocene could be used. Reliably Eocene is only the species *Tribrachiatus bramlettei*, along with some others less important for boundary.

Across the boundary there are no sedimentation changes. In Paleocene taken place normal flysch deposition with carbonate turbidites that contain in base coarse grained breccia. Upwards follow sandstone and in the uppermost part grey marl (called opoka). In-between occurs fast interbedding of marl and sandstone. Eocene starts with carbonate turbidite about 20 metres thick. Therefore no samples for nannoplankton studies could be collected from this interval. Sampled was only the grey marl above turbidite

The isotopic composition of oxygen and carbon at the transition from Paleocene to Eocene changes perceptibly by increase of the sediment with rare oxygen and carbon isotopes. The variability of isotopic composition of oxygen and carbon is most probably the result of temperature and climatic variations that caused also changes in the carbon cycle. Based on results of investigations in the beginning of Eocene somewhat colder conditions than in Upper Paleocene are indicated. This probably caused the decrease of organic carbon production, as confirmed by the jump of the $\delta^{13}C$ from negative values (- 4.95‰) to positive values (+ 1.66‰).

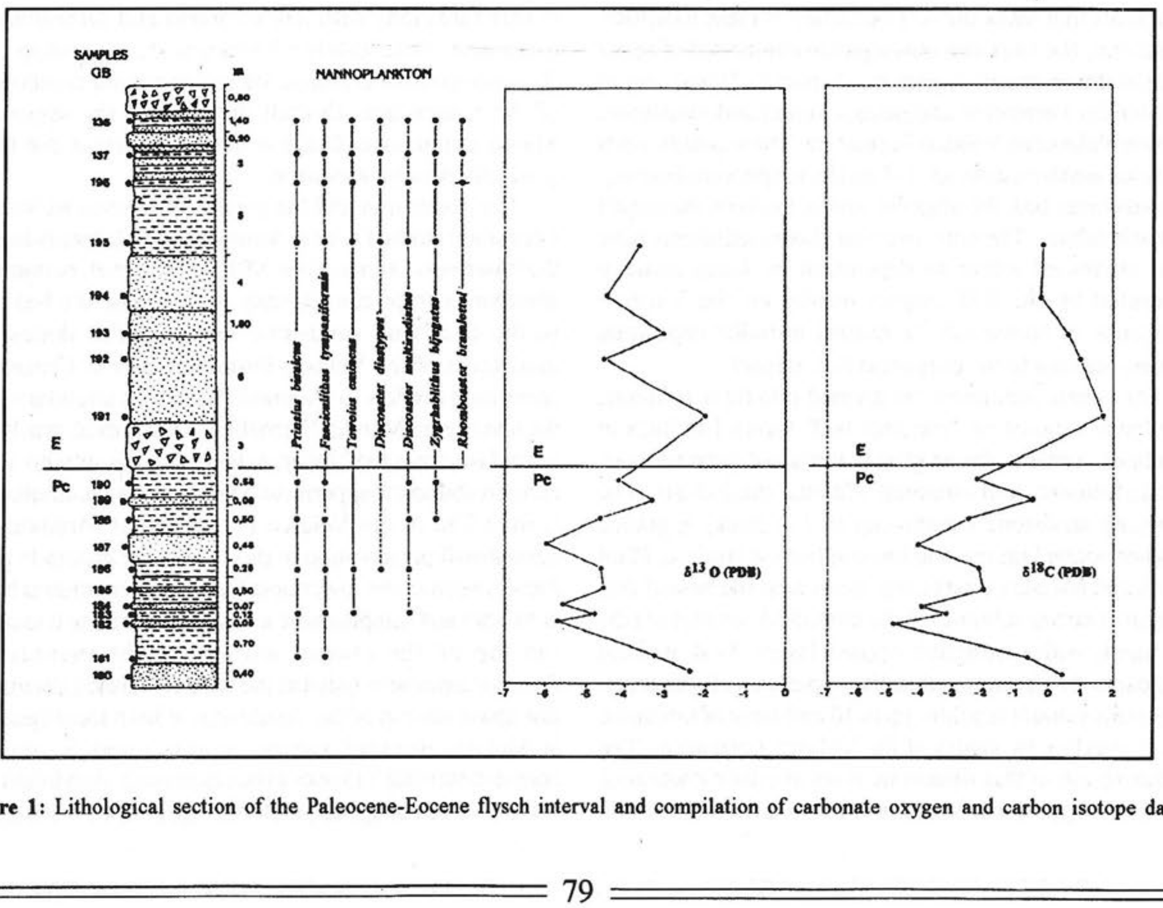

Figure 1: Lithological section of the Paleocene-Eocene flysch interval and compilation of carbonate oxygen and carbon isotope data.

MORPHOMETRIC AND BIOCHRONOLOGIC STUDY OF *COCCOLITHUS MIOPELAGICUS*

Alyssa Peleo-Alampay
Poster session

Coccolithus miopelagicus is among the most cosmopolitan species. Its last occurrence can potentially offer a valuable datum for global stratigraphic correlations of Miocene sediments. This could be especially useful in the high latitudes where most standard index species are either rare or absent. As *C. miopelagicus* appears to differ from *C. pelagicus* mainly by size and the latter species persists to the present, it is important to make detailed size measurements of this group and determine whether *C. miopelagicus* is a distinct species that can be used in biostratigraphy. It is also important to establish the age of this potential stratigraphic marker by correlation with magnetostratigraphy at various sites.

Detailed morphometric and magneto-biochronologic study of *C. miopelagicus* has been carried out at 8 DSDP/ODP sites from low through high latitudes in both hemispheres. The size definition for the total placolith length (>13 microns) for *C. miopelagicus* has proven to be a reliable criteria for differentiating this species from the other *C. pelagicus* complex species. Its last occurrence consistently correlates with the lower part of magnetic Chron C5n, with an age of 10.6-10.8 Ma in the low to mid-latitudes (DSDP/ODP Sites 563, 845, 588 and 608). The species is generally less abundant in the Southern Hemisphere. At high southern latitude Sites 744 and 747, the last occurrence of the species is earlier, correlating with C5r (~11.7 Ma) at Site 744 and C5An (~12.3 Ma) at Site 747.

CALCAREOUS NANNOFOSSILS, TSUNAMITES AND THE K/T BOUNDARY OF NORTHEASTERN MEXICO

James J. Pospichal
Tuesday, 11.35 and poster session

Calcareous nannofossils from closely-spaced samples across the Cretaceous/Tertiary (K/T) boundary from the Arroyo el Mimbral and el Mulato sections in northeastern Mexico were examined in order to determine the nannofossil biostratigraphy and extinction patterns. In particular, the objectives were to note the relationship of nannofossil abundance of assemblage changes to unique clastic sediments that mark the K/T boundary at these localities. In general, the Mexican outcrops are comprised of upper Maastrichtian greenish-grey marly pelagic limestones of the Mendez Formation and pelagic shales and marlstones of lower Paleocene Velasco Formation. These pelagic units are separated by a distinct, 1-3 m-thick, spherule-bearing, layered clastic bed, the origin of which, has been the subject to much debate. The controversial clastic sediments have been attributed either to deposition by mega-tsunami generated by the K/T impact nearby on the Yucatan Peninsula, or conversely, to normal turbidite deposition with no relation to the purported K/T impact.

The clastic sediments are divided into three subunits: The lower subunit, or "spherule bed" (up to 1 m thick at Mimbral), contains altered glass (tektites and microtektites), shocked quartz, and common Mendez marl clasts. The overlying sandstone subunit (up to 2 m thick) is graded with horizontal laminae and low-angle cross laminae. Plant debris and Mendez clasts are present near the base of this subunit. The top subunit (10-20 cm thick) consists of silts and sands with distinctive rippled layers. Peak iridium abundance has been noted in the upper part of this layer. Above this subunit is a thin (up to 10 cm) layer of limestone that is overlain by shales of the Velasco Formation. The consideration of this limestone layer as either lowermost Danian or uppermost Maastrichtian is a debatable topic and one that bears heavily on the interpretations of timing and origin of the controversial clastic unit.

Calcareous nannofossils from the topmost 3 m of the Mendez Formation at Mimbral and the topmost 1.5 m at Mulato are common to abundant and moderate to poorly preserved. Nannofossil assemblages there belong to the upper Maastrichtian *Micula princii* Zone. *Micula princii* is very rare along with few *M. murus* and *Lithraphidites quadratus. Watznaueria barnesau, M decussata,* and *Prediscosphaera cretacea* are the dominant components of the assemblage. Overall diversity of the uppermost Maastrichtian assemblage at both localities is due to the generally poor preservation.

The clastic unit and the portion of lowermost Velasco Formation studied at both Mimbral and Mulato belong to the lowermost Danian Zone NP1. As expected, nannofossil abundance drops considerably in the "spherule bed" and in the overlying sandstone units. In the shales and marlstones of the Velasco Formation above, Cretaceous specimens are few to common, but not as abundant as in the underlying Mendez Formation. At Mimbral, marlstone intraclasts from the "spherule bed" and the subunit above contain abundant uppermost Maastrichtian nannofossils. Only 2.5 m of the Velasco is exposed at Mimbral and nannofossil preservation in this interval is generally poor. Preservation in the lowermost Velasco Formation is better at Mulato and samples were analyzed from up to 6 m above the top of the clastic unit. A slight increase in *Thoracosphaera* is noted at the base of Velasco Formation just above the top of the clastic unit at both localities, and at Mulato, *Braarudosphara bigelowii* and *B. alta* are common starting 1 m above the clastic unit. At Mulato, the survivor assemblage also includes rare to few *Chiastozygus* *ultimus*, *Cyclagelosphaera reinhardtii*, *C. alta*, *Zygodiscus sigmoides*, *Markalius inversus* and *Octolithus multiplus*. The first Danian species to appear at either locality, *Neobiscutum parvulum*, first occurs at 1 m above the top of the clastic unit at Mimbral and 25 cm above the clastic unit at Mulato. *Cruciplacolithus primus* first occur about 5 m above the top of the clastic unit at the latter site.

Nannofossil assemblages are interpreted to indicate that the K/T boundary should be placed at the base of the "spherule bed", contrary to some previous interpretations in which the boundary is located at the top of the clastic unit. This is suggested by the drop in abundance of Cretaceous specimens at the base of the "spherule bed" along with the observation that Cretaceous specimen abundance does not recover above the clastic unit. Notably, this includes abundances within the limestone layer that immediately overlies the clastic beds. The few to common Cretaceous nannofossils present in basal Velasco are probably reworked as are those present within the clastic unit. In addition, upper Campanian-lower Maastrichtian species are more conspicuous in the Velasco sediments above the clastic unit, which also indicates persistent reworking.

