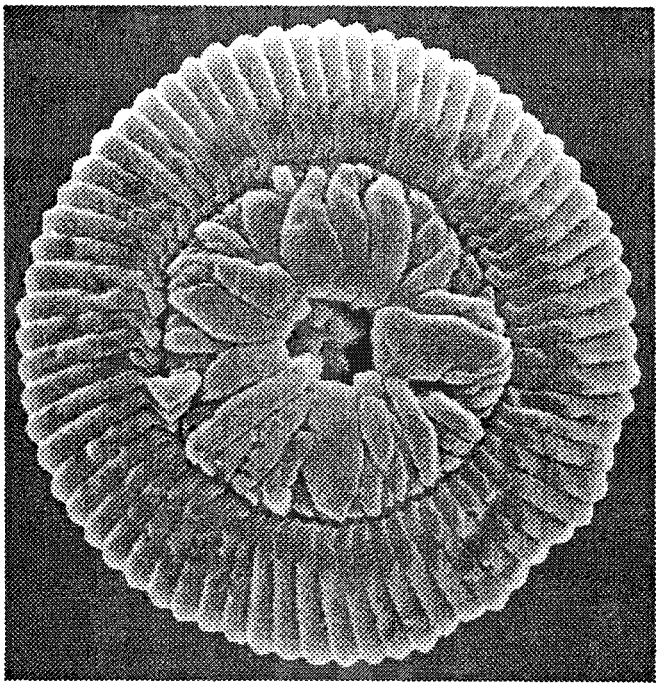
JEREMY YOUNG

INA NEWSLETTER



5th INA CONFERENCE, SALAMANCA 1993

ABSTRACTS

INTERNATIONAL NANNOPLANKTON ASSOCIATION

VOLUME 15 NUMBER 2 1993

JEREMY YOUNG

INTERNATIONAL NANNOPLANKTON ASSOCIATION

5th CONFERENCE

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ABSTRACTS

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EDITORS NOTES AND ACKNOWLEDGEMENTS

The abstracts are not exactly as submitted since this volume was mainly produced via a Kurzweil text scanner - which converted the heterogeneous original copy into word processor files. The accuracy of scanning is dependant on the print quality of the originals and despite checking it is inevitable that some errors will have been introduced. Accents are a special problem, since they have to be individually re-inserted, and some will have been lost. We have made corrections to spelling (including standardisation to UK spelling) - and to grammar where there were obvious problems with English usage. There has, however, been no scientific editing or vetting of the abstracts, other than removal of other *nomina nuda*.

Some addresses have been shortened to save space, full postal addresses can be found in the INA Membership directory (INA Newsletter 14/3, p.118-124)

The format adopted is virtually the same as for the Prague Abstract volume (INA Newsletter 13/2, 1991), including the use of topic codes similar to those used in the INA Bibliographies. These codes are (1) Age range covered. (2) Geographical provenance of studied material. (3) General topic of paper, N.B. *Biostratigraphy* - applied biostratigraphic study. *Zonation* - development of zonation scheme. (4) Particular feature of the abstract.

We are very grateful to the co-operative set of authors who sent abstracts by E-mail or on disk, and to most authors for submitting their abstracts on or near the dealine and for closely observing the reference format, etc.

Jeremy R. Young, Paul R. Bown

Abbreviations in the abstracts.

a, ka, Ma - year, 1000 years, 1,000,000 years e.g. "deposition occurred over a 1Ma period".

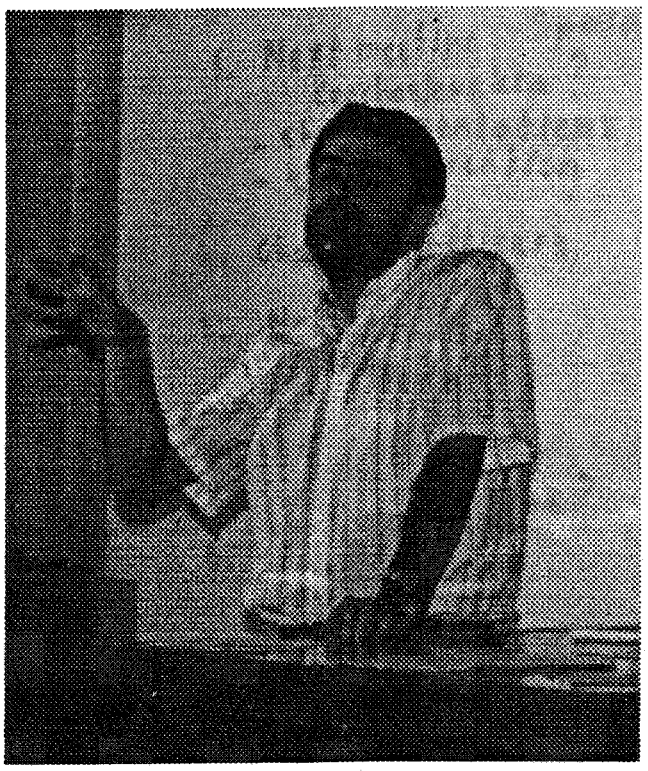
a, ka, Ma - 1 year ago, 1000 years ago, 1,000,000 years ago; e.g. "deposition occurred between 19 and 20Ma". We have applied this as a standard system throughout the volume.

P'ecol/oc - palaeoecology and palaeoceanography

s.s. - *sensu stricto*, narrow definition.

s.l. - *sensu lato*, broad definition.

p.p .- pro parte; in part



Florence 1989 - José invites the INA to come to Salamanca.
(Photo Ben Prins)

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TITHONIAN AND CRETACEOUS CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY IN THE BETIC CORDILLERA (SOUTHERN SPAIN).

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Topics: Tithonian-Maastrichtian, S. Spain, Biostratigraphy

This research has been based upon some 1000 samples from 30 sections of the Penibetic, Subbetic (Internal, Middle and External) and Intermediate Units – palaeogeographic domains of the Betic Cordillera (Southern Spain). They cover a wide geographical area including the provinces of Málaga, Córdoba, Granada, Jaén, Almería and Murcia. Smear slides have been made and studied using the technique of Hay (1970), for relative abundance determination. 180 species have been distinguished (four of them in open nomenclature), grouped into 82 genera, 18 families and one *incertae sedis* group,

The biostratigraphical analysis has lead to differentiation of 26 zones within the Tithonian-Maastrichtian interval (Fig. 1), six of which are modifications of previous biozones, and one is new. Several of these zones have in turn been subdivided, giving rise to 26 subzones (four modified and 13 new). Counting zones and subzones, a total of 41 intervals were differentiated . Correlation of the proposed zonation (based on nannofossils) with those based on other groups (such as ammonites and planktonic foraminifera; Fig. 1) has received special attention. Correlations are high-order ones and have been carried out in all cases using the same sections and, frequently the same samples. The planktonic foraminifera-based zonation has been synthesized from the proposals of Robaszynski *et at.* (1984), Caron (1985) and Aguado *et al.*, (1992). For ammonites, the standard zonation proposed for the Mediterranean Lower Cretaceous at the 2nd Workshop of the Lower Cretaceous Cephalopod Team (IGCP Project 262) held at Mula (2-5 July, 1992) has been used.

From the palaeobiogeographical viewpoint, associations are characterized by the presence of tethyan species, with some boreal influence in the Lower Cretaceous. By comparing our associations with those of higher palaeolatitudes, three periods can be differentiated. First the Tithonian-Barremian interval, when nannofossil biogeographical distribution seems to be controlled essentially by palaeogeographic factors (isolation of the Boreal and Austral realms from the Tethys) and, possibly, by a weak latitudinal thermal gradient (Mutterlose, 1992a,b). The second period (Aptian-Santonian) is characterized by palaeobiogeographical homogeneity, and the distribution of associations is essentially related to neritic-oceanic gradients and to the pattern of oceanic currents (Roth & Krumbach, 1986), together with a weak latitudinal factor. The last period (Campanian- Maastrichtian) is characterized by a palaeobiogeographical distribution whose main control seems to be latitudinal temperature gradients (Wind, 1979a,b).

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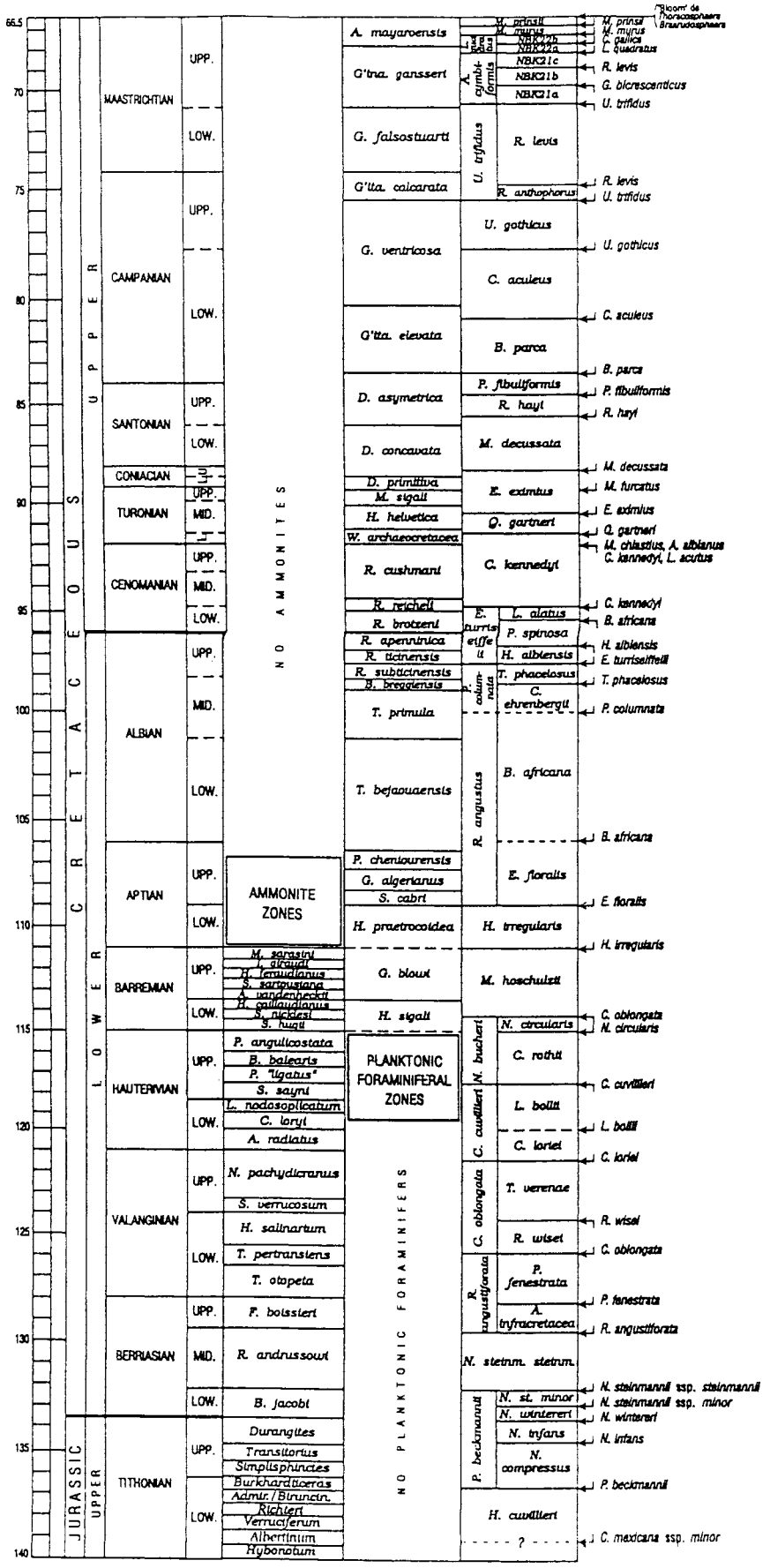

Fig. 1. Calcareous nannofossil zonation for the Tithonian-Maastrichtian interval in the Betic Cordillera and correlation with ammonite and planktonic foraminiferal based zonations.

TERTIARY EVOLUTION OF THE REGENCIA PALAEOCANYON (ESPIRITO SANTO BASIN, BRAZIL) ACCORDING TO CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY

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POSTER Topics: Tertiary, Brazil, Biostratigraphy, Palaeocanyon

The Regência Palaeocanyon is a geological feature of the emergent portion of the Espírito Santo Basin - Brazil (Poster Figs., 1 and 2). Biostratigraphical analyses based on calcareous nannofossils were carried out on samples from 26 exploratory wells. The zonation utilized is shown in Figure 3 together with the biostratigraphic schemes of Martini (1971) and Okada & Bukry (1980). All PETROBRAS' biozones are interval zones in which the limits are characterized by the local extinction level of the species which lend their names to the zones.

The results plotted in biostratigraphic sections (Poster Figs 1 and 4 to 7) permitted improvements in the knowledge of the Tertiary sedimentary history of the Regência Palaeocanyon. This important feature was originally carved during one or more erosive episodes penecontemporaneous with deposition of the Regência Member. (Albian, Poster Fig. 2). It was completely filled up in the Middle Eocene (zones N - 445/ N - 450). However, at least six post-Cretaceous erosive episodes (named EVTA to AVTF) have been detected in the Tertiary section. Some of these gave rise to troughs which were partially eroded during subsequent events. The configuration of the preserved parts of the troughs suggests that the main sedimentary flow shifted from north to south during the Tertiary.

Absolute ages with their respective error margins established for each erosive event allowed a tentative correlation between them and the relative sea-level falls in Vail's curve (Poster Figs. 8 and 9). Due to the significant error margins, each event can actually be related to one or more relative falls within a short period.

The biostratigraphic sections indicate that the present-day palaeocanyon limits have not been sculptured by a single erosive event. Contrarily, following the carving of a large trough, subsequent erosive processes have conditioned the construction of smaller internal channels. The appearance of these minor troughs and the shift of the palaeocanyon axis modified and widened the original shape of the initial trough.

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MORPHOMETRICAL VARIATIONS OF QUATERNARY *COCCOLITHUS PELAGICUS* COCCOLITHS FROM THE NORTHERN NORTH ATLANTIC AND THEIR PALAEOCEANOGRAPHICAL IMPLICATIONS

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Topics: L. Quaternary, N. Atlantic, Biometrics, *C.pelagicus*

Consistent variations in the morphometrical distribution patterns of *Coccolithus pelagicus* coccoliths are observed in upper Quaternary sediments of the Norwegian-Greenland Sea. In general, the distal shield of *C. pelagicus* coccoliths show a wide range of size variation, typically 8-16μm in length and 6-14μm in width. Element counts for the distal shield is 30-65. Length, width, and the number of distal shield elements are strongly correlated to each other. This indicates that coccolith size can be determined by the length alone.

The coccolith assemblages in sediments of the Norwegian-Greenland Sea are drastically influenced by glacial-interglacial climatic changes. *C. pelagicus* occurs in high abundances only during oxygen isotope stage 7 and during the Holocene. Within these intervals there is a drastic decrease in size while the interspecific proportions do not change. Although all samples contain specimens up to 15μm, the absolute majority is 8-12μm in length. Assemblages from below and above these intervals only contain larger specimens (generally >10μm).

Investigations of *C. pelagicus* coccolith size variation in surface sediments of the northern North Atlantic show that a decrease in size of the proximal shield occurred towards the north. Whereas on the Rockall Plateau a wide range of size variation occurs, the bulk of specimens are always <12μm in length in the Norwegian-Greenland Sea. In contrast, in sediments from the Fram Strait only very small coccoliths (7-11μm were observed. Thus, it can be inferred that variations in size and abundance of this species probably reflects ecological differences on a genetically unchanged population.

JURASSIC CALCAREOUS NANNOFOSSILS FROM PORTUGAL

James A. Bergen, Amoco Production Company, Houston, Texas

Topics: Jurassic, Portugal, Zonation, Evolution

The Lusitanian Basin in northern Portugal contains an excellent record of late Sinemurian to late Callovian nannofossil evolution. Five basinal limestone/marl sections sampled in detail relative to the ammonite biostratigraphy provided the foundation for a revised biozonation of the Portuguese Lower to Middle Jurassic. The nannofossil zonal framework for northern Europe was adapted to the Portuguese Jurassic (12 zones) with minor modifications. The proposed subzonal framework (29 subzones) for the Portuguese Jurassic is based either on local stratigraphic ranges or taxa whose stratigraphic ranges are not well documented outside of Portugal. Graphic correlation methodology helped identify these subzonal events. An upper Bajocian to upper Callovian section sampled at Mareta Beach in southern Portugal provided additional control. For the Upper Jurassic, nannofossils appear limited to a short stratigraphic interval spanning the Oxfordianan/Kimmeridgian boundary. However, this interval does contain the oldest reported occurrences of the genera *Micrantholithus* and *Eiffelithus*. Pulses of redeposited Lower and Middle Jurassic assemblages were also observed in the two sections sampled in north-central Portugal, whereas a single section sampled in southern Portugal lacked any redeposition. In contrast, such redeposition is much more extensive in northern Europe.

The most striking feature of recovered nannofossil assemblages were two periods of gradual assemblage turnover during the Pliensbachian and Bajocian. The Pliensbachian turnover, evident at the familial and ordinal rank, was associated with a major abundance decrease within the ancestral muroliths (family Crepidolithaceae) and the radiation of the placolith coccoliths. The Bajocian turnover, evident at the generic rank, was most profound within the imbricate placolith family Ellipsagelosphaeraceae. These turnovers provide additional insight into Jurassic nannofossil evolution and classification. Specimen transfer techniques and the re-examination of type material have led to several other taxonomic revisions.

CALCAREOUS NANNOFOSSILS FROM THE VOCONTIAN TROUGH (S.E. FRANCE) AND DEEP SEA DRILLING SITE 534: NEW IMPROVEMENTS IN MID-MESOZOIC BIOSTRATIGRAPHC RESOLUTION AND CALIBRATION, ASSOCIATED SEA LEVEL TRENDS, AND ASSEMBLAGE TURNOVERS.

James A. Bergen, Amoco Production Company, Houston, Texas.

Topics: Bathonian-Turonian, S.E. France/DSDP Site 534, Zonation, Evolution

The Mesozoic Vocontian Basin in southeastern France is unsurpassed as a biostratigraphic reference because of the continuity of section and excellent microfossil recoveries within the deep basin, as well as the control provided by its Tethyan ammonite biostratigraphy. Its utility is further enhanced by recent sequence stratigraphic work within the basin. Pioneering research on Lower Cretaceous nannofossil biostratigraphy was also based on sections in this basin, but was not correlated to the ammonite biostratigraphy. Site 534 contains the most extensive mid-Mesozoic calcareous nannofossil record of the sections drilled by the Deep Sea Drilling Project, containing at its base the oldest oceanic section drilled in the North Atlantic. The magnetostratigraphy (M-sequence) of this site will also serve as a reference for a portion of a new Mesozoic time scale being developed at this time.