Overall, the study indicates that Cretaceous nannoplankton suffered a rapid reduction at the K/T boundary (marked by the clastic unit) and never recovered following the deposition of the spherule sandstone units. This perhaps suggests a fundamental link between end-Cretaceous nannoplankton extinctions and the event(s) associated with the deposition of the unique clastic sediments in northeastern Mexico.

CALCAREOUS NANNOFOSSILS AND PALYNOMORPHS FROM VALANGINIAN AND HAUTERIVIAN (LOWER CRETACEOUS) STRATA OF CERRO DE LA PARVA, CENTRAL - WESTERN NEUQUÉN, ARGENTINA

M. Prámparo, W. Volkheimer, and E. Mostajo

Poster session

At Cerro de la Parva locality are outcropping pelites and psammites of the Valanginian Mulichinco Formation (with the ammonite Olcostephanus atherstoni of Upper Valanginian age, which occurs in the upper part of the Formation) and pelites of the Lower Member of Agrio Formation (Hauterivian). A detailed sampling for nannofossils and palynomorphs has been carried out in both mentioned stratigraphic units. The following species could be identified:

1) Nannofossils:

a) Mulichinco Formation: *Watznaueria barnesae*, *Watznaueria britannica*, *Cyclagelosphaera margerelii*, *Micrantholithus hoschulzii*, *Micrantholithus obtusus*, *Calcicalathina oblongata*, *Zeugrhabdotus embergeri*, *Nannoconus steinmannii*, *Nannoconus steinmannii minor*, *Watznaueria* sp. and *Rucinolithus* sp.

b) Agrio Formation (Lower Member): *Watznaueria barnesae*, *Watznaueria britannica*, *Cyclagelosphaera margerelii*, *Micrantholithus obtusus*, *Micrantholithus hoschulzii*, *Zeugrhabdotus embergeri*, *Cruciellipsis cuvillieri*, *Cretarhabdus surirellus*, *Nannoconus steinmannii*, *Nannoconus cornuta*, *N. globulus*, *N. bucheri*, *N. kamptneri*, *N. broennimannii*, *Watznaueria sp.*, *Chiastozygus* sp. and *Nannoconus* sp..

2) Palynomorphs:

a) Mulichinco Formation: The assemblage is characterized mainly by terrestrial species: *Balmeiopsis limbatus*, *Calliaslasporites turbatus*, *Callialasporites dampieri*, *Podocarpidites ellipticus*, *Microcachrydites antarticus*, *Equisetosporites caichigüensis*, *Classopollis simplex*. A few marine species are present: *Cribroperidinium orthoceras*, *Muderongia* sp., *Cymatiosphaera* sp. and *Baltisphaeridium* sp..

b) Agrio Formation (Lower Member): In this part of the sequence marine species are more frequent; amongst them dominate: *Oligosphaeridium* cf. *complex*, *Cribroperidinium orthoceras*, *Sentusidinium* sp., *Pareodinia* sp., *Gonyaulacysta* sp., *Pterospermella* sp., *Muderongia* sp., *Escharisphaeridia pocockii*, *Leiosphaeridia* spp. Prominent terrestrial forms are: *Deltoidospora* sp., *Biretisporites* sp., *Cyclusphaera psilata* (very frequent), *Araucariacites australis*, *Callialasporites dampieri*, *Callialasporites trilobatus*, *Classopollis simplex* and *Podocarpidites* sp.

PALEOECOLOGY OF CALCAREOUS NANNOFOSSIL ASSEMBLAGES AND ITS RELATIONSHIP TO SEA - LEVEL VARIATIONS IN THE FIGOLS GROUP (EARLY EOCENE, SPANISH PYRENEES)

Viviana Reale

Tuesday, 10.45

Sea-level fluctuations are a determining factor in influencing ecological conditions of shelfal settings. Little is known about the relationships between such changes and the abundance and diversity of calcareous nannofossils. If sea-level changes can be documented thanks to the study of depositional sequences (Vail et al. 1991), then it seems of overall importance that paleocological studies be tied to a well-known sequence stratigraphic framework. These conditions are met in the Early Eocene Figols Group of the Spanish Pyrenees (Tremp-Garus Basin) studied by Mutti et al. (1988;1994) and Carminatti (1992). Here a high-resolution framework has been made available through extensive facies analyses carried out along a 25 km-long stratigraphic cross-section running in an onshore-offshore direction, from shallow water to distal shelf settings (Carminatti, 1992).The Figols Group spans between the Zone NP11 and the NP12 (Reale 1994). It is composed of four Large Scale Composite Depositional Sequences (LSCDSs, named FG1-4, Mutti et al., 1994) which are the product of third-order sea-level variations. These are in turn composed of Elementary Depositional Sequences (EDS), 20-200 m thick, produced by high-frequency sea-level changes (fourth and fifth order). The maximum thickness of the Figols Group in the study area is about 1200 m.

A quantitative analysis of calcareous nannofossil assemblages has been carried out on three sections outcropping between Esera and Isabena Valleys: Merli Est, Teraza and Navarri, from proximal to distal. The results will be discussed from two different points of views, the first regarding the distribution of abundance and diversities at large scale (group), the second at a small scale (EDS).

1) The study of the distribution of taxa of "shallow water" affinity (pentaliths, *Rhabdosphaera, Rhomboaster, T. ortostylus*) shows asharp increase in the upper part of the group. It coincides with sequences FG3 and FG4 which mark a basin narrowing and a decrease of bathymetry.

Sphenolithus and *Z. bijugatus* show opposite trends, the first being maximum during the main transgressive part of the group (FG2).

The quantitative analysis of reworked taxa (mainly Createaceous) shows that reworking is greatest during the regressive part of the group.

A study of diversity of fossil assemblages has been also performed. Species richness, Shannon-Weaver Index and Equitability have been calculated. The highest values are again concomitant with the deposition of FG3 and FG4.

2) A cyclic trend correlative to EDSs development and high-frequency sea-level changes is clear in the distribution of reworked taxa along the succession. Reworking has the highest value during highstands and the lowest during the transgressive intervals.

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CALCAREOUS NANNOPLANKTON FROM THE BOUNDARY DEPOSITS OF MAASTRICHTIAN AND DANIAN OF THE UKRAINIAN CARPATHIANS

Anna Romaniv

Poster session

Calcareous nannoplankton on the boundaries of Maastrichtian and Danian was studied within the northern and southern hillsides of the Ukrainian Carpathians.

The upper Cretaceous and Paleocene deposits considerably occur in the Carpathians. They are presented by rather monotonous terrigenic flysch. Gradual transition from Maastrichtian to Paleocenic deposits is observed, and it is difficult to establish the boundary between them under the field investigations. Nowadays it is possible to prove the presence of Danian stage in some sections by means of microfauna (Vialov et al., 1960; 1965) and by nannoplankton (Grigorovich, 1971; Romaniv, 1991).

Calcareous nannoplankton of Maastrichtian deposits has rich quantitative and species content. It numbers about 60 species which occur in 28 genera and 8 families. The families Zygodiscadeae Hay et Mohler, Coccolithacaea Kamptner and Syracosphaeraceae Lemmermann are presented by the majority of genera. Among the most characteristic genera we should note *Markalius nielsenae, Nephrolithus frequens, Broinsoinia parca, Cribrospaerella ehrenbergi, Kamptnerius magnificus, Micula concava, M. staurophora, Predeiscophaera cretacea, Tetralithus aculeus, Titrifidus. Tetratlithus murus* can be observed in some sections.

On the boundary of Maastrichtian Danian significant changes in content of fossil assemblages take place. Their content is almost totally renewed taking Paleocenic features.

Danian nannofossils are less different by their species content and they number not more than 20 species. Zones NP 1 *Markalius inversus*, NP 2 *Cruciplacolithus tenuis* and NP 3 *Chiasmolithus danicus* have been noticed in Danian of the Carpathians.

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NANNOFOSSILS AND PLANKTIC FORAMINIFERA ACROSS THE K/T BOUNDARY IN TWO SECTIONS OF NORTHEASTERN MEXICO

Antonieta Sanchez-Rios, Héctor Ruiz-Ruiz, Patricia Padilla, and J. Manuel Grajales-Nishimura
Poster session

Floristic and faunistic changes in calcareous nannoplankton (CN) and planktic foraminifera (PF) were observed through the Cretaceous/Tertiary boundary from the Lajilla and Coxquihui sections, NE Tamaulipas and NE Veracruz states, respectively.

Three lithologic units can be distinguished in both sections: Unit I (uppermost Mendez Formation) is composed by marls; Unit II (clastic unit) contains tektites, cross-bedded and parallel-bedded sand-stones, siltstones, and rare reworked limestone clasts; Unit III (basal Velasco Formation) is formed by marls, calcareous shales, and clayey limestones.

Unit I (Lajilla = 1.20 m, Coxquihui = 3.45 m thick). At the Lajilla section, 38 CN and 55 PF species were identified, whereas at Coxquihui these abundances correspond to 37 and 80, respectively. Moderate preservation of fossils is shown at both localities, where both uppermost Maastrichtian species *Micula prinsii* and *Abathomphalus mayaroensis* were found.

Unit II (Lajilla = 1.1 m, Coxquihui = 0.80 m thick). Compared to Unit II, Cretaceous PF abundance decreases around 60%, and that of CN does it at 50%. *M. prinsii* is absent at both sections and *A. mayaroensis* continues only at La Lajilla; at this latter section, scarce "small globigerina" appear at the top of this unit.

Unit III (Lajilla = 2.80 m, Coxquihui = 1.60 m thick). In contrast with the 80 PF species from the Unit I at Coxquihui, only 30 were found in the Unit III, crossing the K/T boundary; by the other hand, only 16 out of 55 were registered at La Lajilla. Both *Biantholithus sparsus* FAD and the *Thoracosphaera* "bloom" are detected at the base of this unit; one meter above, the *Braarudosphaera bigelowi* "bloom" was identified; at La Lajilla, *Neobiscutum* cf. *parvulum* is present. In both localities the first occurrence of the Early Paleocene *Parvolarugo-globigerina eugubina* is registered at this level.

Both sections share good chronostratigraphic correlation; the K/T boundary was placed between the Unit II and III.

LATE PLIOCENE NANNOFOSSIL EVENTS RECOGNIZED IN THE UPPERMOST SEQUENCE IN THE JAPAN SEA SIDE, WITH REFERENCE TO THE GLACIATION IN THE ARCTIC SEA

Tokiyuki Sato and Koji Kameo
Poster session

The remarkable floral change of the calcareous nannofossils from *Reticulofenestra* spp.(small form) assemblage to *Coccolithus pelagicus* assemblage, is found in the Upper Pliocene sequence in Akita area, located in the Japan sea side of Japan. This event is correlated to the latest Gauss Normal Epoch. The relation between the magnetic polarity and the nannofossil event is also found in the Upper Pliocene of Hole 911A, ODP Leg 151, and is correlated to the horizon of the drastic increase of dropstones, which is related to glaciation of the northern hemisphere. These results indicate that calcareous nannofossil event recognized in Upper Pliocene in the Japan Sea side is strongly related to the increase of ice sheets in the northern hemisphere occurs at latest Gauss Normal Epoch.

LATE CRETACEOUS BIOSTRATIGRAPHY AND PALEOCEANOGRAPHY OF THE ATLANTIC COASTAL PLAINS, USA

Jean Self-Trail
Wednesday, 9.15

Subsurface Upper Cretaceous marine sediments from nine coreholes in South Carolina, one corehole in northern North Carolina, one corehole in central Delaware, and four coreholes in southern New Jersey were examined for calcareous nannofossils using the light microscope and the scanning electron microscope. Correlation of lithologic units across state boundaries is possible on the basis of the calcareous nannofossil biostratigraphic data.

Biostratigraphic ages of the lithologic units remain fairly constant from north to south. In New Jersey, ages of marine sediments range from latest Cenomanian (Zone CC 10b) for the Bass River Formation to late Maastrichtian (Zone CC 26a) for the Navesink Formation. Marine sediments in South Carolina, Delaware, and probably North Carolina range in age from the Santonian (Zone CC 15) to the late Maastrichtian (Zone CC 25). Latest Cenomanian and latest Maastrichtian marine units have not been documented in these three states. Cenomanian marine sediments, which do occur in New Jersey, are rare throughout much of the Atlantic coastal plain. There is a regional unconformity documented in all four states between the top of Zone CC 22 (probable top of the Campanian) and the base of Zone CC 25 (lower to middle Maastrichtian).

Calcareous nannofossils document possible changes in the position of the Gulf Stream current during the Campanian and Maastrichtian. *Quadrum trifidum* and *Quadrum sissinghii* are rare in New Jersey, with only one specimen of each species found in each of the four cores examined. This is remarkable when compared to South Carolina, where both species are very abundant. Differences in the abundances of these two species between the more subtropical area (South Carolina) and the more temperate area (New Jersey) reflect the position of the Gulf Stream. During the Late Cretaceous, *Quadrum sissinghii* and *Q. trifidum* preferred the warmer waters of the South Atlantic and Gulf Stream to the cooler waters found off New Jersey and Delaware. *Nephrolithus frequens*, which first appears in the Campanian in high-latitude waters and in the Maastrichtian in more temperate waters, is absent in South Carolina but common in New Jersey. It's appearance or absence also is thought to be related to the position of the warm-water Gulf Stream.

PALEOGENE AND NEOGENE PRODUCTIVITY IN THE INDIAN OCEAN

William G. Siesser

Poster session

Primary productivity in the oceans is an important process with ramifications for biological, geological, and chemical oceanography. Productivity removes enormous amounts of carbon and smaller amounts of other elements from ocean waters. Vast quantities of these elements eventually become locked away in sediments on the sea floor and in onshore deposits that originally formed in ancient oceans. The geological record of the carbon system is thus important in understanding global change.

Paleoproductivity in the oligotrophic areas of the world's oceans has been investigated less than in the more fertile nearshore areas, in part because of the absence of a reliable proxy to measure productivity in oligotrophic areas. A transfer function has recently been proposed which directly translates carbonate mass accumulation rates into a quantitative measure of productivity. This transfer function has been applied at six ODP sites in the oligotrophic Indian Ocean in order to investigate temporal and spatial changes in Indian Ocean productivity during the Tertiary Period.

Early Paleogene productivity in the Indian Ocean was considerably higher than in the late Paleogene and Neogene. A warmer, more confined sea, with large riverine nutrient input from close lying land masses may account for the generally higher early Paleogene productivity. Productivity increased sharply during Paleocene nannofossil Zone NP 5 and during Eocene Zone NP 11. These productivity peaks may be related to abrupt climatic changes which reorganized oceanic circulation and stimulated major changes in productivity. Global cooling and the initiation of the modern Indian Ocean circulation system caused productivity to decrease in the Oligocene. This trend continued into the Neogene, which was characterized by generally low productivity, interspersed with occasionally higher productivity levels, especially at the more northern sites in the Indian Ocean.

DEVELOPMENT OF THE PLIO - PLEISTOCENE COCCOLITH ASSEMBLAGES IN THE NE ATLANTIC CORRELATED TO CLIMATIC CHANGES

Xin Su

Monday, 12.25

A quantitative study of Plio-Pleistocene calcareous nannoplankton of the DSDP/ODP sites 664, 659 608, 609, 610 from the Northeast Atlantic was carried out to evaluate the development of the coccolith assemblages under the ecological impact of climatic changes during the last 5.2 m.y.

The main results of this study are:

1. Various species of *Reticulofenestra* and *Gephyrocapsa, Pseudoemiliania lacunosa* and *Emiliania huxleyi* are the main components of the coccolith assemblages. Major evolutionary processes in these species are recognized by downcore variations in their accumulation rates. The decline and extinction of Miocene forms, i.e most *Reticulofenestra* species, and two genera *Discoaster* and *Sphenolithus,* and the appearance and increase of Pliocene and Pleistocene species, especially the evolutionary changes within *Gephyrocapsa*, are seen as the main mechanisms of the development of the coccolith assemblages.

2. Eight developmental stages of the coccolith assemblages are distinguished on the base of fundamental changes in their essential components:

Coccolith assemblages in the Pliocene stages are dominated by *Reticulofenestra* species and those in the Pleistocene stages are characterized by frequently alternating dominances of *Gephyrocapsa* species and *P. lacunosa.* Today, *E. huxleyi* is the dominant species. In the Pleistocene changes in the dominant species are more rapid and abrupt than in the Pliocene.

The coccolith assemblages show a variety of geographical variations throughout the eight stages, which are caused by the various ecological affinities of these species. For example in the Early Pliocene *Discoaster* spp. and *Sphenolithus* spp. are common in low latitudes and rare in high latitudes; in the late Pleistocene (0.60 - 0.25 Ma) *Gephyrocapsa oceanica* and *G. margereli* are abundant in low latitudes whereas *G. caribbeanica* is prominent in high latitudes.

3. In order to make a link of climatic changes and the coccolith development, a statistical method (CV ratio) is introduced to analyze the variability of the benthic $\delta^{18}O$ data at site 659 (Tiedemann et al., 1994) and of accumulation rates (ARcoccoliths) of six coccolith species from the five studied sites and. Generally, the $\delta^{18}O$ CV ratios reflect the variability of temperatures/ice-volumes or climatic changes and the ARcoccoliths CV ratios of a species are related to the variability of its production levels, which is the results of climatically induced changes in marine ecosystem, as changes in temperatures and light.

For the most time intervals the ARcoccoliths CV ratio curves of most species show a good correlation to the $\delta^{18}O$ curve. In the Pliocene low ARcoccoliths CV ratios parallel low $\delta^{18}O$ CV ratios, this indicates that coccolith species showed small variations in production within stable climatic conditions. In the Pleistocene strongly increased $\delta^{18}O$ CV ratios are parallelled by strongly increased ARcoccoliths CV ratios, this suggests that coccolith species showed large-amplitude variations in production, in response to increased climatic instability due to frequent glacial-interglacial alternations. The extinction rates of species increase in the Pleistocene when $\delta^{18}O$ CV ratios increase. This implies that the strongly increased climatic instability in the Pleistocene may lead to the extinction of more species. Thus, the rapid and abrupt changes of the coccolith assemblages in the Pleistocene are correlated with increased climatic instability.

However, the ARcoccoliths CV ratios in several intervals, e.x near the appearance of a species (e.g. *G. oceanica*) or the intervals where certain changes in their ecological affinities are observed, do not parallel the $\delta^{18}O$ CV ratios and the appearance rates of species are not in parallel with the $\delta^{18}O$ CV ratios. This indicates that the variations in abundances which are induced by biological evolution are not directly correlated with climatic changes.

RARE OCCURRENCES OF *PETRARHABDUS COPULATUS* DEFLANDRE ON THE NORTHERN HEMISPHERE (CENTRAL EUROPE)

Lilian Švábenická

Poster session

Topics: Campanian, Central Europe, bioprovinces

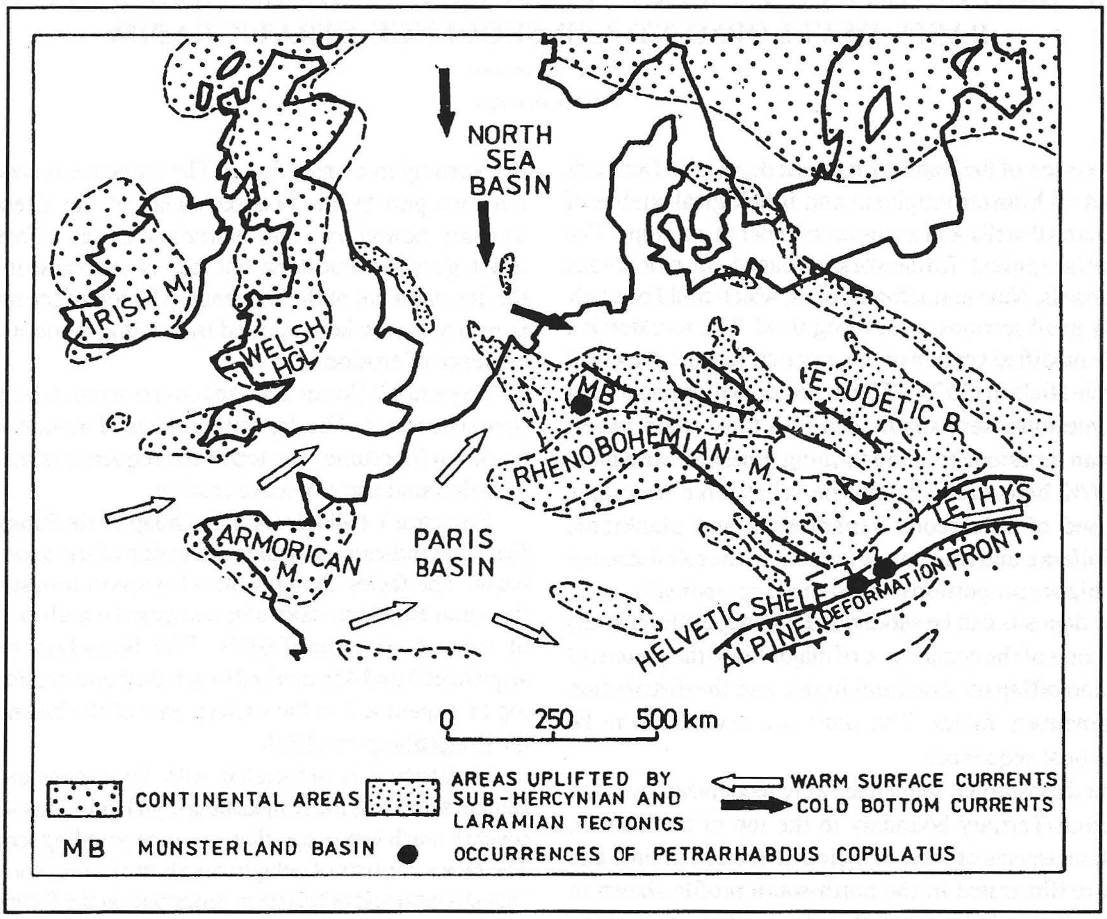

Figure 1. Paleogeography and water circulation in the late Upper Cretaceous of Central Europe (modified after Ziegler (1982) and Kaever and Lommerzheim (1991)) with marked finds of *Petrarhabdus copulatus* Deflandre (hypothetic locations). 1. Waschberg Zone, Low Austria, 2 - Ždánice Unit, South Moravia.