A composite of 17 sections in the Vocontian Trough, spanning the upper Bathonian to basal Turonian, were examined for the current investigation. Nannofossil diversity trends

obtained from these sections correspond to long term sea level trends interpreted for this basin. However, nannofossil distributions must still be correlated to sequence stratigraphic interpretations. Numerous biostratigraphic events have been identified in these sections and were tied to the ammonite biostratigraphy for the middle Oxfordian through basal Turonian. Comparisons were then made to new data generated from D.S.D.P Site 534 (Callovian to Barremian), the Lower Cretaceous Speeton Clay, and five Cenomanian outcrop sections (England, Tunisia, western United States). Significant improvements in biostratigraphic resolution and calibration are demonstrated for the Valanginian-Hauterivian and the Cenomanian. Biostratigraphic interpretations of D.S.D.P. Site 534 are also revised, the most significant revision being an older basement age for this site.

Patterns at various scales were also observed in the nannofossil distributions. At the highest order, periods of gradual floral turnover during the Tithonian and Aptian are evident at the generic rank. The Tithonian saw permanent abundance changes among the genera of the dominant placolith family (Ellipsagelosphaeraceae) and a major radiation. A distinct low latitude assemblage (*Nannoconus/Micrantholithus/Conusphaera*) was established at this time and its demise typified the Aptian turnover. This same period (Tithonian-Aptian) also corresponded to the deposition of the deep sea Blake-Bahama Formation in the North Atlantic and was characterized by a 3rd order, alternating pattern of species appearance/extinctions in the Vocontian Trough. At another order, increased numbers of species extinctions were observed for the Hauterivian, Aptian, and Cenomanian. Most Cenomanian extinction events were not restricted to the Cenomanian/Turonian boundary interval and their number may exceed that of any other Mesozoic stage (except for the terminal Cretaceous).

TETHYAN LATE BATHONIAN TO TITHONIAN NANNOFOSSIL BIOSTRATIGRAPHIC EVENTS FROM SE FRANCE AND DSDP SITE 534: EMPHASIS ON CALLOVIAN EVENTS AND REGIONAL CORRELATIONS (PORTUGAL & NORTHWEST EUROPE)

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Silvia Gardin, BRGM SGN, Avenue du Concyr B.P. 6009, Orleans Cedex 02, France

POSTER Topics: Bathonian-Tithonian, France, Zonation

Except for the Tithonian, nannofossil biostratigraphic studies of the post Bajocian Middle Jurassic and Upper Jurassic have concentrated on outcrop sections in northwest Europe and correlations to the Boreal ammonite biostratigraphy. For the current study, the succession of nannofossil events within a composite upper Bathonian to Tithonian section in the Ardèche region of southeastern France was tied to the Tethyan ammonite biostratigraphy. Upper Bathonian to Kimmeridgian nannofossil assemblages recovered from the nearby GPF Balazuc 1 borehole reinforced this nannofossil biostratigraphy. These results were then compared to coeval Tethyan nannofossil assemblages recovered from DSDP Site 534. New nannofossil biostratigraphic data generated for this deep-sea section extended the ranges of several taxa relative to the sparse floras recovered from the Ardèche sections, but also indicated which taxa may be useful in Tethyan correlations. In this regard, the genus *Stephanolithion* had the highest biostratigraphic utility. For the Tithonian, additional nannofossil events relative to recent published studies of southern European and North Atlantic deep-sea sections are proposed.

Further comparisons to recent investigations of the upper Middle Jurassic and Upper Jurassic in northwest Europe have also identified potential correlative events in the Boreal Realm. As an example, the study of additional sections in the Ardeche (Uzer, Serre du Cocu, Quissac, La Cadière), Normandy (Escoville Quarry), and Portugal (Cabo Mondego) have indicated a precise order of Late Bathonian to early Callovian nannofossil events that may be used to tie the Boreal and Tethyan ammonite biostratigraphies. Again, the genus *Stephanolithion* is crucial to this biostratigraphic framework. These results also clearly indicate that the original middle Callovian basement age for DSDP Site 534 is much older.

EVENNESS AND SPECIES-RICHNESS IN MODERN COCCOLITH AND FORAMINIFERA ASSEMBLAGES

J. Bollmann, H. Hilbrecht, & H.R. Thierstein, ETH Zürich Geological Institute, Switzerland

POSTER Topics: Holocene, Global, P'ecol/oc.

Evenness and species-richness are commonly used as ecological and evolutionary parameters. In ecological models, a low species richness reflects an unstable environment, while a high species richness reflects a stable environment. A high dominance is assumed to represent sub-optimal conditions (e.g. pollution), while a low dominance is thought to represent optimal conditions. These assumptions have been used to infer global environmental changes in the geological record (e.g. Tappan 1968; Tappan & Loeblich 1973; Fischer & Arthur 1977).

Changes in both parameters occurred among coccolithophores and planktic foraminifera in the geological past, but relationships between species richness, dominance, and environmental conditions are still poorly documented in these two groups for the Holocene. Globally distributed Holocene sediment assemblages (364 samples for coccoliths, 467 samples for foraminifera) were analysed using data collected by CLIMAP (1976). In this data set 26 taxa of modern coccolithophores and 35 taxa of modern foraminifera were considered. We have attempted to correlate species richness and dominance in surface sediment samples with various environmental parameters (MSST, seasonality, salinity, thermocline characteristics). As a measure for evenness we have used dominance (% of the most abundant species in any assemblage; Berger & Parker Diversity Index).

Coccoliths: The highest number of species in any sample was 20 and the lowest was 4. The highest abundance observed was 96% *C.pelagicus*. The following species have been observed to dominate any of the 364 assemblages: *E. huxleyi, G. oceanica, G. carribbeanica, C. leptoporus, C. pelagicus, U. sibogae. C. pelagicus* is dominant at high northern latitudes. Assemblages dominated by *E. huxleyi* are found globally but are more frequent in the Atlantic Ocean than elsewhere. *G. oceanica* is dominant in the tropics. *C. leptoporus* and *G. carribbeanica* tend to be dominant in the transitional zones of the southern hemisphere.

Foraminifera: The highest species richness in any sample was 31 and the lowest was 1. The highest abundance was 100% *N. pachyderma*. The following species have been identified as dominating any of the 464 samples: *N. pachyderma, G. inflata, G. bulloides, G. ruber, G. menardii.*

On a global scale dominance in assemblages of planktic foraminifera and coccoliths does not show significant correlation with the studied environmental parameters. Thus dominance *per se* is not a useful parameter for reconstruction of singular palaeoenvironmental parameters. Rather dominance of particular species are related to their adaptation for particular environments. The dominance of *E. huxleyi* in globally distributed samples is unique and has no analogue among the planktic foraminifera or other plankton groups.

Species richness in planktic foraminifera and coccoliths shows different correlations. The number of planktic foraminifera species increases with surface temperature and decreases with latitude. Coccolith species richness shows poor correlation with surface temperature, salinity and seasonality, but includes an interesting threshold related to the thermocline structure: species richness lower than 10 only occurs in regions with a temperature gradient lower than 4°C between 0 and 200 meters. The same pattern is observed among the foraminifera assemblages with a threshold of 15 species.

EARLY CRETACEOUS NANNOFOSSILS FROM THE EASTERN INDIAN OCEAN: BIOSTRATIGRAPHIC AND BIOGEOGRAPHIC OBSERVATIONS

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POSTER Topics: E. Cretaceous, Indian Ocean, Zonation/Biogeography.

Lower Cretaceous sediments have been recovered at nine DSDP/ODP sites in the eastern Indian Ocean: Sites 256, 257, 258, 259, 260, 261, 263, 765 and 766. The calcareous nannofossils from these sections vary greatly in preservation and abundance, but most have yielded biostratigraphical events and assemblage compositions which differ significantly from the well known Boreal and Tethyan areas. The application of existing biostratigraphical zonation schemes was generally

successful and will be discussed. A number of interesting biogeographical features have been observed, including the presence of "Boreal" or "bipolar" species, such as, *Biscutum salebrosum, Ceratolithina bicornuta, C. hamata, ?Laguncula* sp., *Repagulum parvidentatum, Seribiscutum primitivum*, and Austral species such as *Sollasites falklandensis*. The assemblage composition found in these sediments and distributions of biogeographically significant species will be discussed with respect to the palaeogeographical setting of the Indian Ocean and the provinciality of Early Cretaceous nannofloras, particularly the evidence for a southern high latitude "Austral" province at this time.

NANNOFOSSIL-LAGERSTATTE: THE TOARCIAN (LOWER JURASSIC) OF NORTHERN GERMANY

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Topics: E-M. Jurassic, Germany, Taphonomy, Laminites

A fossil-Lagerstatte is any rock containing fossils which are sufficiently well-preserved and/or abundant to warrant exploitation, and in the scientific realm this includes exploitation for research purposes. Macrofossil-Lagerstatten are well known, particularly deposits such as the Burgess Shale, Solnhofen Limestone, and Grube Messel, which have yielded invaluable information concerning soft-part morphology, taphonomy, evolution and palaeoecology. Nannofossil-Lagerstatten are less well documented but a number of examples have been described, for example, the Lower Cretaceous Munk Marl Bed (Thomsen, 1989), the Lower Jurassic Schiste Carton (Goy, 1981) and the Upper Jurassic White Stone Band (Young & Bown, 1991). The Nannofossil-Lagerstatte described here is from the Hambuhren Borehole, Northern Germany which cored a sedimentary sequence of Early Jurassic to Mid Jurassic age. The exceptional preservation, revealed by electron microscopy of rock surface, occurs in the Toarcian and Aalenian interval and includes the Posidonienschiefer. The assemblages observed conform to the two defining characteristics of Lagerstatten, that is, they are exceptionally abundant, with laminae and patches which are 100% nannofossils with no clay or cement; and they are superbly preserved, often as coccospheres or collapsed coccospheres. The excellent preservation is illustrated by the presence of the earliest holococcoliths, found as collapsed coccospheres. The most striking feature of the assemblages is the high abundance of species of *Stradnerlithus*, a genus which is rarely observed in Lower Jurassic assemblages. The nannofossil data will be discussed with respect to nannoplankton taphonomy and palaeoecology and the palaeoecology of the Posidonienschiefer.

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PALAEOCEANOGRAPHICAL SIGNIFICANCE OF LATE CRETACEOUS NANNOFLORAS FROM THE INDIAN OCEAN

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Topics: Late Cretaceous, Indian Ocean, P'ecol/oc

Data generated from eight DSDP/ODP sites, which compositely represent the Late Cretaceous of the Indian Ocean, will be utilised to describe the Late Cretaceous history of the Indian Ocean Basin in terms of nannofloral stratigraphical and geographical distributions. Estimated quantitative species abundances and diversity will be assessed in terms of both (a) biostratigraphical correlativity within the Indian Ocean Basin, and (b) palaeoceanography.

BIOSTRATIGRAPHY IN THE BISCAY REGION: THE K/T BOUNDARY SEQUENCES AT ZUMAYA, HENDAYE AND BIDART RE-EXAMINED

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POSTER Topics: K/T boundary, NE Spain - SW France, Biostratigraphy, Strontium isotopes

The Maastrichtian stage appears to be expanded in the Biscay region, cropping out at Zumaya (NE Spain), Hendaye and Bidart (SW France). The occurrence of easily recognisable lithostratigraphical units coupled with a prolific nannoflora, and planktonic foraminiferal and ammonite faunas led to an attempt to produce an integrated stratigraphy for the Tethyan Maastrichtian stage here. Sr isotope data from the sections has also been evaluated. The integrated stratigraphies will be presented for discussion.

HIGH RESOLUTION STRATIGRAPHY OF THE ILERDIAN FIGOLS ALLOGROUP (SOUTHERN PYRENEES, SPAIN)

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POSTER Topics: E. Eocene, Spain, Biostratigraphy, Sequence stratigraphy

The 1200 meter thick Figols Allogroup (Ilerdian, Southern Pyrenees, Spain), bounded by two regional unconformities and outcropping along a 25 km stretch, offers an unique opportunity to study high frequency cyclicity in the sedimentary record. Interpretation of the Figols Allogroup is based on measurement of 19 stratigraphic sections with a total thickness of 22 km. We have recognized variations in vertical and lateral facies associations making it possible to frame the stratigraphy in terms of depositional sequences. Eleven stratigraphic units, bounded by unconformities and their correlative conformities, have been recognized; other lower order units within them were also detected. The eleven units range in thickness from 15 to 300 meters and they provide an informal chronostratigraphic subdivision of the Figols Allogroup.

A study of calcareous nannofossils has been carried out in part of the study area. The Figols Allogroup consists of NP11 and NP12 Zones. The boundary between these zones is marked by the first appearance of *Discoaster lodoensis* which is common in the upper part of the Figols. Thus biostratigraphic analyses shows that the time interval of the Figols Allogroup deposition is shorter than 2.3 Ma. Biostratigraphic resolution is still not as fine as that of physical stratigraphy, which resolves, by means of facies stacking patterns, 4th (0.1-1 Ma) and 5th (0.01-0.1 Ma) order sedimentary cycles.

THE JURASSIC SEQUENCE OF THE BREGGIA GORGE: CALCAREOUS NANNOFOSSIL AND FORAMINIFERA BIOSTRATIGRAPHY.

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POSTER Topics: Carixian-Bajocian, Switzerland, Biostratigraphy

At the Breggia Gorge (Ticino Switzerland), in the Lombardian basin (Southern Calcareous Alps), a continuous Jurassic-Cretaceous sequence of hemipelagic/pelagic sediments crops out. The foraminifera and calcareous nannofossils of the Carixian-Early Bajocian interval, which is well-dated by ammonites, has been studied.

The studied section, is characterized, from bottom to top, by: the Molino Member (Upper Carixian to Lower Domerian) of the Lombardian Siliceous Limestone, the Morbio Member (Domerian *p.p.*) of the Rosso Ammonitico Lombardo, the red nodular marls and marly limestone (Toarcian *p.p.*) of the Rosso Ammonitico Lombardo *s.s.* and finally pelagic limestones and marls with pelagic bivalves (Upper Toarcian to Lower Bajocian).

The abundance of nannofossils allowed quantitative analysis of the assemblages by light microscopy, whereas the foraminifera were analyzed semi-quantitatively. The nannofossil study was completed by analysis with SEM. Study of the nannoflora enabled refinement of the biostratigraphy, which was further integrated with the planktonic and benthic foraminifera data.

NANNOPLANKTON OF RECENT SEDIMENTS OF THE CATALANO-BALEARIC SEA (NORTHWESTERN MEDITERRANEAN)

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Topics: Recent, NW Mediterranean, P'ecol/oc

The distribution of phytoplankton in the Catalano-Balearic Sea (NW Mediterranean) reflects a considerable hydrographic heterogeneity. It could be expected that a relative conservation over time in the position of the most productive hydrographic structures could be reflected in the distribution of the hard parts of phytoplankton eventually preserved in the sediments.

The study area is between the Balearic Islands and the Catalan Coast between 39° to 41° 30' N and 0° 30' to 4° 30' E. During the VALSIS I cruise, 15 cores were collected at depths between 1000 and 2100 m. The superficial sediments (0-3 cm) were sampled andcleaned using ultrasonic and centrifugation techniques. The coccoliths have been identified and assemblages quantified by Scanning Electronic Microscopy (SEM).

We noted dissolution of diatoms but there was good preservation of the calcareous nanoplankton; for example we found complete coccospheres of *Emiliania huxleyi* and *Gephyrocapsa* spp. These genera were the most abundant with relative abundances in the order of 70 to 80% for *Emiliania* and between 10 and 20% for *Gephyrocapsa*. Other genera found with some frequency were *Syracosphaera, Umbilicosphaera, Helicosphaera, Calcidiscus, Umbellosphaera, Rhabdosphaera, Calciosolenia, Discosphaera, Scyphosphaera* and *Ceratolithus*.

APPLICATIONS OF CALCAREOUS NANNOFOSSILS BIOSTRATIGRAPHY ON THE BRAZILIAN CONTINENTAL MARGINS.

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POSTER Topics: Tertiary, Brazil, Biostratigraphy

The purpose of this poster is to present the "state of the art" of calcareous nannofossil biostratigraphy in Brazilian marginal basins through summaries, with the main illustrations, of five published papers:

Pelotas Basins: biochronostratigraphy based on calcareous nannofossils (Gomide,1989). Study of cores and cuttings from seven onshore and five offshore wells drilled in the Pelotas basin (southern Brazilian continental shelf) permitted the establishment of a nannofossil biochronostratigraphy of the marine section. In the onshore wells, the oldest strata reached are of late Early Miocene age. In the offshore areas the Upper Cretaceous and Tertiary sections are complete.

Cenozoic erosive events in the central-northern portion of the Santos Basin- Brazil: a biochronostratigraphic study based on calcareous nannofossils(Antunes,1989). This work aims to recognize the most important Cenozoic hiatuses in the Santos Basin. Biostratigraphic analysis of the nannofossil contents of 15 exploratory drillings allowed recognition of seven major interruptions in the sedimentary record (four Palaeogene and three Neogene). An attempt has been made to establish a correlation between the observed events and the sea-level change curve.

The Enchova palaeocanyon (Campos Basin-Brazil): its Oligocene-Miocene history based on calcareous nannoplankton stratigraphy and seismostratigraphy(Antunes et. al.,1988). The sedimentary history of the Enchova palaeocanyon has been investigated in detail by biostratigraphic analysis of calcareous nannofossils, electrical logs and tracing of the most significant seismic features. Integration of these data allowed us to conclude that the palaeocanyon was carved during a significant erosive event in the Late Oligocene and filled up the Early Miocene. The data obtained allowed the construction of a qualitative sea-level fluctuation curve for the Oligocene and Early Miocene.

Hiatus recognition and gaps in the Tertiary section of the Mundaú Subbasin, Ceara Basin: a study based on calcareous nannofossils(Cunha,1991). Analyses of the calcareous nannoplankton content of 20 wells in the Ceará Basin enabled the recognition of 15 biozones (Palaeocene/Early Miocene). Biostratigraphic correlation of these wells made it possible to recognize six hiatuses associated with erosive or non depositional events. Of these hiatuses, the late Middle Eocene one

has a special importance for the area in which it occurs because of its geochronologic amplitude.

Espirito Santo Basin (northern Regência Shelf): Biostratigraphic characterization and geological contribution (Oliveira et .al.,1992). The sedimentary and tectonic history of the Regência Shelf has been investigated by integration of biostratigraphic data, electrical logs and seismic sections. This paper emphasizes a new biostratigraphic scheme for the area studied. The study of calcareous nannoplankton and palynology enabled the recognition of 13 biozones and eight hiatuses (Alagoas/Oligocene).

EVOLUTION OF CALCAREOUS NANNOFLORA IN CENOZOIC ATLANTIC AND INDIAN OCEANS

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Topics: Cenozoic, Atlantic/Indian oceans, Evolution

Analysis of the species and genera in nannofossil assemblages of the Atlantic and Indian Oceans (using data from the Deep-Sea Drilling Project and some Russian expeditions) was made for 25 time-slices and intervals of the Cenozoic. The Martini (1971) and Bukry (1978) zonal schemes and the datum events of Okada & Bukry (1980) were used. The development and changes of the assemblages were very rapid and inconsistent in time. The number of originating and disappearing species during the Cenozoic and rates of species origination and extinction (number of species/million years) were calculated.

Following the K/T boundary ectinctions the minimum species diversity was seen in the Danian and Early Palaeocene. Maximum species origination occured at 50, 40 (early and middle Eocene), 23-21, 18-17 (early and middle Miocene) and 5-4 Ma (early Pliocene). Intensive extinctions occurred at 50-40 and 30-25 Ma. in the Palaeogene, 15-14 Ma. in the middle Miocene, 5-4 Ma in the early Pliocene, 1.8 and 0.9 Ma in the Quaternary (the former was the stronger).

The maximum rates of evolution were in Eocene. The favourable periods for development of nannoplankton and positive rates of evolution were connected with time-intervals 65-45 and 20-4 Ma. Intervals of marked worsening of conditions, retarded rates of evolution and reduced the tempo of evolution were 65 and 40-15 Ma. The most pronounced changes in nannofloral species and generic composition took place 65 and 1,8 Ma, and less pronounced changes occurred at 18-17, 15-14, and 5-4 Ma.

The direction of the evolutionary reorganizations of the Cenozoic nannoflora correlates with changes of the surface water temperatures and other environmental attributes. Several stages with domination of different generic groups were identified in the evolutionary development of calcareous nannoflora.

HIGH-RESOLUTION INVESTIGATIONS INTO CHANGES OF CALCAREOUS NANNOPLANKTON ASSOCIATIONS DURING THE LAST 500 ka OF THE CRETACEOUS

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Topics: Maastrichtian, Global, P'ecol/oc, Extinctions.

Intervals corresponding approximately to the last 500,000 years of the Cretaceous were examined in five deep-sea cores (DSDP/ODP Holes 217, 528, 690C, 761B, 761C) and one land-based section (Millers Ferry Section, Alabama) to investigate perturbations in calcareous nannoplankton associations prior to the turnover at the Cretaceous/Tertiary (K/T) boundary. The selection of these sections was based on good preservation of calcareous nannofossils, evidence of sedimentary continuity across the K/T boundary, and the availability of palaeomagnetic data. The sections represent palaeobioprovinces of high as well as mid/low latitude regions. Sample spacing corresponds to a temporal resolution of about 20,000 years; immediately prior to the K/T boundary, sample spacing was decreased to correspond to about 5,000 years. Counts of nannofossil assemblages were performed on settling slides.

Several taxa (e.g. *Biscutum constans*, *Nephrolithus frequens*, *Placozygus fibuliformis*) show

significant abundance variations throughout the intervals investigated, although the timing and the magnitude of the variations varied between different holes. Other species (e.g. *Lucianorhabdus cayeuxii, M. staurophora*) showed pronounced abundance variations only in some sections, and were either absent or of constant abundance in other holes. The temporal variability observed at each site is interpreted as environmental perturbations. The different abundance variations of the same taxa between sites is interpreted as environmental heterogeneity: it was apparent not only between high- and low-latitude palaeobiogeographic provinces, but also between sections of comparable latitude.

Identification of the environmental factors responsible for the conspicuous nannofossil variability was attempted by comparison with published stable isotope data. The interpretations were complicated by insufficient resolution of the stable isotope records. Preliminary results seem to indicate that high- and low-latitude taxa (e.g. *N. frequens, M. staurophora*) are not exclusively and/or not very sensitive temperature indicators. Abundance decreases of *B. constans* may be indicative of decreasing nutrient availability (as previously proposed elsewhere) during the last 500 ka of the Cretaceous.

Although environmental perturbations may have stressed the calcareous nannoplankton during the last 500 ka of the Cretaceous, no stepwise extinctions of calcareous nannfossils prior to the K/T boundary could be documented.

THE CALCAREOUS NANNOFOSSIL SPECIES *Nephrolithus frequens* GORKA (1957) AND ITS MORPHOTYPES

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POSTER Topics: Maastrichtian, Southern Ocean, Morphology/Taxonomy, *Nephrolithus*

A complete morphologic intergradation from biperforate to multiperforate specimens of *Nephrolithus frequens* Górka (1957) occurs in the uppermost Maastrichtian chalk at southern high-latitude ODP Holes 750A (Kerguelen Plateau, southern Indian Ocean) and 690C (Maud Rise, Weddell Sea). Previous workers have assigned taxonomic importance to the number of pores of the central area. Two subspecies, *N. frequens* subsp. *frequens* and *N. frequens* subsp. *miniporus*, were recently differentiated (Pospichal and Wise, 1990), based on this character (four or more pores and two, respectively). The observation of specimens of *Nephrolithus frequens* with three pores in the central area indicates that there is no "natural" breaking point in a progression from two to numerous pores, and that specimens of *N. frequens* with different pore numbers should be considered morphotypes of a single species exhibiting a high intraspecific variability. In addition, our observations with the scanning electron microscope and light microscope illustrate that, in well-preserved specimens, each pore in the central area is surrounded by two cycles of elements. The margin of the nannofossil consists of two cycles, with the elements of the inner cycle extending proximally about twice as far as the elements of the outer cycle.

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SPECIATION OF MESOZOIC CALCAREOUS NANNOFOSSILS FOREWARN ANOXIC EVENTS

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Topics: Mesozoic, Global, Evolution, Anoxic events

The evolutionary trends of Mesozoic calcareous nannofossils are punctuated by peaks in rate of evolution. Roth (1979, 1987, 1989) quantified species diversity, rate of speciation, rate of extinction, rate of diversification, rate of turnover, survivorship, and species accretion of Mesozoic nannofloras. He correlated major changes in evolutionary rates with major palaeoceanographic events (="anoxic events") and suggested that predominantly abiotic parameters control nannoplankton evolution.

The early history of nannofossil evolution is marked by "speciation events" which occurred in the Early Toarcian, Oxfordian-Kimmeridgian, Early Aptian, and Late Cenomanian, all times characterized by "oceanic anoxic events". Accelerated rates in nannofossil diversification were also documented for the Late Valanginian, an interval marked by a $\partial^{13}C$ positive anomaly and $C_{organic}$-enriched shaly lithologies.

In the past few years, Mesozoic nannofossil biostratigraphy has been strongly improved resulting in a relatively high resolution stratigraphic tool. Available stratigraphies are applied to estimate the rates of nannofloral evolution and to evaluate the time lag between the peaks in nannofossil diversification and the Mesozoic "anoxic events" in the geological record.

The inception of nannofossil diversification peaks is 1-2 Ma older than "oceanic anoxic events", which appear to abruptly interrupt the evolutionary trends. These data suggest that in Mesozoic oceans the marine biosphere was very sensitive to anomalies in the environment and somehow heralded the deposition of black shales. Interactions among ocean, atmosphere, and biosphere must be taken into account to better understand the role of calcareous phytoplankton in the history of Mesozoic oceans. Is nannofossil speciation a cause or a consequence of "anoxic events"?

It is here suggested that the onset of speciation events was the early response to major environmental changes and "anoxic events" might have resulted from accelerated biological processes. If calcareous nannofossils acted as "biological pumpers", they controlled the biological carbon fixation and storage in the oceanic reservoir. Most probably, global changes in climate (increased runoff) introduced higher nutrients into the oceans, which in turn triggered an accelerated biological extraction of excessive CO_2 from the atmosphere-ocean system and, ultimately, resulted in the deposition of $C_{organic}$-rich black shales.

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CALCAREOUS NANNOFOSSILS AND PALAEOPRODUCTIVITY: EXAMPLES FROM CAMPANIAN-MAASTRICHTIAN AND K/T BOUNDARY STRATA IN ISRAEL

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Topics: L. Cretaceous & K/T bdy, Israel, P'ecol/oc, Productivity

In the last years, studies of Upper Cretaceous rocks in Israel enabled the recognition of criteria to reconstruct palaeoproductivity levels in a variety of oceanic ecosystems based on palaeontological (palynology and foraminifers), geochemical and petrographical results. These studies involved sections from Coniacian-Maastrichtian organic-rich carbonates that were deposited in an upwelling system, and open marine shelf sediments from the K/T boundary.

Diverse and generally well-preserved assemblages of calcareous nannofossils were recovered from these sections. The abundance of several nannofossil taxa was found to be controlled by ecological conditions, mainly the productivity level:

1. The abundance of the genera *Thoracosphaera* and *Biscutum* is usually higher in intervals of relatively low productivity.
2. *Micula decussata* is usually typical of medium-scale productivity.
3. In the highest productivity levels, species diversity seems to decrease but total abundance is usually high.

These conclusions are still preliminary and more data is currently being collected from additional sections to test their validity. Additional taxa whose distribution seems to contain clues on oceanic palaeoecology are *Watznaueria* and *Arkhangelskiella*. They will be studied in the following stages of this research.

LINKS BETWEEN NANNOFOSSIL PRESERVATION AND CARBONATE SEDIMENTATION IN NEOGENE SEDIMENTS FROM THE EASTERN EQUATORIAL PACIFIC (ODP LEG 138)

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Topics: Neogene, E. Eq. Pacific, Sedimentation, Fluxes

We examine the Neogene history of carbonate preservation and flux in two latitudinal transects of drill sites from the Eastern Equatorial Pacific by combining calcareous nannofossil preservation data with measurements of calcium carbonate concentration (weigh percent of dry bulk sediment) and mass flux (g/cm^2/ka). During Ocean Drilling Program Leg 138, nearly 1,700 nannofossil smear slides from eleven drill sites were rapidly and qualitatively evaluated for both biostratigraphic and taphonomic data, and data on nannofossil preservation, abundance, etching and overgrowth. We also measured %$CaCO_3$ in over 2,600 samples for the eleven sites. The %$CaCO_3$ data are converted into $CaCO_3$ flux estimates by using shipboard measurements of dry bulk density and sedimentation rates derived from age models published in the ODP Initial Reports for Leg 138. To meaningfully examine the results, the nannofossil and $CaCO_3$ data from the various holes at each site are converted from the shipboard depth-in-hole scale (meters below sea floor), to a composite depth scale (meters composite depth). The composite depth scale for each site is constructed from the stratigraphic information gathered from the two or more holes drilled at each site. This scale accounts for, and by-passes, missing sediments intervals between cores and intervals disturbed by the coring process. The nannofossil preservation data help us interpret the %$CaCO_3$ data.

Sedimentary intervals characterized by low %$CaCO_3$ and poor nannofossil preservation are interpreted as times of enhanced dissolution. Intervals with low %$CaCO_3$, but correspondingly good preservation, suggest dilution by terrigenous sediments in some instances and increases of biogenic opal in others. Additional information from shore-based studies allows us to differentiate between these two choices. Certain events in the sedimentary records, such as an extreme dissolution event at 9 Ma, are common to all sites. while other events are less regional in extent. A chronology of $CaCO_3$ sedimentation and nannofossil preservation will be presented from each site, and will be interpreted in a palaeoceanographic and palaeoclimatic framework.

WORKSHOP - A COMPREHENSIVE VIEW ON THE NANNOFOSSIL STUDY OF THE K/T BOUNDARY, WITH SOME ADDITIONAL DATA FROM CENTRAL TETHYS.

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Topics: K/T Boundary, Global, Biostratigraphy

Study of the K/T boundary, by nannofossils, raises several problems, as everybody dealing with it knows. Whereas it is easy, in many successions, to distinguish the Late Maastrichtian from the Danian, when we come across a more continuous section, in which a real gradual change occurs, we find that the events elsewhere adopted to mark the boundary are scattered over a more extended thickness.

This is the reason why the events taken as references to mark the boundary have changed from time to time; beginning with the last Cretaceous assemblage of Martini and the FO of *Markalius inversus*, to continue with the first Tertiary assemblage, the FO of *Biantholithus sparsus* or the FO of *Biscutum romeinii*.

Many studies suggest adoption of additional data in order to help in the determination of the interval in which the K/T boundary falls. Unfortunately, many events were recovered only in a few sections; therefore their utility is doubtful, even considering the environmental control on nannofossil preservation. The reliability of FOs and LOs is also doubtful, since they do not always occur in the same order and are the events most easily affected by reworking and contamination. Moreover, duplicate zonations have been developed for this time interval at high and low latitude, adding more limits to the applicability of any one scheme.

A very important tool would be the correlation of nannofossil events with other events

occurring at the boundary. First of all, with those of foraminifers, in order to verify the entity of the "extinction"; but even with those which might look not directly connected to them, such as the iridium peak. A detailed study of nannofossil lineages across the boundary would help in this direction, as well as chemical analysis of the nannofossil tests, which might give information on how much they contribute to the quantity of minerals, other than calcite, present in the sediments, or how their composition changes depending on the physical events taking place.

A few new data have been obtained from sections collected for the first time, in Greece and Albania, which give us more indications of fractionation of the Tethyan realm into smaller subprovinces. This renders correlation in this area even more complicated.

LATE QUATERNARY COCCOLITHS FROM A WESTERN MEDITERRANEAN CORE PALAEOCEANOGRAPHIC AND PALAEOENVIRONMENTAL IMPLICATIONS

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Topics: Late Quaternary, W. Mediterranean, P'ecol/oc

The Core K-10 was collected from the continental slope in the Algero Balearic Basin, SW of Ibiza, Western Mediterranean (3° 03, O'N; 1° 00, 9'E; depth 1957 m). The total length of 440 cm is composed by green-grey to light brown homogeneous hemipelagic oozes, rich in coccoliths and planktonic foraminifera.

A quantitative analysis of the calcareous nannoplankton assemblage with a sampling interval around 10 cm was carried out. These data were compared with the ^{16}O and ^{13}C isotope signals, obtained from planktonic foraminifera, and other sedimentological results (Vázquez et al., 1991). The coccolith assemblage is mainly composed by *Emiliania huxleyi* in the upper part, and different morphotypes of *Gephyrocapsa*, in the lower part of the core. The general pattern is similar to that observed by Weaver (1983) in the Atlantic and Flores et al (1991) in the Gulf of Cádiz. Coccolith intervals 1 and 2 of Weaver (1983) are clearly defined; the boundary between intervals 2 and 3 is not defined. These intervals are correlated with the isotopes stages 1 to 5 (middle part).

The coccolith data are in agreement with the preliminary results of Vázquez *et al.* (1991) and support the model of Pujos (1985) for the Atlantic: Interglacial periods coincide with maxima in the total of coccoliths counted. This pattern could correspond to changes in productivity in the surface waters, (highest during interglacials) and/or variations in dilution, (more intense during glacial periods). No clear relationship between ^{13}C values and the total record of coccoliths is showed.

At the same time, the response of some quantitatively important taxa, such as *Coccolithus pelagicus*, *Syracosphaera* spp., *Calcidiscus leptoporus* or *Helicosphaera* spp,.to palaeoenvironmental changes is analyzed.

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EFFECTS OF THE LATE PLIOCENE GLACIATION ON THE BENTHIC AND PLANKTONIC COMMUNITIES IN THE NORTH ATLANTIC (DSDP SITE 606).

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Topics: Late Pliocene, N. Atlantic, P'ecol/oc., DSDP Site 606

Site 606 is located in the North Atlantic on the western flank of the Mid- Atlantic Ridge at 37°20'N; 35°30'W. The current depth at this point is 3007 m. The calcareous nannofossils and the planktonic and benthic foraminifera of the late Pliocene from Site 606 are studied in order to reveal the impact of the late Pliocene glaciation over the surface and deep oceanic dynamics.

On the basis of the palaeomagnetic record registered by Clement & Robinson (1987), as well as on calcareous plankton data we have calculated the age of each sample. The ages of the studied samples extend from 3.6 Ma to 1.6 Ma, according to the geochronological scale of Cande & Kent (1992). The events that we have recorded from nannofossils coincide with the biostratigraphy established by Takayama & Sato (1987) and Backman & Pestiaux (1987) (Fig. 1). The LAD of *Discoaster tamalis* is found between 86.84 and 83.75 m and the LAD of *D. surculus* between 78.53 and 77.02 m, coinciding with the inversion of magnetic polarity dated as 2.6 Ma. Therefore the samples included between these two events are included in the CNl2b Zone. The upper boundary of the next zone -CNl2c-, defined by the extinction of *D. pentaradiatus*, cannot be accurately established due to the scarce proportion of asteroliths. Nevertheless, it is tentatively placed between 77.00 and 75.5 m. The top of the CNI2d Zone, defined by the LAD of *D. brouweri* has been found between 61.17 and 54.54 m, coinciding with the onset of the Chron C2n. We have included the two youngest samples within the CNI3 and CN14 Zones. The limit between them, defined by the FAD of the medium *Gephyrocapsa* spp. was placed between 54.54 and 47.92 m.

From the planktonic foraminifera we have recognized the following events: the LAD of *Dentoglobigerina altispira* and *Sphaeroidinellopsis* spp. between 102.25 and 94.33 m; the LAD of *Globorotalia miocenica* between 75.49 and 73.95 m; the FAD of *G. inflata* is located between 72.41 and 68.87 m and the FAD of *G. truncatulinoides* between 54.54 and 47.92 m. These events permit us to identify the biozones PL-3 and PL-4 from the oldest analyzed sample to 94.33 m. The PL-5 Zone a extends from this level to 73.95 m. The overlying samples are included within the PL-6 Zone, except the youngest one, which is within the N22 Zone. The proposed scheme coincides with the biostratigraphy proposed by Weaver & Clement (1986) and Weaver (1987) (Fig. 1).