Petrarhabdus copulatus Deflandre is mostly known from the southern hemisphere in the Indian Ocean and Atlantic Ocean being common in the Campanian and Maastrichtian sediments of approximate paleotitudes 30° and 40°S but absent from the samples of the same age from the more poleward localities (Wind 1975). Finds of this species from the northern hemisphere are rarely mentioned in the literature (i.e. Deflandre (1959) from the French Maastrichtian sediments or Varol (1992) from Turkey) and may prove the importance for the paleogeographical reconstructions and further bioprovince studies.

Petrarhabdus copulatus has been recorded in the Late Campanian sediments of the Outer Group of the nappes in the West Carpathians (Ždánice Unit in the South Moravia, Czech Republic) and in the Waschberg Zone in Low Austria in the assemblages where mixing of low- and high-latitude nannofossil species was obvious (Švábenická, in press). These sediments were deposited east of their present locations. Besides, this nannolith was observed also in the sediments of the Münsterland Basin which is included into the boreal bioprovince (NW Germany) and where typical low- and mid-latitude nannofossils were absent.

Brief review of the *Petrarhabdus copulatus* occurrences observed by the author:

- Waschberg Zone (locality Ernstbrunn): *P. copulatus* accompanied by *Quadrum trifidum, Q. sissinghii, Neocrepidolithus watkinsii, Biscutum coronum* etc.

- Ždánice Unit (Carpathanian Flysch Belt, locality Pavlov): *P. copulatus* in the association with *Quadrum sissinghii, Ceratolithoides arcuatus, Biscutum dissimilis, B. coronum, Monomarginatus quaternarius, Prediscosphaera stoveri* etc.

- Münster Basin (borehole Longinusturm): *P. copulatus* associated with *Prediscosphaera stoveri, P.* cf. *grandis, Neocrapidolithus watkinsii, Monomarginatus quaternarius, Micula swastica* etc.

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THE DANIAN (LOWER PALEOCENE) LIMESTONE DEPOSITS IN DENMARK: BASIN DEVELOPMENT AND SEQUENCE STRATIGRAPHY

Erik Thomsen

Poster session

This overview of the Danian limestone deposits in Denmark is based on biostratigraphical and lithological studies of more than 40 wells and a similar number of outcrops. The biostratigraphical framework is based on calcareous nannofossils. Nine nannofossil zones, which could be easily identify in all sections, were recognized. The zonation is a slightly modified version of the zonation scheme presented by Perch-Nielsen (1979). The deposits, which consists of pure limestone were subdivided into three main facies: Bryozoan limestone (mound forming limestone with more than 20% bryozoans; calcilutite (chalk-like limestone composed of calcareous nannofossils and planktonic foraminifera); and calcarenite (similar to the calcilutite but with a higher proportion of sand-sized components.

The deposits can be subdivided into depositional units on the basis of the occurrence of major hiati, the pattern of onlap and offlap on structural highs, and the distribution of sedimentary facies. The units are considered to be depositional sequences.

Four depositional sequences were recognized from the Cretaceous/Tertiary boundary to the top of the Danian. Important aspects of their of their distribution in time and space are illustrated in the north-south profile shown in figure 1. It should be noted that the northern part of the profile is missing due to post Danian uplift and erosion.

Sequence 1 (uppermost Cretaceous and lowermost Danian) is confined to a narrow zone in the central part of the Norwegian-Danish Basin. The sequence is subdivided into two part by the boundary clay at the Cretaceous-Tertiary boundary. The boundary event affected the lithology of the limestone, but did not otherwise influence the development of the sequence. The top of the sequence is nearly everywhere marked by a hardground and clear evidence of erosion.

Sequence 2 (lower Danian) covers a much larger area than sequence 1. The deposits consists of mound forming bryozoan limestone. The top of the sequence is marked by a hardground and extensive erosion.

Sequence 3. (Middle Danian) Onlap on the Ringkøbing-Fyn High indicates a further expansion of the depositional basin. The facies changes from bryozoan limestone to a fine-grained pelagic calcilutite composed mainly of remains of calcareous nannofossils. The boundary between sequences 3 and 4 is marked by a hiatus and erosion in the top of sequence 3 in the eastern part of the basin and on the Ringkøbing-Fyn High.

Sequence 4 is associated with an expansion of the Danian sea across the Ringkøbing-Fyn High. This sequence covers a much larger area than any of proceeding sequences. The facies consists of pelagic calcilutite in the Norwegian-Danish Basin and of bryozoan limestone on the Ringkøbing-Fyn High. During this period the northern margin of the basin moved south due to an uplift of the Fennoscandian Border Zone. The boundary between Danian and the Selandian is generally marked by a hiatus and erosion.

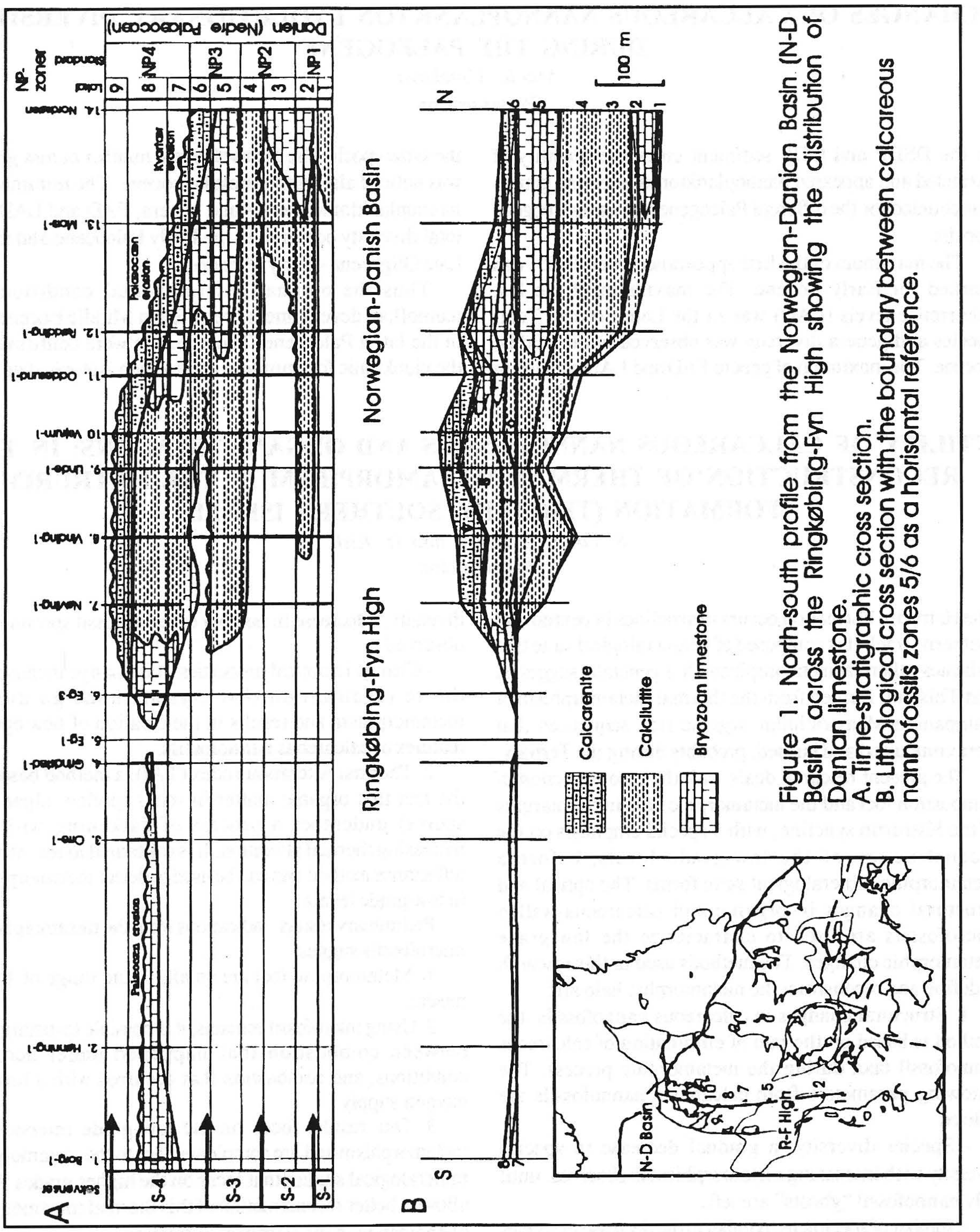

Figure 1. North-south profile from the Norwegian-Danian Basin (N-D Basin) across the Ringkøbing-Fyn High showing the distribution of Danian limestone.
A. Time-stratigraphic cross section.
B. Lithological cross section with the boundary between calcareous nannofossils zones 5/6 as a horisontal reference.

POLAR COCCOLITHOPHORIDS

Helge Abildhauge Thomsen

Monday, 14.50

The preparation of freshly collected samples for TEM has resulted in the finding of a contingent of lightly calcified coccolithophorids, which appear to have their main distribution in polar regions. These organisms were first encountered in subarctic and arctic samples and were later found to form a characteristic nannoplanktonic element also in Antarctic waters. Several taxa of polar coccolithophorids previously considered to be autonomous species are, in fact, part of life histories combining hetero- and holococcolithophorid forms. All species of *Haptophyceae*, with the exception of the enigmatic *Balaniger balticus*, have been considered photosynthetic. However, it has become evident that all polar coccolithophorids are in fact heterotrophic organisms. It remains to be verified whether these taxa are genuine heterotrophic organisms, or forms that have secondarily lost the photosynthetic apparatus.