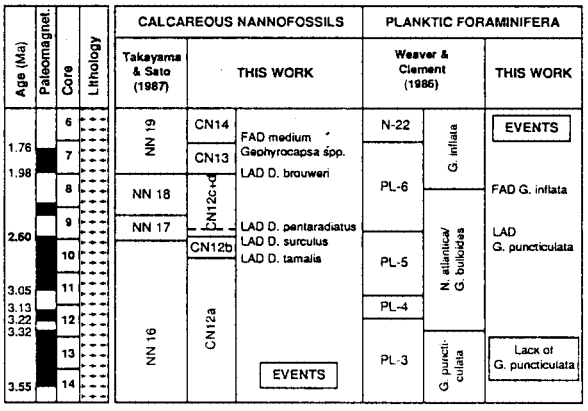

Fig. 1: Biostratigraphic scheme for Site 606

An exhaustive study of the benthic foraminifera allowed us to reveal the main changes of the bottom water masses at this latitude during the late Pliocene. The assemblages are dominated by a few taxa. The most abundant species are *Nuttallides umboniferus*, a typical AABW species, and *Pseudoparrella exigua*, *Oridorsalis umbonatus*, *Globocassidulina subglobosa* and *F. wuellerstorfi*. common taxa inhabiting the NADW. The oscillations in the quantitative composition of the assemblages led us to distinguish three intervals with different characteristics. The first one ranges from 3.6 to 2.6 Ma, a time in which the bottom water was a mixed AABW-NADW mass, with a preponderance of the first component. Coinciding with the onset of the glacial maximum (2.6-

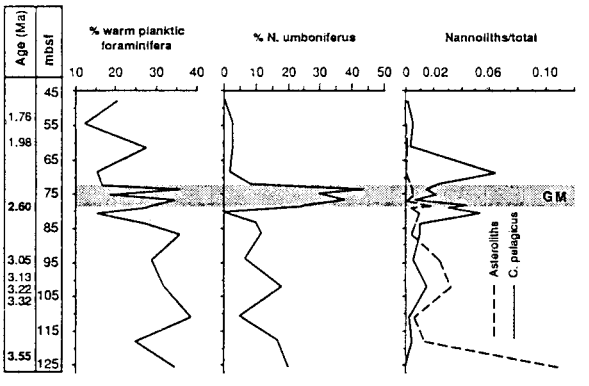

Fig. 2: Abundance of N. umboniferus (AABW marker) and selected planktic paleoclimatic indicators.

2.4 Ma) at this latitude the North Atlantic was invaded by the AABW. This event is clearly shown by the high percentage of N. umboniferus (>40% of the total assemblages). After the glaciation, from 2.4 to 1.6 Ma, we interpreted a retreat of the AABW as a consequence of the southward advance of the NADW.

The decreasing trend of surface water temperature is clearly reflected by a general decline of the relative abundance of warm planktonic foraminifera (*Globigerinoides ruber, G. quadrilobatus, G. sacculifer, Globigerina rubescens* and *Orbulina universa*). In the same way, *Coccolithus pelagicus*, a conventional cool water marker, increases between 83 and 65 m. On the other hand the abundance of asteroliths progressively decreases from bottom to top.

An interesting correlation can be seen between *N. umboniferus*, and the palaeoclimatic indicators such as *C. pelagicus*, asteroliths and warm planktonic foraminifera (Fig. 2). During the glacial maximum the highest abundances of the benthic species coincide with peaks of warm conditions in surface waters. Therefore we conclude that the AABW northward flow was more intense during the warmest pulses of the glacial maximum.

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BIOSTRATIGRAPHIC RESPONSES TO DEPOSITIONAL SYSTEMS TRACTS GIVEN BY NANNOCONID ASSEMBLAGES (LOWER CRETACEOUS OF SE FRANCE)

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Topics: Tithonian-Berriasian, SE France, Sequence stratigraphy, *Nannoconus*

Preliminary quantitative calcareous nannofossil assemblage data for three Upper Tithonian – Berriasian reference sections (Berrias, Broyon, Angles) in the Vocontian trough, southeastern France have been interpreted relative to the existing sequence–stratigraphic framework (Gardin & Manivit, 1993; du Chêne *et al.*, 1993). Abundance and diversity curves for the total assemblage and individual genera were similar but the sharpest response was given by the nannoconids.

Further specific studies on this group allowed us to summarize the Berriasian stratigraphic distribution and abundance of this genus as follows: Early Berriasian assemblages are dominated by the Watznaueriaceae; nannoconids dominated the late Berriasian assemblages, especially during transgressive intervals.

- There is a general abundance increase of *Nannoconus* throughout the entire stage.
- The most significant fluctuations are in terms of abundance rather than specific diversity: Nannoconids are very abundant around the maximum flooding surface, show a decreasing trend during the high systems tracts and display sharp abundance peaks during transgressive systems tracts. Low systems tracts are characterized by a low, yet increasing-upwards abundance of the genus. A sharp abundance decrease in nannoconids (as well as other nannofossil groups) approximate the position of the sequence boundary.
- Larger nannoconids (e.g. *N. steinmannii steinmannii* and *N. kamptneri kamptneri*) are more abundant within the transgressive systems tracts, whereas smaller forms (e.g.. *N. steinmannii minor* and *N. kamptneri minor*) are more frequent within intervals deposited during low sea-level.
- Nannoconid abundance values are higher in the hemipelagic portion of the basin at Angles, as compared to Berrias (outer platform) and Broyon (slope); this can be associated with the development of condensed sections within the basin and/or higher $CaCO_3$ content and produc-

tivity (Erba, 1986; 1989).
- Fluctuations in *Nannoconus* abundance are not solely related to lithologic changes (i.e. limestones/marls), because samples from all three sections were taken from marly intervals. Eustatic changes in sea-level influenced many factors, which include nutrient delivery, surface water fertility, salinity, climate and ocean chemistry. Nannoconid blooms may therefore be related to high fertility and/or changes in salinity, as suggested by Premoli Silva *et al.* (1989); however, direct causal mechanism are still controversial.

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CALCAREOUS NANNOPLANKTON IN THE BENGUELA UPWELLING SYSTEM, SE ATLANTIC: ECOLOGY, ENVIRONMENT

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Topics: Recent, SW African margin, P'ecol/oc, Upwelling

Water-column and sediment-surface distribution patterns of calcareous nannoplankton in the Benguela system are investigated in order (1) to document the ecological tolerances (essentially temperature and nutrients) of individual species in the coastal upwelling environment, and (2) to use this information in subsequent palaeoenvironmental reconstructions of the circulation off southwest Africa.

Coccolithophore standing crop values of up to 700×10^3 cells/l are found in coastal waters off Namibia during relaxation of the upwelling process. Dissipation of turbulence and stratification of the water column favour the dominance of coccolithophores over diatom communities that are normally associated with early stages of the upwelling cycles. *Emiliania huxleyi* is the dominant species, followed in terms of decreasing abundances by *Gephyrocapsa oceanica, C. pelagicus,* and *Syracosphaera* sp. Vertical changes in species dominance are related to various temperature and nutrient preferences.

The sediment-surface distribution of calcareous nannofossils was investigated in 150 samples recovered from the southwest African continental margin (35°S to 17°S). Q-mode factor analysis of the coccolith census data (except *E. huxleyi, C. caribbeanica,* and *G. ericsonii*) yields 4 factors explaining more than 95% of the variance. Their distribution is closely related to the various surface-water masses induced by the coastal upwelling process. A multiple stepwise regression run on the sediment-surface factor matrix and selected biological/physical indexes shows a good correlation between the nannofossil factor loadings and chlorophyll *a* concentrations. The derived transfer function reproduces accurately the modern sea-surface conditions of the Benguela system, with standard error for chlorophyll estimates of ± 0.93 mg.m^{-3} over an observed spectrum of 0.2 - 8 mg.m^{-3} . This palaeoecological equation, when applied to the downcore distribution of Quaternary nannofossils, will provide fully quantitative estimates of the past biological marine environment off southwest Africa.

MARINE STRATIGRAPHY OF THE UPPER PLIOCENE-LOWER PLEISTOCENE OF WESTERN SYRIA: NEW NANNOPLANKTON AND PALAEOMAGNETIC DATA

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Topics: Pliocene-Quaternary, Syria, Stratigraphy

The stratigraphy of marine Pliocene-Quaternary deposits of the Eastern Mediterranean is mainly based on deep-sea sediments. The coastal sections have been studied in much less detail. For this reason the set of cross-sections (Mardido, Msherphy and Jinndiriye, Latheqiye region) of marine Pliocene-Pleistocene deposits of Western Syria, where for the first time detailed biostratigraphical and palaeomagnetic investigations have been carried, are of great interest.

Jinndiriye site contains rich and diverse nannoplankton assemblages of NN15-NN16 zones of Martini standard scale. Palaeomagnetic data in combination with nannoplankton determinations shows that these deposits belong to the upper part of the Gilbert palaeomagnetic epoch. In the lower part of the upper 100 m sandy-clay unit of the Mardido and Msherphy sections diverse nannofossil assemblages were determined, with abundant *D. brouweri, D. pentaradiatus, C.macintyrei, P. lacunosa* and others. These allowed interpretation of the normal polarity interval in the lower part of the section as the upper part of the Gauss epoch.

Above thisthe nannofossil assemblages become impoverished, suggesting shallowing of the basin. *D. brouweri* is present up to 65m from the base of section, the first appearance of *Gephyrocapsa oceanica* - s.l. was seen at the same level. It corresponds, to the upper part of a short normal polarity interval interpreted as the Olduvai episode. In the uppermost part of the sandy-clay unit a normal polarity interval is fixed; it is interpreted as the Jaramillo event.

Thus, biostratigraphic and palaeomagnetic study allow determination of the Pliocene-Pleistocene boundary within the marine Mardido and Msherphy sections of Western Syria. It was proved that Pliocene clays overlain by deposits correlated with Selenuntian considered in the frame of 1.65-0.8 Ma. (Rio et.al., 1991). These deposits form widespread structures 190-200 metres above sea level, that could be interpreted as the 0.9-1.0Ma "Calabrian" terrace.

RANKING OF DIFFERENTIAL DISSOLUTION OF TERMINAL CRETACEOUS CALCAREOUS NANNOFOSSILS.

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Topics: Late Cretaceous, S. Atlantic, Preservation

In studies dealing with applications of calcareous nannofossils it is important to isolate geochemical and other processes that might have altered the original microfossil signal.

A ranking of differential dissolution of terminal Cretaceous calcareous nannofossils is suggested. The study is based on DSDP Leg 74 Sites 525A and 527 from the Walvis Ridge, South Atlantic. A calcite dissolution index based on the degree of fragmentation in planktonic foraminifera and the relative abundance of benthonic foraminifera (in relation to the total foraminiferal faunas) was used. Correspondence analysis showed that 40% of the variability in the calcareous nannofossil assemblages investigated was due to dissolution. Ranking the susceptibility of the 21 most common species to dissolution suggested that the following species were the most resistant (from more to less resistant): *Ceratolithoides kamptneri, Ceratolithoides aculeus, Watznaueria barnesae, Micula decussata, Cribrocorona gallica, Lithraphidites quadratus* and *Micula murus*. Intermediately resistant species were: *Arkhangelskiella cymbiformis, Ahmuellerella regularis,* and *Cretarhabdus crenulatus*. The following species were susceptible (from less to more susceptible): *Cribrosphaerella ehrenbergii, Prediscosphaera cretacea, Zygodiscus spiralis, Microrhabdulus attenuatus, Cretarhabdus surirellus, Prediscosphaera stoveri, Prediscosphaera spinosa, Chiastozygus fessus, Prediscosphaera majungae, Eiffellithus turriseiffelii,* and *Nephrolithus frequens.*

An attempt was made to rank species that were too rare to be included in the correspondence analysis but were encountered in some of the samples during census counts; this resulted in a semi-quantitative ranking of an additional 20 species.

A QUICK AND EASY METHOD FOR ESTIMATING ABSOLUTE ABUNDANCES OF CALCAREOUS NANNOFOSSILS.

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Topics: Techniques

Foraminiferal workers use absolute abundances and sedimentation rate estimates to calculate accumulation rates of foraminifera in marine sediments, as an index for productivity fluxes in the surface ocean. Estimates of the absolute abundances of calcareous nannofossils in sediments are difficult since the nannofossils are too small to be counted in the same way as foraminifera. An easy and relatively rapid method for estimating the absolute abundances of nannofossils is outlined below.

The procedure is as follows:

1. Weigh a slide.
2. Make a smear-slide and make sure that the nannofossils are spread out evenly on its surface. For best result very little sediment should be used and it should be smeared out over a large area of the slide. The edges of the smeared area should be made straight with an eartop.
3. Let the smear-slide dry for a couple of hours.
4. Weigh the smear-slide and subtract the weight of the slide itself to obtain an estimate of the weight of the sediment.
5. Measure the smeared area (a rectangle).
6. Mount a cover-glass in the usual manner.
7. Count the number of nannofossils in many (at least 20) random view-fields over the entire smeared area (size fractionation effects and density differences over the slide are minimized since random fields are counted over the entire slide).
8. The number of specimens per gram sediment is then estimated using the following formula:
   Number of specimens/gram sediment = N*(A/W)/(a*n)
   Where A=smeared area, W=weight of smeared area, a=area of one view-field, n=number of view-fields counted, and N=number of specimens counted.

If the density of the sediment and the sedimentation rate in a section under study are known, several palaeoceanographically important parameters may be estimated.

CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE TERMINAL FLYSCH SEDIMENTS OF THE KROSNO BEDS. (POLISH CARPATHIANS, SILESIAN UNIT)

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Topics: E. Miocene, Poland, Biostratigraphy

195 samples were taken from the shales and mudstones representing terminal flysch sedimentation of the Krosno Beds of the Silesian Unit (Polish Carpathians). These sediments consist mostly of shales with sandstone intercalations. 6 outcrops were sampled. Smear slides were prepared from each sample and then carefully checked under LM and SEM. The nannofossil taxa found led us to the conclusion that the investigated sediments were deposited during the Early Miocene. This age coincides with current findings based on planktonic foraminifera. Nannoplankton species found indicate the presence of at least the NN2 zone (*sensu* Martini). Typical assemblages consisted of lower Miocene taxa e.g.; *Helicosphaera mediterranea, H. scissura, H. ampliaperta, H. carteri , H.* cf. *H. burkei, Coccolithus pelagicus, Sphenolithus belemnos , S. conicus, S. delphix , S.moriformis , Cyclicargolithus abisectus , C.floridanus , Reticulofenestra lockeri , Discoaster deflandrei* , plus many reworked taxa representing various nannofossil families and biostratigraphic ages. Among them the most common were: *Dictyococcites bisectus, Reticulofenestra umbilicus, Zygrhablithus bijugatus, Sphenolithus anarrhopus, S.spiniger*. Calcareous nannoplankton species found in investigated samples indicated that terminal flysch deposition of the Krosno Beds of the Silesian Unit took place during the Early Miocene (at least NN2 zone) . This is earlier than terminal flysch deposition of the Krosno Beds of the Skole Unit (NN 5 zone according to nannoplankton investigation by Janusz M.Slezak).

REFLECTIONS ON THE BIOLOGICAL AFFINITIES OF THE CALCAREOUS NANNOFOSSILS

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Topics: Mesozoic-Recent, Global, Taxonomy/Evolution, Organic scales

Calcareous nannofossils constitute a highly diversified palaeontological group (more than 3000 species), which seems heterogeneous in a biological point of view, but is usually referred (with the exception of Thoracosphaeraceae) to the class of Prymnesiophyceae Hibberd (1976), defined for the extant algae possessing a "third flagellum" (= haptonema). The classification of fossil species within Prymnesiophyceae is mainly based upon the structure of isolated nannoliths. For Mesozoic and Cenozoic times together, about 40 families are distinguished, corresponding to basically different ultrastructural types. If a consensus is established concerning the family definition, the relationship between the morphological types (reflected by the organisation at the suprafamilial level) is so poorly documented and so questionable, that most taxonomic papers list the families according to alphabetical order. The classification of living species of Prymnesiophyceae involves many features other than the structure of the nannoliths (cellular, biological, biochemical characters, ...). This classification is, however, not yet firmly established because of the scarcity of the observations available for most species, especially the coccolithophorid algae. Moreover, the systematic schemes proposed vary, depending on the relative weight assigned to each character. For instance, if nannolith presence is considered as fundamental, all coccolithophorid species are lumped together in one order: Coccolithophorales SCHILLER (1926). If other cellular characters are first taken into account, the genus *Emiliania* is separated from the other species bearing other coccoliths (Isochrysidales and Coccosphaerales *sensu* Parke & Dixon (1976), respectively). In all cases, the result is unsatisfactory, because it does not reflect the natural links revealed by the scarce information obtained from palaeontological observations and life cycle studies.

The aim of this work is to point out the importance of the organic scales for phylogenetic reconstruction. These skeletal elements, commonly secreted by most Prymnesiophyceae as well as some other algal groups, are already used for distinction of some living species and genera. In the case of coccolithophorid species, they play a prominent part in the calcification process. Consequently, each nannolith type may be interpreted as the reflection of peculiar organic scales, and morphological comparison between organic scales and mineralized nannoliths appears as a suitable method to investigate the affinities between calcifying and non-calcifying groups. The taxonomic and geological implications of such comparisons are discussed.

A REVIEW OF THE SYRACOSPHAERACEAE

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POSTER

Topics: Recent, Global, Taxonomy, Syracosphaeraceae

Over the last few decades there has been a considerable amount of literature on the various genera within the family Syracosphaeraceae. However, few of these papers have discussed the integrity of the family as a whole. The original family definition has not been emended despite the gathering information on its members. At present it is generally accepted that the main coccolith type of this family is the caneolith, although some genera have somewhat modified basal structures. To alleviate this problem we have attempted to review the family and to investigate the structure of the caneolith in detail. Preliminary observations suggest that all the genera in the family have a common character within the basal structure of their caneoliths, and thus their taxonomic position looks justified.

The type genus, *Syracosphaera*, has also received a lot of attention and has been the focus of several taxonomic debates. The species of this genus provide a wide morphological variation and have often been subject to separation at either generic or subgeneric level. Preliminary observations suggest that the genus could be split into several groups on the basis of a small number of characters. However, raising these groups to generic level would be impractical and merely cause confusion in their identification. The alternative presented here is to maintain the genus as a mixed bag, whilst retaining a degree of cohesion.

HIGH-RESOLUTION BIOSTRATIGRAPHY: A PRELIMINARY GLOBAL COMPOSITE SCHEME FOR THE LATE QUATERNARY

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Topics: Late Quaternary, Global, Zonation

Late Quaternary sediments are generally the best preserved and the most useful for studying palaeoceanography and palaeoecology. High-resolution sampling (every 10cm or less) is essential for the investigation of short duration events (e.g. deglaciation stages) and thus for finer control on chronology. From studies of living coccolithophorid biogeography it is clear that latitudinal and longitudinal differences occur within the photic zone of the same ocean as well as for different oceans. It is therefore not surprising that the underlying sediments reflect these differences to a great extent and that a single global biostratigraphic scheme is not possible. Previous attempts to achieve these aims (e.g. CLIMAP) have been fruitless owing to a number of problems; 1) an inability to separate *Gephyrocapsa* spp., 2) a failure to recognise small dominant species (eg *Florisphaera profunda*) and 3) a decision to ignore important non- placolith components (e.g. *Neosphaera coccolithomorpha*). Equally the geographic coverage of these studies has been poor, with few investigations of coastal, upwelling and Mid-Atlantic Ridge samples. Recently, it has been shown that the assumed dominance of *Emiliania huxleyi* during the last four oxygen isotope stages is incorrect and therefore there is a need to re-examine and re-devise the global scheme (cf. those of Martini, Gartner, and Hine & Weaver) of the Late Quaternary. This project is on-going and thus we are presenting only a preliminary report at this meeting.

NEW IDEAS ON THE ORIGIN AND EARLY EVOLUTION OF PLACOLITH COCCOLITHS IN THE EARLY JURASSIC: FAMILIES BUSSONIACEAE, BISCUTACEAE AND ELLIPSAGELLOSPHAERACEAE

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POSTER Topics: E. Jurassic, Europe/N.Africa, Evolution, Placoliths

Lower to Middle Jurassic basinal marl/limestone sections in the Lusitanian Basin of Portugal, the High Atlas of Morocco, DSDP Site 547B and in the Jura mountain of Switzerland contain continuous successions of calcareous nannofossil assemblages (de Kaenel 1990; Bergen, *in press.*). Definitions of precise genus and species concepts allow a significant taxonomic revisions and provide new information on the early evolution of placoliths.

The appearance of the placolith rim construction during the late Sinemurian was a major development in the early evolution of coccoliths. At the end of the early Jurassic, all Jurassic placolith families had been established during a rapid diversification.

The first group of non-imbricate, three-shield placoliths (*Triscutum, Mazaganella*) are observed in the upper Sinemurian at the base of the section in DSDP Site 547B (de Kaenel and Bergen, in press). Morphological rim features and central area structures of early Bussoniaceae have close relationships with species of the genus *Crucirhabdus*. Moreover, the development of an incomplete third proximal shield has been observed in some Sinemurian *Crucirhabdus* in Portugal and may represent the possible ancestral form of this group.

The development of the three-shield placolith leads to the evolution of the two-shield placolith in the late Sinemurian - early Pliensbachian. The oldest Biscutaceae, genus *Similiscutum*, shows considerable variations in coccolith outline and central area construction but all have the same rim construction characterized by the presence of a proximally extended inner rim cycle of the proximal shield. The family Biscutaceae diversifies quickly during the Pliensbachian with the occurrence of three new genus, *Palaeopontosphaera* (latest early Pliensbachian), *Discorhabdus*, and *Biscutum* (late Pliensbachian).

The further evolution of the three-shield placolith through the appearance of genus *Bussonius* during the earliest Pliensbachian leads to the development of the first imbricate placolith of the genus *Lotharingius* in the mid Pliensbachian. Early *Lotharingius* species are small

but have a relatively wide central area with a central cross structure, and the rim construction is closely related to that of *Bussonius*. The genus *Lotharingius*, including species with a central cross structure, quickly diversifies in the late Pliensbachian - early Toarcian. The appearance of the genus *Watznaueria* (with a closed or vacant central area) and the appearance of *Ellipsagellosphaera* (with a bridged central area) occurs during the middle and late Toarcian respectively.

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MORPHOMETRIC STUDY OF *CALCIDISCUS LEPTOPORUS* AND *C. MACINTYREI* AND ITS BIOCHRONOLOGICAL APPLICATIONS

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Topics: Pliocene-Holocene, Atlantic/Pacific oceans, Biometrics, *Calcidiscus*

One major difficulty encountered in using the current Quaternary zonations is the definition of the last occurrence of *Calcidiscus macintyrei* (or *Calcidiscus tropicus*) and its correlation with oxygen isotopes stages. In numerous studies, *Calcidiscus macintyrei* has been observed as high as Zone NN21, which is possibly the result of reworking. To resolve this problem, a detail morphometric study of the *Calcidiscus leptoporus - Calcidiscus macintyrei* has been carried out on samples from the upper Pliocene (last occurrence of *Discoaster brouweri*) to the Holocene. The samples were obtained from DSDP and ODP drill sites in the South Atlantic (517, 704), North Atlantic (558, 647), East Pacific (677) and West Pacific (593).

Three main factors were analyzed: the number of elements, the diameter, and the outline of the distal shield. The results show that the mean size of the *Calcidiscus* assemblage is closely related to the surface temperature of the oceans. In addition there is a general trend throughout the Pleistocene of a reduction in the mean size and the mean number of elements of the placoliths. On a finer scale, the curve defined by the variations of the mean size of the distal shield is related to the oxygen isotope curve, indicating that during glacial events, the mean size decreases with the cooling of the surface water.

The circular to elliptical outline of each specimen is a function of the number of elements and the length of the distal shield. In each assemblage, these two factors, when plotted against each other, define a line, that separates the circular from elliptical forms. The position of this line is fixed through time or through glacial or interglacial periods suggesting that all the different forms of the *Calcidiscus* group may belong to the same species. Variations in size and shape of the placoliths are only dependant on thetemperature of the oceans, but more interestingly the curve defined by the mean size of an assemblage has a similar pattern in all sites studied. Some variations in the size of end-members occur simultaneously in the Atlantic and Pacific Oceans, which could be used as biochronological markers during the Pleistocene. From the high southern latitude Site 704, a reference curve calibrated by oxygen isotope stratigraphy has been constructed, which could be used in other oceans to determine the age of *Calcidiscus* assemblages.

LATE PLIOCENE NANNOFOSSIL BIOSTRATIGRAPHY AT SITE 607. DSDP-IPOD LEG 94 (NORTH ATLANTIC OCEAN) AND ITS OCEANOGRAPHIC SIGNIFICANCE

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POSTER Topics: Late Pliocene, N. Atlantic & Japan, Zonation, reticulofenestrids

Cenozoic calcareous nannofossil zonation schemes have been established by numerous investigators. Among them, the Standard Zonation of Martini (1971) and the Low-latitude Zonation of Bukry (1973, 1975; Okada & Bukry, 1980) are mostly applicable and widely accepted. According to their zonations, only three or four datums are described in the late Pliocene. However, we cannot often find these datums in upper Pliocene sediments at mid to high latitudes because of the absence of discoasters.

Based on analyzing the calcareous nannofossil floras at Site 607, DSDP-IPOD Leg 94, four new additional biohorizons were detected in the upper Pliocene sediments. Their biohorizons are mainly defined by sequential changes of size and of the number of specimens of *Reticulofenestra* coccoliths. We found two acme intervals of *Crenalithus doronicoides* (small placoliths above 5 μm in diameter) in the upper Pliocene; Acme Zones I and II in descending order (see figure 1). Acme Zone II is in the lower part of the Gauss Chronozone and Acme Zone I is in the lowest part of the Matuyama Chronozone. Their terminations are good stratigraphic indicators. *Reticulofenestra ampla*, described in Sato et al. (1991 - Proc. ODP Sci Res. 117), disappears near the level of LAD of *Discoaster tamalis*. Furthermore, small *Gephyrocapsa* specimens, occasionally found throughout the Neogene, are particularly abundant in the middle and in the uppermost Pliocene. Especially, the uppermost one is a distinctive bioevent and its' initiation is easy to find. These biohorizons were found both in the ODP Leg 117 sites and in the Japanese Neogene sequences. Consequently, these bioevents seem to be useful datums.

Recently, Pliocene oceanographic changes have been clarified by some studies of oxygen isotope analyses. The termination of Acme Zone II of *C. doronicoides* mostly coincides with the beginning of northern hemisphere glaciation (Whitman & Berger, 1991). It suggests that this datum is influenced by cooling of the ocean water.

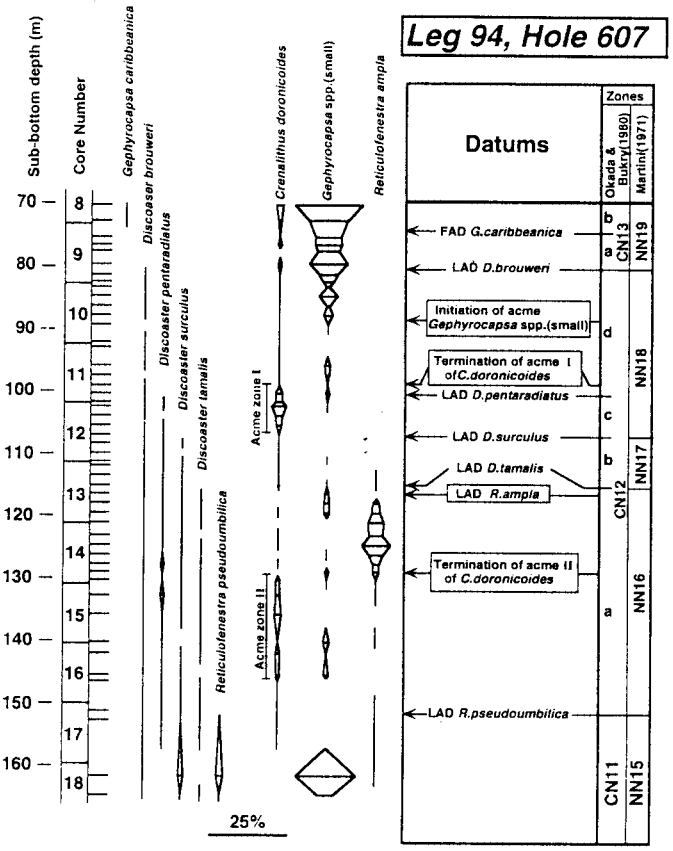

Figure 1. Stratigraphic distribution and relative abundance of the main calcareous nannofossil specimens in the upper Pliocene sediments in Hole 607, DSDP-IPOD Leg 94.

CALCAREOUS NANNOFOSSIL ASSEMBLAGES OF THE LATE CENOMANIAN, LATE CAMPANIAN -EARLY MAASTRICHTIAN AND LATE OLIGOCENE OF TANZANIA.

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Topics: Late Cretaceous & Oligocene, Tanzania, Biostratigraphy

Eleven uphole samples (TPDC - 1989 Seismic Surveys) collected during 1989 when TPDC were running seismic surveys in Southern Tanzania were subjected to standard calcareous nannofossil preparations and many smear-slides and centrifuged-slides were prepared for each sample. Samples yielded enormous amounts of calcareous nannofossils. A highly diverse group of calcareous nannofossils were observed in the studied section. The samples ranged from Late

Cretaceous to Early Tertiary. Few zones were identified. For the biozonal subdivision the standard schemes of Sissingh, 1977 (Cretaceous) and Martini, 1971 (Cenozoic) were used.

The Early Tertiary of Southern Tanzania consists of argillaceous and carbonate deposits. The Late Oligocene calcareous nannofossil assemblages consists of *Reticulofenestra, Discoaster* spp., *Sphenolithus, Helicosphaera, Cyclicargolithus* and *Braarudosphaera* spp.

The Upper Cretaceous marine claystones and shales of the studied section have a high abundance and diversity of the Late Cretaceous forms. A number of zones were also identified based on the Upper Cretaceous zonal markers. A high influx of species of *Nannoconus* and *Eprolithus* in the Late Cenomanian and Santonian, Late Campanian – Early Maastrichtian, a high abundance and diversity of species of *Reinhardtites, Prediscosphaera, Eiffellithus, Retacapsa, Zeugrhabdotus, Micula, Cribrosphaera, Arkhangelskiella, Chiastozygus, Microrhabdulus, Corollithion, Lithastrinus, Quadrum* etc. These represent the first record of Cretaceous and Tertiary calcareous nannofossil assemblages in East Africa.

COCCOLITHOPHORID DISTRIBUTION IN THE INDIAN OCEAN TO EASTERN NORTH ATLANTIC SURFACE WATERS: A COMPARISON WITH THE ATLANTIC AND PACIFIC BIOGEOGRAPHIC ZONATIONS

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Topics: Living, N.Atlantic-Mediterranen-Indian Ocean, Ecol/oc, *Umbellosphaera*

Coccolithophorid samples from the Indian Ocean, Red Sea, Mediterranean Sea and eastern North Atlantic surface waters (0-5m) have been investigated, to study the distribution and geographic variation in coccolith morphology of the individual species, and to identify coccolithophorid assemblages (Snellius-II Expedition Cruise Gx, June-July 1985). Four main assemblages were found, dominated by: (A) *Emiliania huxleyi*; (B) *Gephyrocapsa oceanica*; (C) *Umbellosphaera* spp.; and (D) *Calciopappus rigidus, Ophiaster* spp., *Syracosphaera orbiculus* and *Gephyrocapsa oceanica* (in low absolute frequencies and associated with high numbers of diatoms).

The northern Indian Ocean coccolithophorid distribution mirrors that of the Pacific, with *Gephyrocapsa oceanica* and *Emiliania huxleyi* as the dominant species. At the highest temperatures and under oligotrophic conditions *Umbellosphaera irregularis* and *U. tenuis* Types O and I dominate the flora. The cosmopolitan *E. huxleyi* dominates the flora along the larger part of the Cruise Gx-transect. At mid-latitudes and under oligotrophic conditions it co-occurs with holococcolithophorids and *Umbellosphaera tenuis* Types II-IV, corresponding to the Subtropical North Atlantic Zone, whereas in the nutrient-enriched western Arabian Sea it co-occurs with *G. oceanica*. Assemblage D is found in the centre of the upwelling area South of India and in the Strait of Bab al Mandab, while *G. oceanica* increases in abundance at the margins of these tropical nutrient-enriched areas, in the more 'mature' water.

Umbellosphaera tenuis Type I, one of the five morphotypes that were distinguished within this species, shows maximum numbers at 30-32°C and has a preference for even higher temperatures than *U. irregularis*.

PALAEOECOLOGICAL SIGNIFICANCE OF CALCAREOUS DINOFLAGELLATE CYSTS (MIDDLE AND UPPER EOCENE)

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POSTER Topics: M-Late Eocene, Denmark & Paris Basin, P'ecol/oc, Calcispheres

Calcareous dinoflagellate cysts (Calciodinellaceae Deflandre 1947) from the Middle and Upper Eocene of Jutland (Denmark) and the Paris basin (France) have been studied with SEM and are compared with cyst associations from other localities of Palaeocene to Miocene age (Tremp, Heiligenhafen, Mainz basin, Algeria). Both, the taxonomic composition of the observed florae (relation of orthopithonelloid and obliquipithonelloid species) and the morphology of cysts (crystal size, wall thickness, diameter) change from neritic to offshore (pelagic) palaeoenvironments. With increasing distance from the coast, the following trends can be observed:

• The content of orthopithonelloid species and individuals increases, while obliquipithonelloids

decreases correspondingly.
• The species diversity increases (from 7 species in neritic conditions to more than 30 species in the pelagic realm).
• The cysts diameter decreases (from 70 to 25-30 μm).
• Thickness of the calcareous wall decreases (from 10 to 2 μm).

Due to the long stratigraphic ranges of many species, (*Obliquipithonella edgarii* from the Middle Jurassic to Eocene) calcareous dinoflagellate cysts are poor index fossils for biostratigraphy. However, the strong correspondence of morphology and taxonomical composition to different environments allows the use of calcareous dinoflagellate cysts for reconstructions of palaeoecological conditions.

HOW DID THE CALCAREOUS NANNOPLANKTON ASSEMBLAGES REFLECT THE PALAEOENVIRONMENTAL CHANGES INDICATED BY MASS MORTALITY OF EARLY OLIGOCENE PTEROPODS.

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Topics: Oligocene, Paratethys, Palaeoecology, Laminites

Three thin laminated horizons overcrowded by pteropods on bedding planes have been studied in detail from the Subchert Member of the Menilitic Formation (Zdánice Unit, the West Carpathian Flysch Belt) in South Moravia, Velké Nemcice section. They are known from the NP22 biozone of the Central and Eastern Paratethys as *Spiratella* horizons and have been interpreted as mass mortality bio-events. They form thin intercalations within layers characterized by high-productivity normal-marine assemblages of calcareous nannoplankton and planktonic foraminifers.

On the bedding planes with pteropods, *Lanternithus minutus* and *Zygrhablithus bijugatus* are abundant whereas the more open marine *Reticulofenestra umbilicus* is usually absent. On some bedding planes with pteropods, small planktonic foraminifers are also frequent which indicates the general influence of the bio-event. It suggests very short periods of ecologic stress which caused mass mortality of stenokous pteropods (probably due to decrease in salinity). Between the periods of pteropod mass mortality nannoplankton and planktonic foraminifers thrived. It seems that the absolute value of ecologic parameters reached during the period of the pteropod mass mortality was less important than the contrast with optimal ecological conditions established before the development of the *Spiratella* horizons.

BIOSTRATIGRAPHY AND PALAEOENVIRONMENTAL IMPLICATIONS OF THE MESSINIAN SEDIMENTS FROM THE TORREMENDO MARLS (ALICANTE, SPAIN)

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Topics: Late Miocene, S. Spain, P'ecol/oc., Messinian Crisis

The upper part of the Torremendo Marls consists of homogeneous and laminated marls interbedded with calcarenite layers. In a regional context these deposits are overlaid by gypsum and calcareous sandstone correlated with the Lower Evaporites of the Mediterranean (Figs. 1 a and b). Biostratigraphically the section is Upper Messinian, CN9b (Okada & Bukry, 1980) as indicated by the co-existence of *Discoaster berggrenii* and *Amaurolithus* spp. The presence of abundant *Neogloboquadrina acostaensis* preferentially dextral also support this correlation. In these sediments sporadic circular reticulofenestrids (4-5 μm) occur.

During the Messinian the Mediterranean basin began to be restricted. This event was probably amplified in a small basin like this. In general the calcareous plankton and benthos are characterized by low diversity assemblages typical of highly fluctuating environments, reflecting strong anomalies in surface and bottom water properties. The nannofossil assemblage is mainly composed of very small and small reticulofenestrids; other taxa such as *Coccolithus pelagicus*, *Helicosphaera* spp., *Geminilithella* spp., and asteroliths appear at lower relative abundance. The preservation is in general moderate, however, a large number of reworked forms occur in some intervals. The planktonic foraminifera association is dominated in the majority of samples by only one or two species although the most abundant species changes between levels.