CHANGES OF CALCAREOUS NANNOPLANKTON EVOLUTIONARY DIVERSITY DURING THE PALEOGENE

Maola Ushakova

Poster session

In the DSDP and ODP sediment cores the quantity of extincted and appeared nannoplankton species and genera was counted for the different Paleogene and Early Neogene epochs.

The maximum of the first appearance level (FAD) was marked for Early Eocene. The maximum of the last occurrence levels (LAD) was in the Late Eocene. Total species and genera diversity was observed in the Middle Eocene. The maximum of genera FAD and LAD situated in the same epoch. The relatively great number of new genera was noticed also in the latest Paleocene. The minimum of nannoplanktonic species and genera, FAD and LAD and total diversity occurred in the Early Paleocene and in the Late Oligocene - Early Miocene.

Thus the optimal environmental conditions of nannoflora development prevailed in Middle Eocene and in the latest Paleocene. These results were confirmed by the planktonic foraminifera and oxygen isotopic data.

UTILITY OF CALCAREOUS NANNOFOSSILS AND ORGANIC REMAINS: IN THE RECONSTRUCTION OF THERMAL METAMORPHISM IN THE HATRURIM FORMATION (TERTIARY, SOUTHERN ISRAEL)

S. Volin, Y. Eshet, and H. Kish

Poster session

The Hatrurim Formation occurs in synclines in central and southern Israel. It is composed of a mineralogical suite that indicates a thermal metamorphism. It is generally suggested that This unit formed from the thermal metamorphism of Campanian-Maastrichtian organic-rich sequences that were combusted and burned, probably during the Tertiary.

The present research deals with the reconstruction of combustion foci and the metamorphic halo in the margins of the Hatrurim syncline, with a special emphasis on the reconstruction of the low-grade levels, before a metamorphic mineralogical suite forms. The optical and structural changes in organic and calcareous-walled microfossils are used to characterize the low-grade metamorphic changes. The methods used in this research to define and reconstruct the metamorphic halo are:

1. Structural changes in calcareous nannofossils: the method is based on the rate of elimination of calcareous nannofossil taxa during the metamorphic process. The following parameters from calcareous nannofossils are utilized:

- Species diversity: a gradual decrease in species diversity with increasing metamorphism is observed, until only nannofossil "ghosts" are left.

- Number of specimens: parallel to the decrease in species diversity, a decrease in number of nannofossil specimens is observed.

- Change in optical properties: this change is caused by the re-organization that crystals undergo during metamorphism and results in the creation of new optical features of calcareous nannofossils.

2. Thermal Alteration Index (TAI): a method based on the fact that organic matter in rocks (pollen, algae and spores) undergoes a process of darkening with the increasing thermal alteration. It is calibrated to the vitrinite reflectance method and can be used to detect metamorphism in low grade levels.

Preliminary results: Indications from the metamorphosed microfossils suggest:

1. Metamorphic foci are small, in the range of 10-40 meters.

2. Using microfossil remains, it is possible to distinguish between combustion that happened under aerobic conditions, and combustion that occurred with a limited oxygen supply.

3. Our results focus on the low-grade intervals of metamorphism and are complementary to the metamorphic mineralogical studies that focus on the higher grades. This allows a better reconstruction of this thermal metamorphic phenomenon in the Hatrurim Formation.

CALCAREOUS NANNOFOSSILS IN THE ARTS

Katharina von Salis

Wednesday, 14.00

Calcareous nannofossils have a long evolutionary history which makes them important in dating marine sediments of up to 200 million years of age. Since such rocks have been used for the construction of houses and churches as well as for grounds for paintings, the analyses of fossil coccoliths can also contribute to the solving of archaeological and art historical riddles.

Thanks to the widespread occurrence of chalk - a sediment widespread in Scandinavia and Northern Europe and consisting mainly of coccoliths - the art historical aspect of coccolith study has been very fruitful here. Archaeological examples come from southern areas.

The following examples will be reviewed. They give an incomplete but interesting overview of the work accomplished during the past quarter of a century:

Ancient Mortar from Turkey and Egypt

The problem: was the fine material between the building-blocks really mortar, that means the result of a man-made chemical process?

The answer, based on nannofossil study: no in one and yes in the other case.

Mummy Cases from Egypt

The problem: none, really — sheer curiosity.

The answer: calcareous nannofossils found in the ground of the paint include a Paleogene assemblage that could have derived from nearby sources.

Icons from the former Soviet Union

The problem: none, really — sheer curiosity.

The answer: various ground of late Cretaceous age was used. No attempt was so far made to investigate the possible origin of the material.

Medieval churches in Jutland, Denmark

The problem: few medieval churches in Denmark are built of rocks from the underground — most are built of brick or of erratic blocks transported to Denmark by the glaciers during the ice-ages. Nine churches in the northeastern part of Djursland are different, in that they consist mainly of local limestones. Where did the limestones come from? What were the transport routes? Why were certain types of limestone used for construction and others not?

The answer: Coccolith investigations by Erik Thomsen using the Danian zones of Perch-Nielsen (1979) allowed for the detailed dating of the outcrops in the region and of the building stones and therewith allowed for the determination of the origin of the building blocks.

Ribe Domkirke, Denmark

The problem: Limestone used for the capital of Ribe Domkirke (and for other sculptures) looked similar to local danish limestone, but looked enough different to be submitted to the author for investigation.

The answer: The coccolith assemblage includes an upper Cretaceous assemblage with not uncommon *Nannoconus*. Such assemblages are not found in Scandinavia, the limestone thus must have been imported.

Relief from Roskilde Domkirke, Denmark

The problem: A relief owned by the National Museum of Copenhagen was known to stem from the dome of Roskilde. A wooden sculpture "head of Christ" from the dome of Roskilde's "Triumfkrucifiks" was shown to have been painted over. Did the two pieces of art originally belong together and were part of the early french gothic aspect of this church? Were they made in France or in Denmark?

The answer: Only the relief furnished coccoliths. Their Maastrichtian aspect points to a local origin of the painting ground and thus the object, rather than to an import from France.

Other medieval Churches in Scandinavia and northern Europe

In medieval Norway and other Scandinavian and north european countries, chalk ground was used to level and smooth the surface of wooden sculptures and panels before painting. The special interest of studying medieval chalk grounds from Norway was based on the fact that here exceptionally many medieval paintings are preserved and that white chalk is not available in Norway itself. This led to several questions:

- where had the chalk come from?
- was the same source of chalk used everywhere in Norway?
- was the same source of chalk used through the time from 1100-1550?
- does there exist any link between chalk provenance and style?

To answer these questions, the distribution of chalk in an area where it reasonably could have come from had to be investigated. The distribution of chalk is quite well known in general. Less well known is, however, the distribution of the various coccolith zones in outcrops or quarries that might have existed at the time and that were of easy access to sea transport.

Over 100 tiny samples from art objects from churches were analyzed in the 1970-1980ies and their zonal assignment determined mainly according to Sissingh (1977). First results were published by Perch-Nielsen (1972) and in Plahter et al. (1974). Further investigations answering the above questions were presented in von Salis and Plahter (in press, 1995) and are summarised below.

The chalk used has come from different sources. During the 12th and the early 13th century, chalk of late Maastrichtian age (including *Nephrolithus frequens*) was used widely in the north and east of Norway. This is possibly linked to the stylistic impulses received from southern Scandinavia and northern Germany during that time. In the western bishoprics, exclusively older chalk was used, the origin of which most likely was southern England or the Channel region. The chalk trade seems to have changed around 1250, when the latter type of chalk was used all over Norway at the same time as an increase in influence of English style can be found in the whole of Norway. Late medieval objects increasingly include the young chalk, a feature that conforms with the increased influence from northern, now hanseatic Germany.

Besides objects from Norway, also chalk-grounds from ancient works of art from the Fœrø Islands, Iceland, Sweden, Belgium and England were investigated and presented in von Salis and Plahter (in press, 1995). While the "virgin" (period 1250-1400) from Kyrkjebø on the Fœrø Islands included an upper Maastrichtian ground possibly deriving from Denmark, chalk ground from Mörivellir on Iceland from the period of 1250-1350 contained a Turonian coccolith assemblage and thus chalk from England or the Channel region. A 12th century crucifix from Hemse, Sweden included a Santonian coccolith assemblage, while the sample from St. Halvard from Skresvik furnished a late Maastrichtian age.

The Belgian works of art dating from the 13th through the 17th century and including a Rubens and two Vermeer paintings all contained chalk of Santonian to Campanian age. These findings are partly supported by those of Robaszynski (1988) who describes the presence of Santonian white chalk from a medieval cave below the "Ancienne Maison De Greef".

Švábenická (1993) reported Maastrichtian nannofossils from High Gothic paintings in Bohemia.

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NANNO NOTES: AN INTERACTIVE DIGITAL IMAGE CATALOG OF CENOZOIC CALCAREOUS NANNOFOSSILS

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Poster session

Nanno Notes is an icon-driven digital image catalog consisting of over 600 illustrated calcareous nannofossil taxa with original descriptions. The present version of the catalog was developed for the Ocean Drilling Program to assist their micropaleontologists at sea where hard-copy literature resources are limited. The program would also be useful for students, teachers, and experienced professionals making or refining taxonomic identifications at the microscope. The program is written for the Windows operating environment and, at this writing, has been delivered to ODP for beta- testing aboard the JOIDES RESOLUTION.

When the program is opened, the first or "main" icon screen presents the investigator with icons for 20 families, closely related family groups and the catch-all "Incertae sedes". Clicking on an icon with the right button of the mouse brings up a short text definition of the group, whereas clicking the left mouse button brings up a second icon screen that displays the genera within the selected group. From this second screen generic definitions can be called up as before with the right button of the mouse; the left button, however, brings up a scroll list of species within the genus. Clicking on a species name in turn brings up a text description and a set of illustrations of the taxon. Illustrations for up to 4 similar species can also be called up and compared simultaneously on the computer screen.

THE INITIATION OF NORTH ATLANTIC DEEP WATER AS DATED BY NANNOFOSSILS

Wuchang Wei

Monday, 14.00

The relatively warm, salty North Atlantic surface water flows into the Norwegian-Greenland Sea, releases heat and becomes cold. The resulting denser water sinks and spills over the sill between Greenland and Iceland (Denmark Strait) and between Iceland and Scotland. This is North Atlantic Deep Water (NADW), which follows contours through the western Atlantic, moves southward and ultimately spreads into the South Atlantic, Indian Ocean, and Pacific Ocean. NADW plays a vital role in the ventilation of the world's deep oceans, distribution of nutrient contents of deep water, and redistribution of planetary heat budget. Variations in NADW have been considered to be an important factor controlling glacial-interglacial changes in atmospheric CO^2. It is thus fundamental to understand the history of NADW. A basic question of when NADW was initiated still remains largely unanswered. A number of studies (e.g., Schnitker, 1980; Blanc et al., 1980; Woodruff and Savin, 1989) proposed that NADW began in the middle Miocene (13-15 Ma); Miller and Fairbanks (1985) suggested that NADW existed as early as the Oligocene; Wright et al. (1992) argued that NADW was produced from 20 to 16 Ma, and again from 12.5 Ma to the present. All these studies were based on relatively indirect evidence (mostly carbon isotope data) from mid to low latitudes.

Here I use more direct evidence from ODP Hole 642B in the Norwegian Sea and Hole 918D just south of the Denmark Strait to constrain the initiation of NADW. The interval from the middle of Core 642B-19 down to the bottom of the hole (early Miocene) is virtually non calcareous and the benthic foraminifers are very rare and almost exclusively agglutinated assemblages. NADW was apparently absent during this time, when the Norwegian Sea water was stagnant and bottom water was corrosive to carbonate. The interval above the middle of Core 19 is calcareous, with abundant nannofossils, planktonic and benthic foraminifers. This indicates the presence of NADW, which ventilates the Norwegian Sea and enhances the production and preservation of calcareous planktonic and benthic organisms. Core 19 is above the last occurrences of

Cyclicargolithus floridanus and *Calcidiscus premacintyrei* (both 12 Ma) and below the last occurrence of *Coccolithus miopelagicus* (11 Ma). The initiation of NADW is thus dated at about 11.5 Ma.

Core 38 of Hole 918D south of the Denmark Strait contains glauconitic hardgrounds and glaucony rip-up clasts. Benthic foraminiferal assemblages with Norwegian Sea affinity begin to occur above this core. This suggests that Norwegian-Greenland Sea deep water began to overflow the Denmark Strait sill at this time. This level is also above the last occurrences of *C. floridanus* and *C. premacintyrei* and below the last occurrence of *C. miopelagicus*. This also suggests that NADW began at about 11.5 Ma.

Various sources of data from other areas are also reviewed and shown to be consistent with my interpretation here.

CALCAREOUS DINOFLAGELLATE CYSTS AT THE K/T BOUNDARY OF THE GEULHEMMERBERG (LIMBURG, THE NETHERLANDS)

Helmut Willems

Wednesday, 9.40

The association of calcareous dinocysts is described for the first time from the K/T boundary at the Geulhemmerberg (South Limburg, The Netherlands). A high diversity of 31 morphotypes has been found, and 2 additional morphologically related incertae sedis organisms of the genus *Bonetocardiella*. The dinocysts can be related to the three subfamilies of calcdinocysts belonging to the family Calciodinellaceae DEFLANDRE 1947 within the Peridiniinae: the Orthopithonelloideae with an orthogonal (radial), the Obliquipithonelloideae with an irregularly oblique, and the Pithonelloideae with an uniquely oblique orientation of the crystallographic c-axis of the calcite crystals relative to the cyst surface.

The placement of the K/T boundary based on the vertical distribution of the calcdinocysts has to be taken with caution as there is no clear evidence how much of the material has been reworked from the Campanian and Maastrichtian. In the uppermost Maastrichtian as well as in the lowermost Danian, the quantitatively dominating representatives are the Pithonelloideae, nearly exclusively *Pithonella sphaerica*, accompanied by up to 14 % Bonetocardiella spp. Thus, both forms cross the K/T boundary, which is new for the latter form. Whereas in the Maastrichtian, *Pithonella* and *Bonetocardiella* occur exclusively, Obliquipithonelloideae and Orthopithonelloideae occur with higher diversities in the lowermost Danian. Most dinocysts in the Danian (22 of the 31 species) are survivors of the boundary event, and only 8 species first appear above the K/T.

The diversities of the Obliquipithonelloideae and Orthopithonelloideae show a variable distribution closely connected to changing lithofacies. With up to 18 species, the diversity is highest in the clay layers, especially in Clays A, B, C, and E. In these horizons, the number of orthopithonelloid dinocysts increases in comparison to the obliquipithonelloid ones. In general, the lowest diversity is observed within the calcarenites, and in some horizons this correlates with the lowest frequency of specimens. The cyclic diversity distribution of calcdinocyst morphotypes may possibly be attributed to sea-level changes, whereas the maximum transgression correlates to the diversity as found in clay layers A/B, C, and E.

LIVING COCCOLITHOPHORID ASSEMBLAGES OFF THE PUERTO RICAN SHELF

A. Winter and R.W. Jordan

Monday, 9.40

In recent years, living coccolithophorids have received a great deal of attention, mainly through the activities of the *Emiliania huxleyi* programmes. However, since the contributions of Okada and colleagues in the 1970's, little has been added to our knowledge of the composition of assemblages and of the spatial and temporal distributions of these organisms. This paucity of new information has been influenced by a number of factors; a decrease in the funding of floristic studies, a dwindling of taxonomic expertise, and the ever-increasing cost of running ocean-going research vessels. In addition, many scientific cruises are of a short duration and contain a multidisciplinary team of researchers, resulting inevitably in a compromised sampling strategy. This state of affairs has led many phytoplankton workers to become opportunistic samplers.

At La Parguera (Puerto Rico), the University of Puerto Rico has marine research facilities, including a small boat capable of collecting oceanographic data. Over the last three years, water samples have been taken at intervals of two to three weeks from a number of depths (between 0-140 m) at a station (1000 m water depth) located off the island shelf. The aims of this project are 1) to study the seasonality and annual variation within the phytoplankton community at a single station, 2) to assess the contribution made by the coccolithophorids and to characterise their species assemblage(s), 3) to determine the effect on the community of the northward migration of the Orinoco River outflow, and 4) to combine this floral data with the oceanographic information collected *in-situ*, in order to evaluate the possible ecological preferences of individual species/assemblages.

The samples have been filtered and are now being analyzed. Preliminary observations of the filtered samples suggest that diatoms and coccolithophorids compete for the shelf space throughout most of the year. This reflects the dynamic physical and oceanographic setting of the shelf environment. Within the coccolithophorid community, *Gephyrocapsa oceanica* has been especially abundant in October when the Orinoco River outflow migrates northwards, whilst *Emiliania huxleyi* and species characteristic of subtropical gyres are common from March to August. However, occasionally coccolithophorids are entirely absent from shelf waters and diatoms predominate. On one occasion calcite precipitating bacteria were the major component at the station. Our studies indicate that the shelf and slope of Puerto Rico are much more dynamic than previously thought.

NON - CONVENTIONAL NANNOPLANKTON BIOSTRATIGRAPHY APPLIED TO BIOSTEERING HORIZONTAL WELLS

Charles R. Young

Wednesday, 14.50

Non-conventional biostratigraphic techniques were successfully used in steering and maintaining two horizontally drilled North Sea wells (2/4 A-21a, 2/4 A-2a) in a restricted target zone (upper third of the reservoir unit). The techniques were initially applied to the 2/7-14x (well nearest site of first horizontal well). Verification of these techniques in both the 2/4 A-21a (first horizontal well), and the 2/4 A-8 (well nearest site of second horizontal well) eliminated the need for drilling, coring, and logging a pilot hole in the 2/4 A-2a.

These techniques, which provide high resolution nannoplankton zones with finer resolution than the conventional NN-NP or CN-CP zones, were used to subdivide the major Tertiary reservoir unit (reworked Cretaceous Zone, Field Layer ED) of the Ekofisk Field into three units. These techniques include: (a.) population dynamics, (b.) polar ordination, (c.) morphometric analyses, and (d.) synchronous variation of nannofossil assemblages and petrophysical parameters.

a) The middle unit of the reworked Cretaceous zone was defined by a marked increase in the abundance of *Lucianorhabdus cayeuxii* plus the influx of reworked Campanian taxa.

b) Polar ordination of the nannoplankton assemblages through layer ED verified the three subzones, plus the possibility of a fourth.

c) Morphometric measurements of the reworked Cretaceous taxa *Arkhangelskiella cymbiformis* reflected the same three subdivisions.

d) Two "spikes" in *Thoracosphere-Calcisphere* abundance, which can be used as a proxy for silica abundance, flag two porosity-permeability partitions in the reservoir. These partitions occur at, or near, the subzone boundaries.

The technology, techniques and zonal scheme, was transferred to the Stavanger office and was subsequently used, on wellsite, by paleontologic consultants during the drilling of both horizontal wells.

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COCCOBIOM - A LIGHT MICROSCOPE BASED IMAGE CAPTURE AND MORPHOMETRICS APPLICATION FOR *EMILIANIA HUXLEYI* AND OTHER COCCOLITHS

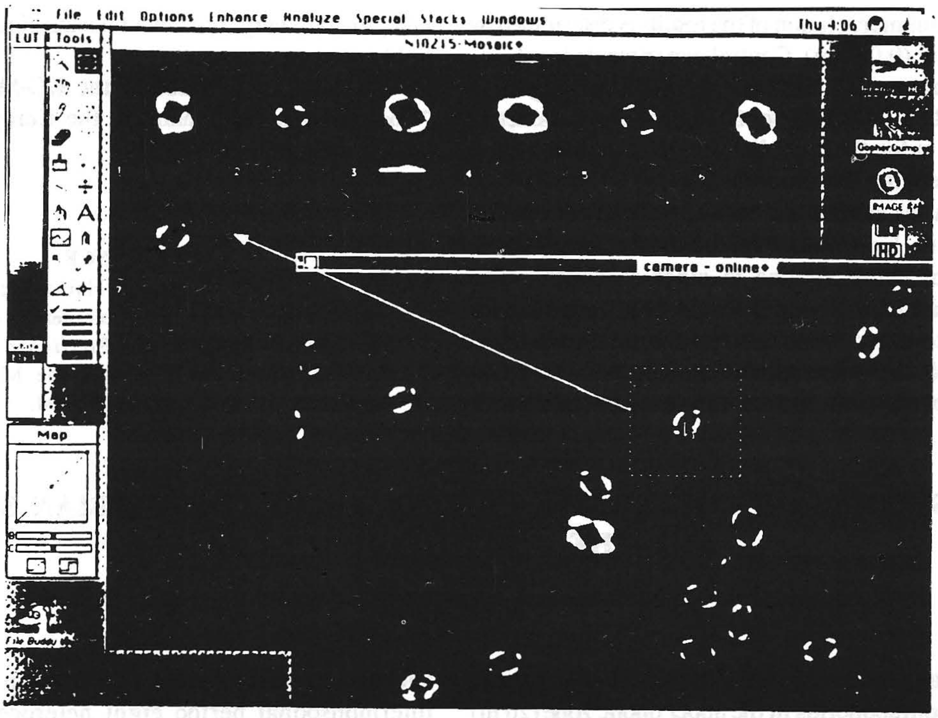
Jeremy R. Young, Jackie A. Burnett, and Michal Kučera