In general the main changes in the micropalaeontological assemblage allow us to conclude that fluctuations in salinity in surface waters are responsible for the main changes in the calcareous microplankton. The coincidence of higher numbers of *Syracosphaera* and *Neogloboquadrina acostaensis* in some laminated intervals seems to be related to decreasing salinities in surface waters due to major fresh-water inputs that probably caused a restriction in ventilation of the bottom. This conditions in the sea floor can be corroborated by the almost exclusive presence of Bolivinids and Buliminids, benthic foraminifera taxa indicating poor oxygenation (Fig. 2).

This contribution has been supported by the DGICYT (project number AMB92-0531 and PB9I- 0097-C02-02) and the Instituto Juan Gil-Albert, Diputación de Alicante.

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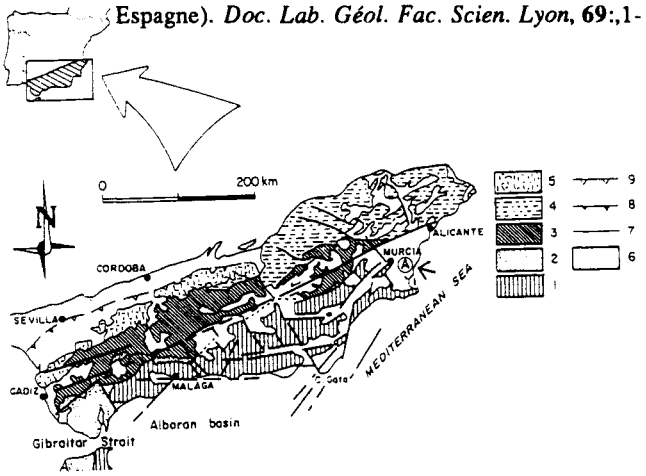

Figure 1a.- Simplified scheme showing the main geological units in the Betic Cordillera (Southern and Southeastern Spain). Keys: 1= Internal Zones; 2= Campo de Gibraltar units; 3+4= External Zones (3= Subebetic, 4= Prebetic); 5= Olistostromes in the Guadalquivir Basin; 7= Main faults; 8= Main overthrusts; 9= Front of the olistostromic units; A= Situation of the studied section

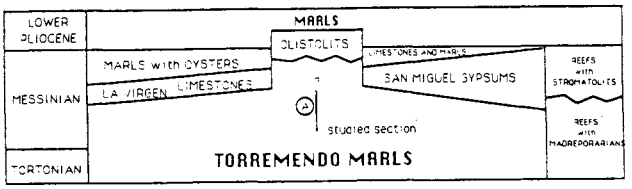

Figure 1b.- Upper Tortonian-Messinian facies in the San Miguel-Torremendo Basin (Montenat, 1977)

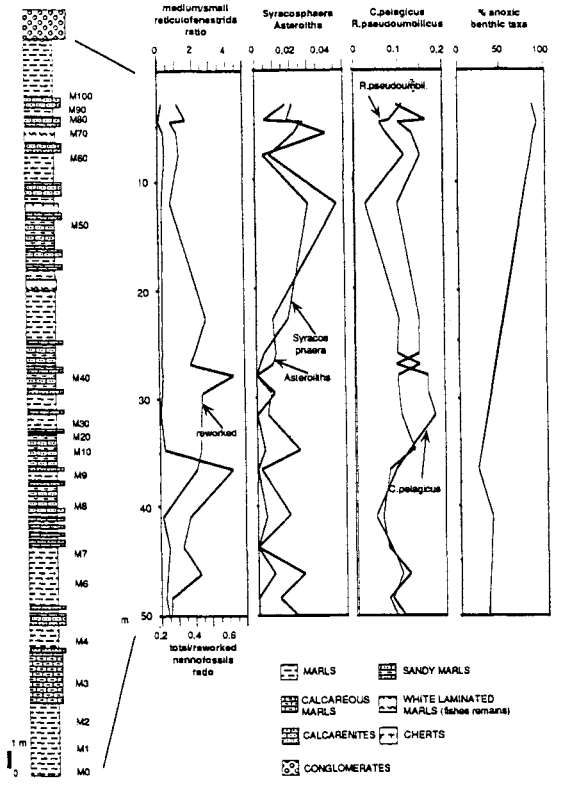

FIGURE 2.- Stratigraphic section from the Messinian of the Torremendo Marls. Quantitative distribution of some selected nannofossil groups and benthic foraminifera oxygenation indicators.

PRELIMINARY ANALYSIS OF CALCAREOUS NANNOFOSSILS FROM ODP LEG 149, EAST IBERIA ABYSSAL PLAIN

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Topics: E. Cret.- Pleistocene, Atlantic Ocean, Biostratigraphy, ODP Leg 149

We report preliminary results of calcareous nannofossil analyses from four sites drilled in Ocean Drilling Program Leg 149, which was designed to investigate the ocean-continent-transition in the Iberia Abyssal Plain by studying the physical and petrological nature of the acoustic basement.

The nannofossil assemblages from Site 897, 898 and 899 define a discontinuous stratigraphic succession from the upper Pleistocene (Zone NN21 of Martini, 1971) to the Early Cretaceous (Zone CC4 of Sissingh, 1977). Most of the sediments recovered from Leg 149 consist of turbidites and contourites. The calcareous nannofossils are generally abundant and well preserved in the uppermost hemi-pelagic parts of turbidite or contourite sequences.

The nannofossil assemblages from Sites 897, 898 and 899 suggest the following: (1) A

continuous stratigraphic succession from the upper Pleistocene (Zone NN21) to the latest Pliocene (Zone NN19); (2) A discontinuous stratigraphic succession, including one to three sedimentary hiatuses, from the late Pliocene (Zone NN18) to Middle Miocene (Zone NN6); (3) A continuous stratigraphic succession from the Middle Miocene (Zone NN5) to late Eocene (Zone NP18); and (4) A discontinuous Cretaceous sedimentary history. These assemblages also indicate there are distinctive differences in the sedimentation rates of each site.

UNUSUAL SILICOFLAGELLATE SKELETAL MORPHOLOGIES FROM THE UPPER MIOCENE-LOWER MIOCENE: POSSIBLE ECOPHENOTYPIC INDICATORS

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POSTER Topics: Miocene-Pliocene, Antarctic, Morphology, Silicoflagellates

Six unusual morphotypes of the silicoflagellate subspecies *Distephanus speculum speculum* comprise the "*pseudofibula* plexus", the distribution of which is concentrated in uppermost Miocene-lowermost Pliocene sediments centered about the Antarctic continent. The occurrence of this plexus in Antarctic and subantarctic waters correlates well with the late Miocene-earliest Pliocene glaciations of the continent, therefore, some type of ecologic control is suspected to account for its distribution in time and space. Distribution maps show that members of the plexus dominate silicoflagellate assemblages closest to the continent (Class I province), but that their numbers diminish away from the continent (through Class II and Class III provinces) as does the thickness of the interval they occupy, thus the stratigraphic boundaries of the plexus may be diachronous.

Only at ODP Site 704 on Meteor Rise does the plexus occur in a continuous pelagic carbonate sequence with well-developed stable isotope, magneto- and biostratigraphies. Its first abundance peak at that site, just above the base of the Messinian Stage, corresponds with a major interglacial event in the planktonic and benthic foraminiferal isotopic record, an episode believed to have produced significant melting of the continental ice sheet and the injection of low salinity melt waters across the surface of the Southern Ocean. The major abundance peak of the plexus at this site occurs farther up section, where it follows closely another anomalous negative excursion in the planktonic isotopic record. At the conclusion of the latest Miocene-earliest Pliocene glaciations, however, the pseudofibula plexus disappears abruptly from the Southern Ocean, suggesting that its existence was closely tied to glacial/interglacial events on the continent, with meltwater injection into a nutrient-rich upwelling environment a possible trigger for its blooms.

PLIO-PLEISTOCENE BIOSTRATIGRAPHY OF TERRIGENOUS SEDIMENTS IN THE SOUTHERN APENNINIC FOREDEEP (ITALY)

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POSTER Topics: Late Pliocene-Early Pleistocene, Italy, Biostratigraphy

The Plio-Pleistocene Argille Subappennine Formation crops out in several areas of the Bradanic foredeep; in particular samples have been collected along the internal border of the foredeep in the Basilicata region. In order to obtain a detailed biostratigraphy of these sediments, a quantitative analysis of nannofossil assemblages and qualitative study of planktonic foraminifera has been conducted.

The zonal schemes, to which the biostratigraphy has been referred, are those proposed for pelagic sediments in the Mediterranean Sea: Rio *et al* (1990) for the nannofossils, and Cita (1975) and Spaak (1983) for planktonic foraminifera. Following these schemes, several biostratigraphic events have been recognized. The planktonic assemblage seems to be represented by a reduced total abundance compared with those in the pelagic sediments; moreover, pre-Pliocene and Pliocene reworking seems prevalent.

The integrated biostratigraphy (nannofossils and foraminifera) and quantitative study have allowed two different transgressive sequences to be differentiated in the sections: the first one is referred to the lower part of the upper Pliocene, the second one to the upper Pliocene and lower Pleistocene. In regard to the nannofossil assemblages it is important to note that quantitative study can also be applied to terrigenous sediments in order to recognize the biostratigraphic events.

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RESPONSE OF CALCAREOUS NANNOFOSSILS TO HYDROTHERMAL ACTIVITY, ODP LEG 139

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Topics: Late Quaternary, Pacific Ocean, Preservation, ODP Leg 139

Upper Quaternary calcareous nannofossils were investigated from ODP Leg 139 drill cores taken on the heavily sedimented Middle Valley of the northern Jan de Fuca Ridge in the NE Pacific Ocean. The host sediments had been subjected at depth to hot hydrothermal fluids that altered or destroyed in part of in toto the nannofossils assemblages, thereby raising at several sites the level of the first stratigraphic occurrence of nannofossils in the holes or of the important *Emiliania huxleyi* datum.

The degree of alteration of the nannofossil assemblages is dependent on the intensity of the hydrothermal activity, which is indicated by paleotemperatures derived independently from studies of color alteration of palynomorphs and by vitrinite reflectance. State of preservation and the downhole level at which assemblages have been destroyed correlate well with the inferred paleotemperature readings. No nannofossils withstood fluids greater than 120°C, and selective species dissolution was evident, with *Coccolithus pelagicus* being the most resistant to the heat, gasses and fluids. More systematic correlation of these phenomena is hampered, however, by the fact that the nannofossil preservation is already mixed at the time of deposition because of the predominance of turbidite activity in the study area.

INTEGRATED CALCAREOUS PLANKTON BIOSTRATIGRAPHY OF PLIO-PLEISTOCENE TERRIGENOUS DEPOSITS (SOUTHERN APENNINE, ITALY)

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Topics: Pliocene-Pleistocene, Italy, Zonation

An integrated biostratigraphic study based on calcareous nannofossils and foraminifera was performed on 9 Plio-Pleistocene terrigenous sections sampled in the S. Argangelo Basin and in the Bradanic Foredeep (southern Apennine). Many important biostratigraphic events were recognized according to the Mediterranean calcareous plankton biozonal schemes proposed by Spaak (1983), Colalongo & Sartoni (1979), Raffi & Rio (1979) and Rio *et al.* (1990).

The integrated biostratigraphy and quantitative analyses on calcareous nannofossils allowed the definintion of a succession of events which were easily recognisable in terrigenous samples for the early Pliocene-early Pleistocene. Nannofloras are generally abundant, despite the remarkable inorganic input (45%-70%); the Pliocene assemblages varied in abundance from 20% to 40% and the reworked specimens from 10% to 15%. Therefore, important chronostratigraphic species are diluted in the samples. In spite of this, the quantitative and integrated biostratigraphic analyses have allowed the recognition of 13 calcareous nannofossil and 9 foraminiferal events in the early Pliocene-early Pleistocene interval.

Discoasters are very important in the upper Pliocene zonal schemes of Mediterranean and oceanic pelagic sediments, unfortunately they are rare in terrigenous sediments. For this reason the counting of discoasters, instead of 100 specimens as in a common analytical method, has been performed within a total number of 20,000 and 30,000 autochthonous Pliocene coccoliths. In this

way it has been possible to obtain meaningful numbers of discoasters and consequently to obtain a better framework of the stratigraphic distribution patterns including the extinction levels of *D. tamalis*, *D. pentaradiatus*, and *D. brouweri*. Fluctuations in the abundance of discoasters and of small *Gephyrocapsa* have been noted shortly after the LO of *R. pseudoumbilicus*.

A good correlation between calcareous nannofossils and both benthic and planktonic foraminifera has been determined; in particular:

- The FO of *Bulimina marginata* and *Neogloboquadrina atlantica*-sinistral occur shortly after the LO of *D. pentaradiatus*;
- The *D. triradiatus* "acme", the FO of *Globorotalia inflata* and *G. truncatulinoides truncatulinoides* occur in the upper part of the *D. brouweri* Zone.
- The FO of "Large" *Gephyrocapsa* and *Gephyrocapsa* sp.3 (*sensu* Rio 1982) are well recognizable events in the lower Pleistocene terrigenous sediments.

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THE RETICULOFENESTRIDS IN THE CATALONIAN PLIOCENE (WESTERN MEDITERRANEAN) - THE STATUS OF THEIR TAXONOMY.

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POSTER Topics: Pliocene, W. Mediterranean, Biometrics, Reticulofenestrids

The reticulofenestrids in the Catalonian Pliocene constitute an important part of the nannofossil assemblages. Five previously described species, *Reticulofenestra pseudoumbilicus* (GARTNER) GARTNER, *R. minutula* (GARTNER) HAQ & BERGGREN, *R. minuta* ROTH, *R. haqii* BACKMAN and *Dictyococcites productus* (KAMPTNER) BACKMAN, have been recognized from the nearshore drilled hole of Garraf and four land outcrops of Baix Llobregat Basin (Catalonia, NE Spain). In cross-polarized light all these species have a similar swastika-like interference figure which can be continuous or discontinuous at the central area. The length of the placolith and that of the central opening are the main diagnostic characters in light microscopy. But specialists do not agree on sizes that typify each species. Consequently the taxonomy of reticulofenestrids remains unclear.

The aim of this work is to solve these taxonomic problems trying to determine if any features observable by electron microscopy, like rim elements or central area structure, could be related to placolith and central opening length . To do this, 20 to 50 reticulofenestrids in some selected samples from the drilled hole of Garraf and outcrops of Baix Llobregat Basin have been observed and measured. Many reticulofenestrids from Miocene and Pliocene outcrops of the Chelif Basin (Algeria) have also been observed and measured to compare.

The results obtained from this investigation allow me to suggest the following subdivision of reticulofenestrid group: *R. pseudoumbilicus* are those forms with a diameter greater than 5.5 microns and a central area covered with a network of delicate pores. These forms disappear near the early/late Pliocene boundary. The small specimens of *R. pseudoumbilicus* have only been found at the base of the early Pliocene. *R. minutula* are those specimens that measure between 3.5-7μm and have a network of thin laths covering their central area. Two morphotypes can be differentiated, *R. minutula* morphotype *haqii* with a smaller central area and *R. minutula* morphotype *minutula* with a larger one. In some samples intermediate specimens are found. *R. minuta* has the same central area morphology as *R. minutula* but it is consistently smaller measuring less than 3.5 μm. *R. minuta* and *R. minutula* present a bimodal distribution pattern in many samples that justifies their classification into separate species. *Dictyococcites minutus* are those reticulofenestrids with a central area completely covered by delicate plates and which measure 2-6 μm.

QUANTITATIVE ANALYSIS OF TOARCIAN CALCAREOUS NANNOFOSSILS OF THE POZZALE SEQUENCE (M. MARTANI, CENTRAL ITALY).

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Topics: E. Jurassic, Italy, P'ecol/oc

Upper Domerian to Middle Toarcian sediments of the Pozzale sequence (central Italy) have been sampled at ten centimetre intervals and a quantitative analysis on calcareous nannofossil assemblages has been carried out. The investigated sediments belong to the upper part of the Corniola Fm., to the Marne di M. Serrone Fm. and to the lower part of the Rosso Ammonitico Fm. The Marne di M. Serrone Fm. (M.M.S.) is widespread in the Umbria-Marche Basin and consists of a pelagic sequence of marls and marly limestones. In some cases, such as at Pozzale, the M.M.S. contains "black-shale" levels. In the Pozzale sequence the total thickness of the M.M.S. is about 10m in which 4.7m of dark laminated sediments are present. Geochemical (TOC, HI, $\%CaCO_3$) and micropalaeontological analyses have been carried out on these sediments.

The quantitative study on the calcareous nannofossil assemblages aimed to characterise: 1) the succession of biostratigraphic events; 2) the preservational state, in correlation with solution and overgrowth phenomena; 3) possible variations of the total and relative abundance, as a result of palaeoecological and/or preservational factors; 4) the timing and pattern of sedimentation.

CALCAREOUS NANNOPLANKTON FROM THE OLDEST FLYSCH DEPOSITS (TITHONIAN-NEOCOMIAN, FROM THE ROMANIAN CARPATHIANS

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Topics: Tithonian-Neocomian, Romania, Biostratigraphy

The oldest flysch facies deposited in the area corresponding to the Eastern and Southern Carpathians is the Sinaia Formation from the Outer Dacides, which spans the Tithonian–Neocomian interval. This flysch is composed of both sandy and calcareous turbidites. The richest nannofossil assemblages occur mainly in the marly limestones and in the calcareous turbidites.

The following nannofossil zones have been identified: *Conusphaera mexicana, Polycostella beckmannii, Nannoconus steinmannii, Micrantholithus obtusus, Stradneria crenulata, Speetonia colligata, Calcicalathina oblongata, Lithraphidites bollii*. These zones fit perfectly with those already established in the pelagic deposits from the same area.

The Sinaia Formation begins with a shaley calcareous sequence, in which red and green shales, radiolarites, and basic rocks are intercalated. In the calcareous rocks an assemblage with: *Conusphaera mexicana minor, Conusphaera mexicana mexicana, Stephanolithion bigotii,* and *Cyclagelosphaera deflandrei* indicated an Early Tithonian age. Above this pre-flysch sequence the turbidites are more and more frequent, representing accumulation of the typical flysch facies. In this flysch facies the *Polycostella beckmannii* zone has been identified. This situation clearly indicates that the flysch deposits accumulated no earlier than the latest Jurassic. It is noteworthy that this situation has been recorded both in the Eastern and Southern Carpathians (Ceahlau and Severin Nappes).

Basic igneous rocks are mostly present in the pre-flysch deposits, but are also recorded in the lowermost part of the flysch facies, this suggests that the oldest flysch deposits accumulated synchronously with the last stages of oceanic spreading on the northern margin of the Tethys.