Monday, 15.15

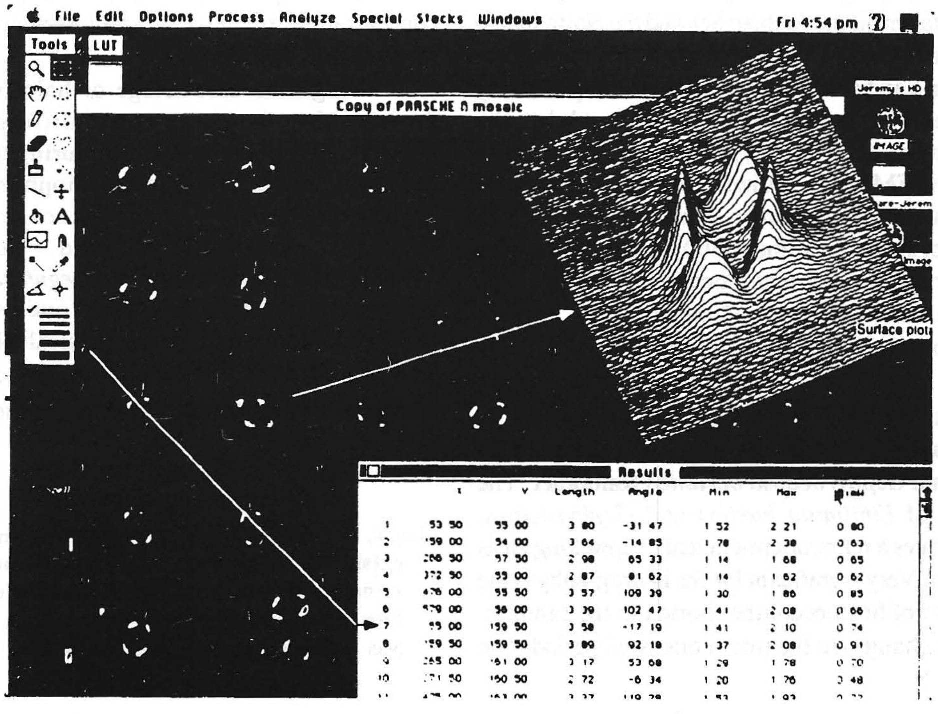
In order to produce quantitative data on key aspects of the morphology of *Emiliania huxleyi* coccoliths an automated image analysis system has been developed (Young et al. in press). The system is based on an Apple MacIntosh microcomputer with direct image capture from a Zeiss Axioplan Photomicroscope via Sony XC77 8-bit CCD and Perceptics Framegrabber. Cross polarised light images are used. The software used is NIH-Image, developed by W. Rasband of the National Institutes of Health. Within this package the macro programming language has been used to develop a coccoliths biometrics application. The application consists of two parts, image capture routines and biometrics routines.

For the image capture routines the user identifies coccoliths on the live image by placing the cursor within their central area. The coccolith image is then copied into a composite mosaic image. The final mosaic images consist of 60 separate coccolith sub-images in a regular array.

The biometric routines commence with identification of the most distinctive feature of the coccolith images, the four maximum brightness peaks. These are used to determine the geometric centre of the coccolith. Using this centre, an ellipse fit is then performed on the four peaks plus some additional points on the central area edge. This gives the orientation, length and width of the central area ellipse. The outer edge of the coccolith is then located at four



A. IMAGE ACQUISITION
Screen grab showing live image, direct from microscope and mosaic image used for specimen storage. Specimens are selected with the cursor in the live image and transferred to the mosaic image with a single mouse click. Creating a mosaic image of 60 specimens takes 10-15 minutes.



B. IMAGE ANALYSIS/MORPHOMETRICS
Screen grab showing mosaic, after specimens have been measured and the resultant data file. The measurement process is entirely automated and takes about 2 minutes per mosaic. A manual data verification step is then needed. The surface plot is a representation of brightness over one specimen (#14) in the mosaic image, it shows the birefringence peaks which are a key feature used in the image analysis.

Figure: *Coccobiom* Morphometric system. The system to be used for producing quantitative data on *Emiliania huxleyi* morphometric variation. This is based on capture of cross-polarized light microscope images to a Macintosh computer using the program NIH-Image and a custom set of macros.

points on radial transects outward from the maximum brightness peaks and the rim width is calculated from these points. The measured results are stored and displayed graphically on the image. This process is entirely automatic and is repeated on each specimen of the mosaic image. After this automated phase the user reviews the displayed results and additional macros allow rapid manual correction of suspect results. This is rarely needed for the central area measurements but is often needed for the rim width determination.

The maximum resolution of the results is determined by the pixel width (0.06 μm). Control experiments involving repeat measurements of individual coccoliths suggest an accuracy of about +/-0.1 μm for the central area parameters and +/-0.2 μm for the coccolith length (calculated from central area length + 2 x rim width).

Although the system has been specifically developed for work with *Emiliania huxleyi* it has considerable potenrtial for being applied to other coccoliths. The automated biometric routines would need rewriting for application to other coccoliths but the semi-automated routines are of much wider application. The mosaic creation routines are of universal applicability for nannofossil work and provide a very convenient means of rapidly collecting light microscope images.

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STUDIES OF COCCOLITHOPHORIDS FROM THE ARABIAN SEA AND THE NORTH INDIAN OCEAN

Alexandra Zeltner

Poster session

The assemblage composition and the distribution pattern of living coccolithophorids in the upper photic zone (20 m) of the Arabian Sea is described. Sampling was carried out during March and May 1995, R.V. METEOR-cruise M31/3 and M32/3. Employing water samplers, 229 nannoplankton samples were taken off the Arabian Sea and the North Indian Ocean between 20 and 2500 m water depth. While sampling the atmospheric and oceanic circulation was impressed by the northeastern monsoon (March) and by the intermonsoonal period (May). Scanning Electron Microscopy (SEM) was utilized for the taxonomical identification and to quantify the standing crop of coccolithophorids. At minimum 300 coccospheres were counted on transects at a magnification of 4500_ (each field measured 374 _m^2). More than 30 hetero-coccolithophore and six holococcolithophore species were recorded in samples collected March 1995, during northeastern monsoon. The floral assemblage during that time is dominated by *Emiliania huxleyi* (Lohmann) Hay and Mohler and *Gephyrocapsa oceanica* Kamptner. The cooccurrence of *Emiliania huxleyi* and *Gephyrocapsa oceanica* indicates a nutrient-enrichment in upwelling areas (Kleijne 1993). Very significant for the hydrography is the low abundance of holococcolithophorids in the samples. This situation changes in the intermonsoonal period. The species diversity seems to be much lower. In the intermonsoonal period eight heterococcolithophore, dominated by *Umbellosphaera irregularis* Paasche and *U. tenuis* (Kamptner), and an increased number of holococcolithophore species, which prefer a low nutrient concentration, occur. This species composition reflects oligotrophic conditions.

Although the assemblage of holococcolithophores during May is completely different from the holococcolithophore community during the northeastern monsoon, some heterococcolithophore species like *Emiliania huxleyi*, *Gephyrocapsa oceanica*, *Discosphaera tubifera*, and *Coronosphaera mediterranea.*, *Umbellosphaera irregularis*, and *U. tenuis* are recorded in the samples of both cruises. These species show a wide range of physico-chemical tolerance.

This distinct temporal distribution reflects the seasonal change of oceanic currents as a result of monsoon.

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PROGRAMME

2nd - 7th September 1995

Monday, 4 September

8.30-9.15	**REGISTRATION**
9.15-9.40	**INTRODUCTION AND WELCOME**
9.40-10.05	**A. Winter and R.W. Jordan** : Living coccolithophorid assemblages off the Puerto Rican shelf
10.05-10.20	**TEA - COFFEE BREAK**
10.20-10.45	**Dorothea Janofske, Helmut Keupp and Helmut Willems** : Calcareous dinoflagellate cysts: ultrastructure types and systematic application
10.45-11.10	**Harald Andruleit** : Production, Sedimentation and Preservation of Coccolithophores in the northern North Atlantic
11.10-11.35	**Mário Cachão and M.T. Moita** : *Coccolithus pelagicus*, a sort of productivity proxy ?
11.35-12.00	**Lluïsa Cros** : Coccolithophorid distribution across a transect between the Iberian Peninsula and the Balearic Islands (northwestern Mediterranean Sea)
12.00-12.25	**Alex Chepstow-Lusty and Mark Chapman** : An examination of the global relationship between the last two "species" of Discoasters at the end of the Pliocene.
12.25-12.50	**Xin Su** : Development of the Plio-Pleistocene coccolith assemblages in the NE Atlantic correlated to climatic changes
12.50-14.00	**LUNCH**
14.00-14.25	**Wuchang Wei** : The initiation of North Atlantic deep water as dated by nannofossils
14.25-14.50	**Beate Kerntopf** : Calcareous dinoflagellates of the equatorial Atlantic Ocean
14.50-15.15	**Helge Thomsen** : Polar coccolithoporids
15.15-15.40	**Jeremy R. Young, Jackie A. Burnett, and Michal Kucera** : Coccobiom - a light microscope based image capture and morphometrics application for *Emiliania huxleyi* and other coccoliths.
15.40-16.00	**TEA - COFFEE BREAK**
16.00-16.25	**Patras Dimitris Frydas** : Biostratigraphy using silicoflagellates and calcareous nannofossils of Neogene-Pleistocene deposits of Greece
16.25-16.50	**Priscilla J. Militante-Matias and Marietta M. de Leon** : A study of the foraminiferal and calcareous nannoplankton assemblages of core samples taken from the Lahar-affected portions of the South China Sea in Zambales Province, Philippines
16.50-17.15	**Jacques Giraudeau and Geoffrey W. Bailey** : Sediment trap studies of coccolith and planktonic foraminiferal fluxes in the Benguela upwelling system

Tuesday, 5 September

9.15-9.40	**Koji Kameo, Tokiyuki Sato, and Toshiaki Takayama** : Late Pliocene nannofossil bioevents and their biostratigraphic and paleoceanographic meanings
9.40-10.05	**Nicolae Mészáros** : Nannoplankton in the volcanic tuffs of the Transylvanian Basin (Miocene)
10.05-10.20	**TEA - COFFEE BREAK**
10.20-10.45	**GROUP PHOTO**
10.45-11.10	**Viviane Reale** : Paleoecology of calcareous nannofossil assemblages and its relationship to sea-level variations in the Figols Group (Early Eocene, Spanish Pyrenees)
11.10-11.35	**Eric de Kaenel** : Paleocene to Early Eocene calcareous nannofossil biostratigraphy based on the EL-Kef section (Tunisia)