CRETACEOUS CALCAREOUS NANNOFOSSILS FROM SOUTH LITHUANIA

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Topics: Upper Cretaceous, Lithuania, Biostratigraphy

Three sections of Upper Cretaceous deposits have been studied in South Lithuania. The sediments consist of chalk, marl and marly limestone. Their lower part is composed of sand. On the basis of nannofossil analysis, nine zones were defined for the stratigraphical interval from Upper Cenomanian to Maastrichtian. The sequence of nannoplankton assemblages has been fixed in all studied sections. The lower boundary of each zone is marked by the first appearance of the nominate species. The nannofossils are generally poorly preserved and rare in the lower (sandy)

part of the sections, whereas they are abundant and well preserved in the upper part.

The nannoplankton zones have been correlated with the planktonic foraminiferal zonal units recognized in the same sections.

NANNOPLANKTON ZONES FROM THE SARMATIAN *S.S.* (THE TRANSYLVANIAN BASIN) AND THE SARMATIAN *S.L.* (THE DACIAN BASIN)

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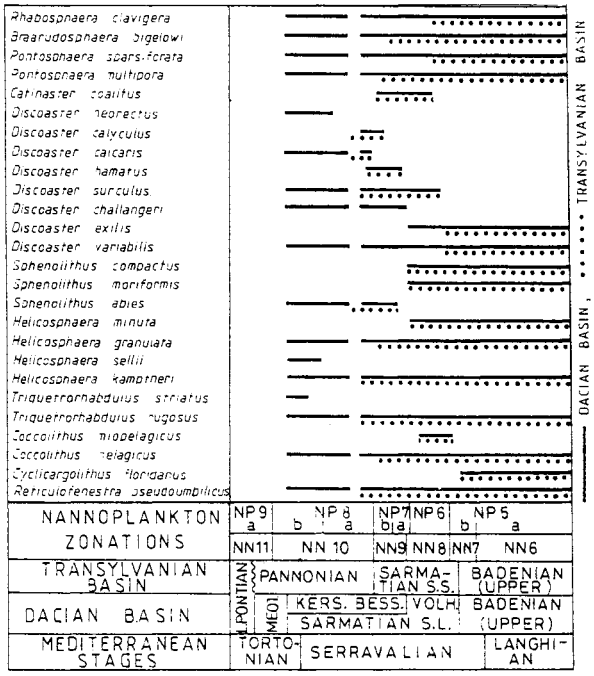
Topics: Miocene, Central Europe, Biostratigraphy

During the late Badenian the Miocene basins of Switzerland, and Bavaria rose and cut the communication between Tethys and the marine basins of Central and Eastern Europe. This was the beginning of the process that turned them into brackish seas. In Central Europe (Viennese, Pannonian and Transylvanian Basins) the Sarmatian *s.s* (Suess,1866) and the Pannonian *s.s.* developed (Stefanovic,1951), the latter including the Upper Bessarabian, the Kersonian and Meotian. Besides the nannoplankton assemblages characteristic of the Sarmatian *s.s.* (CN6,7/NN8,9), a Pannonian interval (CN8a/NN10) was also identified. There are only reworked forms for the rest of the Pannonian.

Within The Dacian Basin, east of the Carpathians (The Moldavian Plateau), a Sarmatian *sensu lato* (Barbot de Marni, 1866) Volhynian, Bessarabian, Kersonian, can be identified, with nannofossil assemblages of zones CN6,7,8/NN7,8,9,10. During the Upper Bessarabian there is a period when sea-water turns into fresh-water, marked by the lack of nannoplankton.

The table contains the most frequent species, that is the most important ones from a stratigraphical viewpoint.



CALCAREOUS NANNOFOSSIL EVENTS ACROSS THE PALEOCENE-EOCENE BOUNDARY OF THE TRABAKUA SECTION (BASQUE BASIN, WESTERN PYRENEES)

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Topics: Palaeocene/Eocene bdy, Spain, Zonation

The Trabakua section, outcropping in the south eastern part of the Biscay Synclinorium (Basque Basin, Western Pyrenees) exposes a continuous succession of latest Cretaceous-earliest Eocene hemipelagic limestones and marls. This section has been evaluated as a prospective deep-water parastratotype for the Paleocene-Eocene boundary (Orue-etxebarria *et al.* 1992).

Calcareous nannofossil quantitative biostratigraphy has been performed across the Paleocene-Eocene boundary and the preliminary results were correlated with planktonic foraminiferal assemblages and events. The nannoflora is abundant, well preserved and well diversified. These features allowed the recognition of several sequential bio-events and the further refinement of biostratigraphy across the P/E boundary. Quantitative analyses show significant fluctuations in terms of abundance of discoasters, braarudosphaerids and of *Z. bijugatus*. These fluctuations are discussed in the context of the recently established sequence stratigraphy of the Trabakua section (Pujalte *et al.*, in press).

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THE RESPONSE OF CALCAREOUS NANNOFOSSILS TO THE ONSET OF THE MID-CRETACEOUS GREENHOUSE

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Topics: Barremian-Aptian, Global, P'ecol/oc, Climate change

Major changes in calcareous nannofloras were quantified close to the Barremian/Aptian boundary in the Tethys, the Boreal Realm, and the oceans. Using available stratigraphies, a synchronous turnover (rate of speciation + rate of extinction) has been documented worldwide. This peak in diversification rates marks the change from the Berriasian-Barremian interval, characterized by a strong provinciality, to the Aptian-Albian interval, displaying a worldwide homogenization of nannofloras. The turnover predates the Early Aptian Oceanic Subevent, OAE1a, and the associated $\partial^{13}C$ anomaly. While the Tethyan-Boreal nannofloral homogenization can be explained by transgression and migration patterns at a regional scale, the worldwide homogenization requires paleoceanographic changes in the mid-Cretaceous oceans at global scale.
The onset of the speciation event in the latest Barremian is correlatable with the beginning of a major transgression and might be the response of calcareous nannofloras to expanded marginal seas and opening of new ecological niches. Dispersion of the new species into the oceans was very rapid and determined the homogenization of Aptian-Albian nannofossil assemblages. The Early Aptian oceanic anoxic event postdates the beginning of the turnover and interrupts evolutionary trends previously established at least one million years before.

Increased spreading rates and abnormal intraplate volcanism have been suggested as a cause of the onset of the mid-Cretaceous Greenhouse state characterized by global warming, high humidity, and sluggish oceanic circulation. It is plausible that elevated CO_2 levels coupled with the warm and humid climate of the Greenhouse conditions triggered accelerated carbon cycling via increased transfer rates of nutrients into the oceans.

The nannofossil turnover close to the Barremian/Aptian boundary might be the response to the transition from geographically restricted habitats to more widespread oceanic conditions and/or to higher nutrient availability.

NANNOFOSSIL AND MICROFOSSIL DISTRIBUTION IN LAMINATED ANOXIC SEDIMENTS FROM THE BANNOCK BASIN (EASTERN MEDITERRANEAN)

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Topics: Quaternary, Mediterranean, P'ecol/oc, laminites

A quantitative analysis of nannofossils and microfossils has been applied to laminated sediments recovered from the Libeccio Basin of the Banock area. The study is focused on Core KC06C collected during the *M. Dufresne* cruise of the Marflux - MAST project funded by the EC (in this core the anoxic sediments comprise several turbidites and finely laminated intervals). in the portion underlying the Bronze Age homogenite belonging to the *E. huxleyi* and *E. huxleyi* acme zones, sections 02 and 16, characterised by varve-like laminations were studied in great detail.

Quantification of calcareous nannofossils was carried out on 116 samples by light microscopy at 1250x, counting at least 300 speciemens per sample. Calcareous and siliceous microfossils were counted in the same slides at 300 x.

Nannofloral assemblages do not show significant fluctuations in composition between light and dark laminae. However, Pliocene reworked specimens are unusually abundant in all the sediment. The dark laminae are characterized by a generally increased number of tests with more abundant siliceous microfossils, with respect to the light laminae. Similar patterns have been observed in other sub-basins of the Bannock area.

A PRELIMINARY REVIEW OF THE NANNOCONACEAE

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Topics: Late Jurassic - E.Cretaceous, Global, Taxonomy/Morphology, *Nannoconus*

In the past the study of nannoconids has relied upon gradational morphological characteristics, e.g. the external shape and dimensions of the skeletal body, as the primary taxonomic identification criterion. The high morphological variability of the outline and internal contour, in addition to problems in the observation of nannoconids in either the light or scanning electron microscope, has promoted ambiguity and synonymy within this group.

Recent observations on the fine structure of nannoconids have led to the recognition of two distinct crystal plate orientations within the skeletal body (van Niel, 1992). Characteristic arrangements of these plates in different species has enabled us to recognise distinct morphogroups to which taxa can be assigned. These wall structure morphovariants can aid in the systematic assignment of individuals to groups, within which the skeletal outline can provide a secondary criterion for taxonomic identifications.

A preliminary compendium of all the described nannoconids will be given based upon material obtained during a doctoral study and from Type Collection material.

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COCCOLITHS AS A TURBIDITE CORRELATION TOOL IN THE SEINE ABYSSAL PLAIN

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Topics: Quaternary, Atlantic Ocean, Biostratigraphy, Turbidites

The Seine Abyssal Plain occupies an area to the northeast of Madeira, off the NW coast of Africa. Six piston cores were collected in 1989 and show thick sequences of distal turbidite units separated by thin bioturbated pelagic units (marls and oozes).

The technique for determining the timing and frequency of emplacement of these turbidite units was developed by Weaver (1983) during an investigation of the Canary Basin and this technique has been applied to sediments of the Seine Abyssal Plain:

A stratigraphic framework for the abyssal plain was obtained by analyzing the thin pelagic units in the cores on the central plain (Cores D11934-39) and on the interbasinal sill (Core D11940) which lies in the SW corner of the abyssal plain and possibly forms an overflow pathway from the Seine to the Madeira Abyssal Plains. The cores range from 0-200,000 years (*E. huxleyi-G aperta* Zone) in the centre of the basin, and to 400,000 years (*G. caribbeanica* Zone) on the sill which was generally less affected by turbidity currents. The zones in conjunction with the lithostratigraphy provide an initial correlation of the pelagic units and indicate the timing of the turbidite deposition.

Each turbidite unit in the Madeira Abyssal Plain contains a reworked assemblage of coccoliths which has been shown to be relatively constant for each unit (Weaver & Kuijpers 1983) providing a sound core correlation. This principle has been applied to the reworked sediments in the Seine Abyssal Plain and using the dominant coccoliths: *E. huxleyi, G. muellerae, G. aperta* and *G. caribbeanica*, individual turbidite units can be mapped across the study area. An example of the correlation of a turbidite unit which has overflowed from the Seine Abyssal Plain into the Madeira Abyssal Plain is also illustrated using coccoliths.

Data on the frequency of the turbidite events and on the accumulation rate of the pelagic intervals will be presented. This correlation framework using coccoliths and lithostratigraphy provides a good basis for further lithological, geophysical and geochemical investigation.

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NANNOFOSSIL RESPONSE TO THE ABRUPT WARMING EVENT NEAR THE PALEOCENE-EOCENE BOUNDARY: ITS PALEOCEANOGRAPHIC AND PALEOCLIMATIC IMPLICATIONS

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Topics: Palaeocene-Eocene bdy, Global, P'ecol/oc, Climate change

The Paleocene-Eocene transition in ODP Site 690 in Antarctic waters was marked by a remarkable short-term (10-100 ka) negative excursion in $\partial^{18}O$ of both planktonic and benthic foraminifers, which coincided with the largest negative excursion in $\partial^{13}C$ in the entire Cenozoic and the largest benthic extinction in the last 90 Ma. This phenomenon was likewise seen to a lesser degree in DSDP Sites 47 and 577 in the Western Pacific Ocean. The present study presents the first detailed calcareous nannofossil data across this interval to examine its response to this warming event. A sharp increase in the warm water genus, *Discoaster* was found in the high latitude site (690) and less distinctly in the low latitude site (577) across this interval. *Chiasmolithus* fragmentation data from Site 690 show improved carbonate preservation during this time and suggest an abrupt drop in global carbonate production and by inference, global primary productivity. In the high latitude core, an increase in the sizes of both *Chiasmolithus* and *Coccolithus pelagicus* further characterizes the warming trend and supports prior observations of the correlation between nannoplankton size and productivity. The abrupt increase in *Discoaster* abundance and in the sizes of *Chiasmolithus* and *C. pelagicus* provide distinct datums for quick recognition of the warming event and for precise correlation especially in the Southern Ocean. The nannofossil fragmentation data do not indicate an increase in carbonate dissolution and argue against the interpretation that the large negative $\partial^{13}C$ excursion resulted from a substantial increase in the transfer of light $\partial^{13}C$ organic matter from the continents to the oceans. We found a major hiatus in DSDP Site 215 in the Indian Ocean coincident with the isotope excursion and this is interpreted as the result of physical erosion due to increased bottom water movement since evidence of greater dissolution during this time was not seen in fragmentation counts in Site 690 from the Antarctic.

CALCAREOUS NANNOFOSSILS ACROSS THE CRETACEOUS/ TERTIARY BOUNDARY, AGOST, SPAIN

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Topics: K/T Boundary, Spain, P'ecol/oc., Blooms

The Cretaceous/Tertiary boundary which crops out near Agost (Spain) is considered one of the most complete K/T boundary sections (Smit, 1990; Canudo *et al.*, 1991). A detailed analysis of calcareous nannofossils in closely spaced samples across this boundary supports these claims if the absence of *Micula prinsii* in samples from below the boundary is attributed to poor preservation. The distribution of this marker in the uppermost Maastrichtian at Agost is problematic and illustrates the difficulties of determining the completeness of a given section where nannofossil preservation is poor.

Samples were only available from an interval of about 1 m below the K/T boundary to 1.3 m above (within NP1). Quantitative analysis reveals a sharp drop in abundance (specimens/field of view) of nannofossils at the base of the K/T boundary clay commensurate with an iridium anomaly, drop in calcium carbonate, and carbon and oxygen isotope shifts measured by Smit (1990). Stepwise or sequential extinctions among nannoplankton was not noted at Agost as was for planktonic foraminifera by Canudo *et al.* (1991).

As in most all K/T sections, nannofossil species above the boundary show a successional abundance bloom pattern within NP1. At Agost, the sequence of blooms is initiated by *Thoracosphaera operculata*, which is then followed by *Braarudosphaera bigelowii, Octolithus multiplus*, and *Neobiscutum parvulum*. The sequence is nearly identical to that at Caravaca (Romein, 1977). *Neobiscutum romeinii* is not present at this site, although very abundant at the not too distant El Kef, Tunisia. Its absence at Agost may be due to extreme provincialism. However, preservation may more likely be the culprit. The Agost section was deposited at deeper paleodepths which may have promoted dissolution of the more delicate *N. romeinii*. In addition, overall nannofossil

preservation at Agost is poor compared to that at El Kef.

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CRETACEOUS NANNOFOSSILS IN DANIAN SEDIMENTS: SURVIVORSHIP OR REWORKING?

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Topics: K/T Boundary, Global, P'ecol/oc, Reworking?

One of the more interesting debates among nannofossil paleontologists is whether or not Cretaceous nannofossil specimens found in Tertiary sediments are reworked or are actual survivors. The record shows that in nearly all K/T boundary sections, Cretaceous specimens gradually decline in abundance above the boundary within nannofossil Zone NP1 and usually disappear by NP2 or NP3. Traditionally these specimens were considered reworked. Some of the classic arguments for this include the site to site diachroneity of the last occurrences of Cretaceous species, or that the pattern of decline across the boundary horizon matches that of common bioturbation mixing models. However, some have questioned the first point since no detailed studies are available which attempt to convincingly demonstrate the point of last occurrence diachroneity. Furthermore, the same pattern of gradual reduction is present at some localities where bioturbation is absent (Site 738). Hence, the argument that physical mixing by bioturbators is questioned.

An independent means of determining the survivorship of Cretaceous species has been the use of the stable isotopic signal of bulk fraction sediments presumed to consist primarily of nannofossils. It has been demonstrated that lowermost Danian sediments have a distinct carbon and oxygen isotope signal, and that because the bulk sediment is comprised mostly of Cretaceous specimens, these were survivors as indicated by the Tertiary isotopic signature. This has been questioned too because of the uncertainties involved with the measurement of bulk fine fraction.

New evidence from the correlation of Cretaceous nannofossil abundance and iridium data suggests that these specimens in Danian sediments are reworked. The close relationship of iridium abundance and Cretaceous nannofossils in Danian sediments at Indian Ocean ODP Sites 738 and 752 demonstrates (by an independent means) the wholesale movement of Cretaceous specimens upsection along with iridium, most likely by bottom currents in addition to bioturbation. This is best illustrated at Site 752 where at 80 cm above the K/T boundary, an additional iridium anomaly is present along with a marked increase in abundance of Cretaceous specimens. Reworking appears to be the only logical explanation for the iridium-nannofossil relationship as no means can be conceived of whereby Cretaceous species living in surface waters can nearly disappear and then reappear in abundance coincident with high levels of iridium.

THE CRETACEOUS/TERTIARY BOUNDARY SECTIONS IN THE EAST BALKAN AREA, BULGARIA

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Topics: K/T Boundary, Bulgaria, Biostratigraphy, Blooms

Cretaceous/Tertiary boundary sections in the East Balkan area, south of the thrust and nappes of the Balkan Mountain have been identified by biostratigraphic, mineralogical, geochemical and magnetostratigraphic methods. From these investigations only on the coast of the Black Sea, near the village of Bjala (Fig. 1), was a real time K/T boundary detected (Preisinger et al.,1993). Two

profies show a mass extinction of Cretaceous nannoplankton species as well as a bloom of survivors at the K/T boundary and the first appearance of new nannoplankton species after the K/T event. Both profiles lie in Chron 29R, show an iridium peak and a minimum of $CaCO_3$.