11.35-12.00	**James J. Pospichal** : Calcareous nannoplankton, Tsunamites, and the K/T boundary of northeastern Mexico
12.00-12.25	**Akmal M. Marzouk and Mohamed K. Abou-El-Enein** : Calcareous nannofossil biostratigraphy of the Late Cretaceous-Early Tertiary of Wadi Feiran and Gebel Qabeliat, south western Sinai, Egypt
12.25-12.50	**Yoram Eshet and Ahuva Almogi-Labin** : Calcareous nannofossils as paleoproductivity indicators in Campanian-Maastrichtian upwelling systems
12.50-14.00	**LUNCH**
14.00-14.25	**Jim A. Bergen** : Cenomanian nannoplankton minor extinctions in low to mid-latitude shelf sections: calibration to ammonite and sequence stratigraphy (abstract missing)
14.25-15.40	**POSTER SESSION**
15.40-16.00	**TEA - COFFEE BREAK**
16.00-17.40	**POSTER SESSION**

Wednesday, 6 September

9.15-9.40	**Jean Self-Trail** : Late Cretaceous biostratigraphy and paleoceanography of the Atlantic Coastal Plains, USA
9.40-10.05	**H. Willems** : Calcareous Dinoflagellate Cysts at the K/T Boundary of the Geulhemmerberg (Limburg, The Netherlands)
10.05-10.20	**TEA - COFFEE BREAK**
10.20-10.45	**F. Naji** : Calcareous nannoplankton biostratigraphy of the Salzgitter-Salder Limestone Quarry, Lower Saxony, Germany
10.45-11.10	**Jorg Mutterlose** : Calcareous nannofossil paleoceanography of the Lower Cretaceous of northwest Europe
11.10-11.35	**Andrea Fiorentino** : Maastrichtian nannofossil biogeography in the Southern Tethys
11.35-12.00	**Francesca Lozar** : Calcareous nannoplankton biostratigraphic analysis as a tool for the study of discontinuity surfaces in the Cretaceous of the Trento Plateau (southern Alpine, Italy)
12.00-12.25	**Marie-Christine Janin, Yann Samson, Maria Saint-Germès, François Baudin and Gérard Bignot** : Comparative variation of calcareous nannofossils (especially Ellipsagelosphaeraceae), foraminifers and organic matter concentration in the Kimmeridgian sequence from la Brière (Normandy, France)
12.25-12.50	**P.R. Bown and C. Ellison** : Jurassic-Early Cretaceous calcareous nannofossils from the Neuquén Basin, Argentina
12.50-14.00	**LUNCH**
14.00-14.25	**Katharina von Salis** : Calcareous nannofossils in the arts
14.25-14.50	**Magdy H. Girgis** : High resolution nannoplankton biostratigraphy and steering horizontal wells (abstract missing)
14.50-15.15	**Charles R. Young** : Non-Conventional Nannoplankton Biostratigraphy Applied to Biosteering Horizontal Wells
15.15-15.40	**Martin Jakubowski** : Biostratigraphy in the oil industry
15.40-16.00	**TEA - COFFEE BREAK**
16.00-16.25	**David Jutson** : The Case of the Missing Nannofossil or "Now you see it, now you don't".
16.25-16.35	**FAREWELL ADDRESS**
18.30	**CONFERENCE DINNER** Søpavillonen, Gyldenløvegade 24, Copenhagen K.

POSTERS

J. Alcober and R.W. Jordan : *Neosphaera coccolithomorpha* and *Ceratolithus cristatus* : are they the same species?

Filomena Ornella Amore : Calcareous nannofossils from Calvello Basin (southern Apennines, Italy)

Gregor Bischoff and Jörg Mutterlose : The turnover of calcareous phytoplankton from the Barremian-Aptian boundary interval in NW Europe

P.R. Bown, S. Davies, J. Didymus, T.W. Ehrendorfer, S. Mann and J.R. Young : Coccolith building blocks: high-resolution analyses of Heterococcolith morphology and crystallography

Jackie Burnett : Albian/Cenomanian to K/T Stage boundaries and nannofossil events: increased precision in Upper Cretaceous nannofossil biostratigraphy and correlation

Georges Busson, Denise Noël, Françoise Monniot and Annie Cornee : Some calcareous nannofossils misinterpreted in literature as *Tetralithus, Triquetrorhabdulus, Fusellinus* sp. Are actually spicules of *Didemnum* ssp. (Tunicata, Ascidian). Evidence from Upper Jurassic sediments of Charentes (W. France)

A. d'Atri, A. Novaretti, R. Ruffini, M.A. Cosca and J.C. Hunziker : Calcareous plankton biostratigraphy and $^{40}Ar/^{39}Ar$ dating of volcanic ash layers from Monferrato (NW Italy) (abstract missing)

Agata Di Stefano : Calcareous nannofossils biostratigraphy of the Plio-Pleistocene deposists of the Peloritani Mountains (NE Sicily)

Y. Eshet, T. Minster, S. Moshkovitz : Calcareous nannofossil datum levels: a key for the understanding of the genesis of Upper Cretaceous oil shale sections in Israel Campanian-Maastrichtian Oil Shale

Y. Eshet and S. Moshkovitz : Calcareous nannofossil biostratigraphy in Santonian-Maastrichtian organic-rich carbonate sections in Israel

Claire Findlay : Calcareous nannoplankton from the Australian Sector of the Southern Ocean

J.A. Flores, F.J. Sierro, I. Zamarreno, A. Vazquez, R. Utrilla and G. Frances : An Example of Eutrophic-Oligotrophic alternances in the Lower Messinian: The Sorbas Basin (Western Mediterranean)

Silvia Gardin and Nicola Perilli : Early Cretaceous calcareous nannofossil biostratigraphy of the internal Ligurids (northern Apennines, Italy) and the onset of coccolith-bearing sediments in the Ligurian-Piedmont oceanic domain

William W. Hay : Oceanic fronts in the Mesozoic

Tania Hildebrand-Habel and Helmut Willems : Calcdinocysts from the middle Coniacian to upper Santonian chalks at Laegerdorf (N Germany)

Ramses P. Hoek and Karin A.F. Zonneveld : Upwelling related dinoflagellate cyst associations of the Benguela current system.

Christine Hoell : Correlation of calcareous and organic-walled dinoflagellate cyst associations in glacial/interglacial cycles, an example of the Equatorial Atlantic

Glen Homeier : Mid-Cretaceous calcareous nannoplankton in an organic-rich facies of the Subbetic and Penibetic (Betic Cordillera, southern Spain)

Richard Howe : Mid-Late Cretaceous nannofossil biostratigraphy of the Papuan Basin, Papua, New Guinea

Dorothea Janofske, Helmut Keupp and Helmut Willems : Calcareous dinoflagellate cysts: ultrastructure types and systematic application

Helmut Keupp : Calcareous dinoflagellate cysts of the Late Albian and their environmental deductions (borehole Kirchrode 1/91, Germany)

Ulrike Kienel : Development of calcareous dinoflagellate cysts (Calciodinellaceae Deflandre, 1947) at the Cretaceous-Tertiary boundary (NE Germany, Denmark)

U. Kienel, U. Rehfeld, S. Bellas and R. Kohring : The Miocene Blue Clay Formation of the Maltese Islands: Sequence-stratigraphic and paleoceanographic implications based on calcareous nannofossil stratigraphy and calcareous dinoflagellatc cysts.

H. Kinkel, N. Dittert, K.H. Baumann : A 300 kyrs calcareous plankton record of the equatorial South Atlantic: Reconstructions of surface water productivity and bottom water dissolution cycles

Anna Lototskaya and Patrizia Ziveri : Calcareous nannoplankton response to termination II and Heinrich event (140-110 KA BP) in the NE Atlantic

Patrizia Maiorano, Maria Marino and Simonetta Monechi : Pleistocene calcareous nannofossil biostratigraphy of Site 577 Leg 86, Northwestern Pacific Ocean

Maria Marino : Calcareous nannofossil biostratigraphy of early-middle Pleistocene terrigenous sediments (Southern Italy)

Emanuela Mattioli and Nicola Perilli : Calcareous nannofossils biostratigraphy of the Fuentelsaz (Spain) and Fiuminata (Italy) Sections: Late Toarcian-Early Aalenian

E. Mostajo, A. Concheyro, F. D zquez : Calcareous Nannofossils (Hauterivian) from "Agua de la Mula " Section, Neuquén Province, Argentina.

András Nagymarosy : The nannoplankton of the Jaslo Limestone horizons

Jernej Pavšič and Tadej Dolenec : Floristic and isotopic changes at the Paleocene-Eocene boundary in Slovenia

Alyssa Peleo-Alampay : Morphometric and Biochronologic Study of Coccolithus miopelagicus

James J. Pospichal : Calcareous nannofossils, Tsunamites and the K/T boundary of northeastern Mexico

M. Prámparo, W. Volkheimer, and E. Mostajo : Calcareous nannofossils and palynomorphs from Valanginian and Hauterivian (Lower Cretaceous) strata of Cerro de la Parva, central-western Neuquén, Argentina.

Anna Romaniv : Calcareous nannoplankton from the boundary deposits of Maastrichtian and Danian of the Ukrainian Carpathians

Antonieta Sanchez-Rios, Héctor Ruiz-Ruiz, Patricia Padilla-Avila, and J. Manuel Grajales-Nishimura : Nannofossils and planktic foraminifera across the K/T boundary in two sections of northeastern Mexico

Tokiyuki Sato and Koji Kameo : Late Pliocene nannofossil events recognized in the uppermost sequence in the Japan Sea side, with reference to the glaciation in the Arctic Sea

William G. Siesser : Paleogene and Neogene productivity in the Indian Ocean

Lilian Švábenická : Rare occurrences of *Petrarhabdus copulatus* Deflandre on the northern hemisphere (Central Europe)

Erik Thomsen : The Danian (Lower Paleocene) limestone deposits in Denmark: basin development and sequence stratigraphy.

Maola Ushakova : Changes of calcareous nannoplankton evolutionary diversity during the Paleogene

S. Volin, Y. Eshet, and H. Kish : Utility of calcareous nannofossils and organic remains: in the reconstruction of thermal metamorphism in the Hatrurim Formation (Tertiary, southern Israel)

Sherwood W. Wise, Jr., Linda Tway, Darren D. Milman, William C. Payton, James J. Pospichal, Jay Muza, Patrizia Maiorano, Andrea Concheyro, Giuliana Villa, Katharina Perch-Nielsen, Laurel M. Bybell, Jean M. Self-Trail, William L. Murphy, William R. Riedel, and Yan Xu : Nanno Notes: An interactive digital image catalog of Cenozoic Calcareous Nannofossils

Alexandra Zeltner : Studies of Coccolithophorids from the Arabian Sea and the North Indian Ocean