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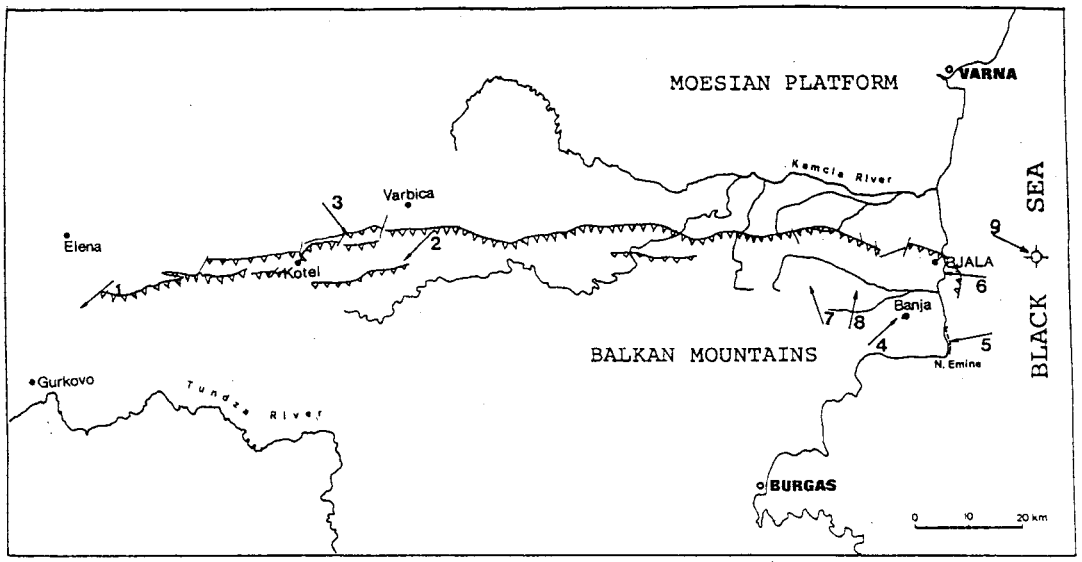

Possible K/T boundary sections in the East Balkan area, Bulgaria.
1 - near Hainboas; 2 - near Varbica pass; 3 - NE of kotel; 4 - west of Banja; 5 - between Cape Emine and irakli; 6 - near Bjala; 7 - east of Panicovo; 8 - west of Koziceno; 9 - Samotino More borehole.

MIOCENE TO PLEISTOCENE CALCAREOUS NANNOFOSSILS FROM THE EASTERN EQUATORIAL PACIFIC OCEAN (ODP LEG 138)

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Topics: Neogene, E. Eq. Pacific, Zonation, ODP Leg 138

The calcareous nannofossil biostratigraphy and biochronology of the sedimentary sequences retrieved during ODP Leg 138 in the Eastern Equatorial Pacific Ocean are presented. In the sediments recovered from eleven sites, drilled along two north-south transects (95°W and 11°W), the calcareous nannofossils are generally common to abundant and provide a detailed biostratigraphy of almost all the sedimentary sequences. In some of them, the late Miocene to late Pliocene time interval is characterized by siliceous clay sediments, and intervals with poor nannofossil contents are associated with this carbonate decrease. Nonetheless, even in these sections it has been possible to obtain a good biostratigraphic classification.

In the time interval from the late early Miocene to the Pleistocene up to more than 35 nannofossil events have been recognized; these allow a detailed inter-site biostratigraphic correlation. Most of them correspond to the zonal boundaries of Martini (1971) and Bukry (1973). Other secondary events, already proposed and discussed in the literature (Fornaciari et al, 1990; Rio et al., 1990; Olafsson, 1991; Fornaciari et al., in press; Raffi et al., in press), are recognized and used to improve the biostratigraphic resolution provided by the standard zonations. The excellent magnetostratigraphic signal in some sites and intervals, and the development of an age model using the composite GRAPE model, allow us to calibrate the nannofossil events according to the new proposal of Shackleton et al (in press).

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QUANTITATIVE DISTRIBUTION PATTERNS AND BIOCHRONOLOGY OF MIDDLE TO LATE MIOCENE CALCAREOUS NANNOFOSSILS FROM EQUATORIAL INDIAN AND PACIFIC OCEANS (ODP LEGS 115 AND 138)

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Topics M-Late Miocene, Eq. Pacific & Indian Oceans, Zonation, ODP Legs 115 & 138

Distribution patterns of selected calcareous nannofossils of the middle and upper Miocene are presented. The stratigraphic sequences studied are ODP Sites 844, 845, 848 and 853 of Leg 138, ODP Site 130-806 and DSDP Site 86-575 in the equatorial Pacific Ocean, and ODP Sites 709, 710, 711, and 714 of Leg 115 in the equatorial Indian Ocean. The nannofossil species and taxonomic groups considered are: *Calcidiscus macintyrei, C. premacintyrei, Coccolithus miopelagicus, Coronocyclus nitescens, Cyclicargolithus floridanus, Minylitha convallis, Reticulofenestra pseudoumbilicus* (>7 μm), *Sphenolithus heteromorphus, Triquetrorhabdulus rugosus - T. rioenesis, T. serratus* ceratolithids and discoasterids. They provided several biostratigraphic events, both conventional and secondary biostratigraphic markers. Abundances of these selected nannofossils were quantitatively determined, and the distribution patterns (abundance, continuity and appearance and extinction modes of the pertinent species) were compared with the available magnetostratigraphic records. The relative position of the events relative to the magnetostratigraphies has been used as the main criterion for ranking their biostratigraphic reliability, in terms of traceability and isochroneity over geographic distance (within and between the equatorial Indian and Pacific oceans and mid-latitude north Atlantic).

The biostratigraphic resolution provided by the conventional markers can be further enhanced by using additional events which appear useful in both areas.

The direct correlation with the good magnetostratigraphic records of Leg 115 and Leg 138 sequences and comparison with mid-latitude magnetostratigraphic record of Site 94-608 allowed us to obtain a significant improvement of the available nannofossil biochronological model in the middle and upper Miocene.

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHICAL AND PALEOECOLOGICAL ANALYSES OF THE FIGOLS GROUP (EARLY EOCENE) IN THE TREMP-GRAUS BASIN (SPANISH PYRENEES)

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Topics: Eocene, Spain, Biostratigraphy, Sequence stratigraphy

A detailed study of the calcareous nannofossil assemblages has been carried out in some sections within the Early Eocene Figols Group, outcropping between the valleys Val de Isabena and Val Esera (Central Pyrenees, Spain).

A basin analysis study was carried out within the Figols Group by Carminatti (1992). On the basis of the sequence stratigraphy analyses, 11 informal stratigraphic units have been defined; Carminatti also recognized in the Figols Group, 4 main third order depositional sequences which can be further subdivided into fourth and fifth order cycles.

The studied sections (Navarri, Teraza, East Merli) have been selected in order to be representative of the whole area and to allow a good correlation between the distal and proximal sites of the basin. The Navarri section, in the literature referred to as the Campo section, was proposed as the parastratotype of the Ilerdian stage (Schaub, 1969).

The studied time slice lies between the Zone NP11 and NP12. Moreover, within these zones

it has also been possible to recognize up to 7 biostratigraphic events that not only allow a further subdivision of the Figols Group but also provide a good time framework for the sequence stratigraphy analysis.

A paleoecological study of the calcareous nannofossil assemblages, compared to the sea-level changes recognized in the area, has been carried out. The quantitative analysis of the assemblages seems to indicate a relationship between the variations in the abundances of the genera *Discoaster, Sphenolithus, Rhabdosphaera, Rhomboaster, Tribrachiatus* and *Zygrhablithus* and the basinal sea-level changes.

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CALCAREOUS NANNOPLANKTON OF BOUNDARY EOCENE-OLIGOCENE DEPOSITS OF THE UKRAINIAN CARPATHIANS

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Topics: Eocene-Oligocene Bdy, Ukraine, Biostratigraphy

Calcareous nannoplankton of the boundary Eocene-Oligocene deposits of the Ukrainian Carpathians have been studied in detail.

The Eocene section of the Ukrainian Carpathians comes to the Sheshora Horizon that has been developed all over the Carpathian arc. Its thickness is 5-15 m. It consists of marls and calcareous argillites with rare interlayers of sandstones. In the Western Carpathians this horizon is known as the *Globigerina* Marls or the horizon with large globigerinas.

In the Ukrainian Carpathians the Sheshora Horizon is divided into two parts by foraminifera (Vialov *et al.*, 1965: Vialov *et al.*, 1974). The larger part of it belongs to the horizon of large globigerinas. It's less thick upper part is related to the horizon of small globigerinas, where the species widespread in Oligocene, have been found. However,the presence here of species, characteristic of the Eocene makes it possible to locate the Eocene-Oligocene boundary at the top of the Sheshora horizon. The majority of the Sheshora Horizon is dated as NP21, *Coccolithus subdistichus* zone, by calcareous nannoplankton. At the top of the horizon the NP22, *Helicosphaera reticulata* zone has been identified.

The Menilite Suite is the beginning of Oligocene section in the northern part and the Dusino Suite in the southern part of the Carpathians. Under the comeous horizon composed of interlayered calcareous argillites, alevrolites and sandstones is traced in the basement. The NP 22 *Helicosphaera reticulata* zone has been identified here too.

So, the results of calcareous nannoplankton study diverge from the generally accepted opinion about identification of Eocene-Oligocene boundary of the Ukrainian Carpathians above the top of the Sheshora horizon.

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LOWER CRETACEOUS NANNOFOSSILS OF THE BOREAL-ARCTIC REALM: A COMPARISON OF MIDDLE AND HIGH LATITUDE ASSEMBLAGES

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Topics: E.Cretaceous, Boreal Realm, Biogeography

Nannofossils show striking provincialism within sediments of Lower Cretaceous age. The marked disparity between assemblages from "Boreal" areas (England, Germany and the North Sea) and those of the "Tethyan Realm" (Mediterranean and North Atlantic Ocean) is often cited, but not well understood. The clays and marls of the North Sea and the nannoconid limestones of Tethys were deposited in areas not widely seperated by palaeolatitude, with at least intermitently good marine connections, yet their nannofloras are remarkably different. Various nannofossil species have been described as endemic to one or other of the realms, inferring specific environmental controls, and it has been suggested that some "Boreal" species may have originated at higher, "Arctic" latitudes. Such biogeographical distributions have been used to infer influxes of warm/cold water, sea level changes and/or climatic variations. Yet, despite the recent interest in nannofloral provincialism and palaeoenvironmental preferences, true "Arctic" assemblages are virtually unknown.

This paper describes the Lower Cretaceous nannofloras of a number of northerly sites. By comparing assemblages from the Barents Sea and offshore mid-Norway with those of more "temperate" sections in the North Sea area some characterisation of "Arctic" nannofloras is acheived. This should aid our elucidation of the palaeoenvironmental preferences of Cretaceous nannofossils.

Four sections are examined in detail - the Speeton Clay of Yorkshire, England (late Berriasian-Albian), a core from offshore mid-Norway (late Berriasian-late Hauterivian), and two cores from the Barents Sea (late Berriasian-late Barremian). The Barents Sea sites are situated 300km north of the Nordkapp, well within the present day arctic circle. The four sections represent an approximately north-south transect of >2000km, across >20° of palaeolatitude, i.e. they are much more disparate than English/German basins were from Northern Tethys. The study areas are generally thought to have been well connected throughout the studied interval, so assemblage differences were more likely caused by environmental factors than by palaeogeographical isolation.

A high degree of biostratigraphic resolution is essential for comparison of coeval assemblages. Modifications to existing zonation schemes have allowed considerably improved accuracy; a number of hitherto generally neglected species provide useful datums within the Berriasian-Barremian interval, and core samples can often be dated to Ammonite Zone level.

In all time slices examined there is a marked northward decrease in nannofossil abundance and diversity. Although nannofossil preservation is generally poor at the Barents Sea sites, it is not sufficiently poor to explain the observed assemblage differences.

The upper Berriasian to upper Hauterivian sediments of the Barents Sea are condensed into a 10m succession of limestones and marls, equivalent to the lower Valhall Formation of the North Sea. Nannofossil assemblages from these carbonates are dominated by three long-ranging taxa: *Watznaueria* spp., *Biscutum salebrosum*, and *Zeugrhabdotus* sp.1. Fortunately these depauperated assemblages also contain most of the Berriasian-Hauterivian marker species used at "temperate" latitudes (most notably *Sollasites arcuatus*, *Triqueterhabdulus shetlandensis*, *Eiffellithus striatus*, *Eprolithus antiquus*, *Chiastozygus* sp., and *Tegulalithus septentrionalis*, in order of stratigraphical appearance). Even the stratigraphically useful acmes of major species (*Biscutum salebrosum* and *Cyclagelosphaera margerelii*) appear to correlate well. Thus, high resolution biostratigraphy has enabled lithostratigraphical and sequence boundary correlation. Several sea level events, equivalent to those identified in the North Sea and onshore N.W. Europe (Rawson & Riley, 1982) can be identified within this condensed unit. The "middle" Hauterivian is especially condensed, with the topmost *regale* to *speetonensis/gottschei* ammonite Zones compressed into a 2m thick nodular limestone, resting non-sequentially on Valanginian marls.

Nannoconids, which make only sporadic appearances in the Berriasian-Hauterivian of Speeton, occur consistently throughout the incomplete Berriasian-Hauterivian section of the core from offshore mid-Norway (accounting for up to 10% of latest Berriasian-earliest Valanginian assemblages), but are entirely absent from contemporaneous carbonates of the Barents Sea. This data suggests that nannoconids were possibly limited by a minimum temperature tolerance, defining a northernmost limit to their distribution; within the broad latitudinal belt below this

limit their distribution seems to have been influenced by other factors (probably nutrient availability).

Nannoconids underwent rapid diversification in the early Barremian of Speeton, in response to basin isolation and climatic warming, and proliferated in the "middle" Barremian. It was during the Barremian "arid phase" that *Nannoconus* finally colonised the Barents Sea; *N.abundans* appears in the mid-late Barremian clays of one core.

Barremian assemblages of the Barents Sea, though generally sparse, are nonetheless very noticeably different to those of Speeton. These impoverished nannofloras yield several new species which are rare or absent at Speeton, and seem to have evolved through endemic speciation at high latitude. Such nannofloral endemism suggests palaeogeographical or palaeoecological isolation of the Barents shelf during much of the Barremian.

BOREAL-ARCTIC NANNOCONIDS: THE BARREMIAN DIVERSIFICATION

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Topics: Barremian, Boreal, Evolution, *Nannoconus*

A thorough restudy of the classic Speeton section (Berriasian-Albian), and of several cores from offshore mid-Norway and the Barents Sea (Berriasian-Barremian) has allowed considerable elucidation of the distribution, preferences, and evolution of the enigmatic genus *Nannoconus*. These observations lend support to current palaeoclimatic and palaeogeographic ideas.

Nannoconids make only sporadic appearances in the Berriasian-Hauterivian of Speeton, never constituting more than 1% of nannofloras. In a core from offshore mid-Norway *Nannoconus* occurs consistently throughout the incomplete Berriasian-Hauterivian section, accounting for up to 10% of latest Berriasian-earliest Valanginian assemblages. Nannoconids are, however, entirely absent in the Berriasian-Hauterivian carbonates of the Barents Sea. This data suggests that nannoconids were limited by a minimum temperature tolerance, defining a northernmost limit to their distribution; within the broad latitudinal belt below this limit their distribution seems to have been controlled by other factors (probably nutrient availability).

Facies changes in marginal basins and endemism among ammonites indicate regression and isolation of the North Sea basin during the Barremian, while clay mineralogical and other sedimentological evidence has recently proven the existence of a Barremian "arid phase" (Ruffell & Batten, 1990). Nannoconids underwent rapid diversification in the early Barremian of Speeton in response to basin isolation and climatic warming, and proliferated in the "middle" Barremian. During this "arid phase" the northern limit of *Nannoconus* was extended, enabling colonisation of the Barents Sea; *N.abundans* appears in the mid-late Barremian clays of one studied core.

The early Barremian diversification began when a short, flangeless nannoconid of Tethyan origin became isolated in the unusually warm North Sea Basin. Favourable conditions led to adaptive radiation, giving many bizarre forms never encountered in Tethys and a number of homeomorphs of Tethyan species. The development of an apical flange, giving *N.abundans*, was a highly successful evolutionary innovation, carried to its extreme development by *N.borealis* (in which the plates of the flange have thickened and rotated). These are the only two flanged species generally recognised, but every gradation between the two end members is observed. The width of the flange on typical *N.abundans* is highly variable, as is the overall size of the test. A further innovation was the development of an antapical flange, giving biflanged forms reminiscent of the much older *N.concavus* (Boreal) and *N.quadratus* (Tethyan). The biflanged forms also show great variation in size, height/width ratio, and in the relative development of their apical/antapical flanges. The flangeless ancestor stock survived throughout the early Barremian, showing considerable variation in height/width ratio and in the relative width of the axial canal, and including homeomorphs of the Tethyan species *N.elongatus*. All of these forms are provisionally assigned to the "*N.abundans* group", which is potentially subdivisable into a number of new species, if Tethyan principles of *Nannoconus* classification are applied. Over-splitting of the group is not desirable, but several named end members could be biostratigraphically useful.

Truly Tethyan nannoconids are extremely rare or absent in all but the very basal Barremian of Speeton, where *N.kamptneri, N.steinmannii,* and *N.globulus globulus* occur in the pale (carbonate-rich) horizons of a pale-dark rhythmic interval. This interval probably reflects a period of fluctuating climatic conditions, prior to the onset of stable warm, dry conditions in the

rarocinctum Zone. With the onset of equable conditions, and the consequent radiation of the *N.abundans* group, the Tethyan forms disappeared.

The *N,adabundans* group declined in abundance through the late Barremian of Speeton, disappearing in the early Aptian when a major transgression renewed connections with Tethys, allowing nannoconids of Tethyan derivation (principally *N.truitti*) to enter the North Sea area.

Due to the limitations of their basic architecture (=a cone constructed from spirally arranged rows of plates) nannoconids are especially prone to homeomorphy, and thus to misidentification. Thus we must to be careful not to jump to conclusions - the prescence of *"N.elongatus"* and other homeomorphs of Tethyan forms in the Barremian of N.W. Europe is unlikely to have been caused by an influx of Tethyan water. The problem of homeomorphy will remain until Tethyan nannoconids are better described - they are at present ill-defined in terms of the criteria of van Niel (1992) (=width and angle of inclination of the birefringent striae).

In a closely sampled darkening-upwards cycle from the early Barremian of Speeton *Nannoconus* blooms towards the top of the cycle, displaying a distribution which is almost exactly opposite to that of the "high fertility indices", *B.constans*, and *Z.noeliae*. This supports the recent suggestion that nannoconids preferred oligotrophic conditions. Their palaeogeographical distribution, large-scale temporal distribution and concentration within the carbonate-rich units of pale-dark rhythmic sections all indicate that nannoconids clearly preferred warmer water.

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WinTaxon: A WINDOWS BASED COMPUTING APPLICATION FOR PALAEONTOLOGY

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Topics: Databases

WinTaxon is a Windows based computing program designed to facilitate quick and reliable entry of biostratigraphic data. The program accepts user input in the form of fossil taxa using either speech technology or "electronic digitizing". Speech recognition is used in the WinTaxon

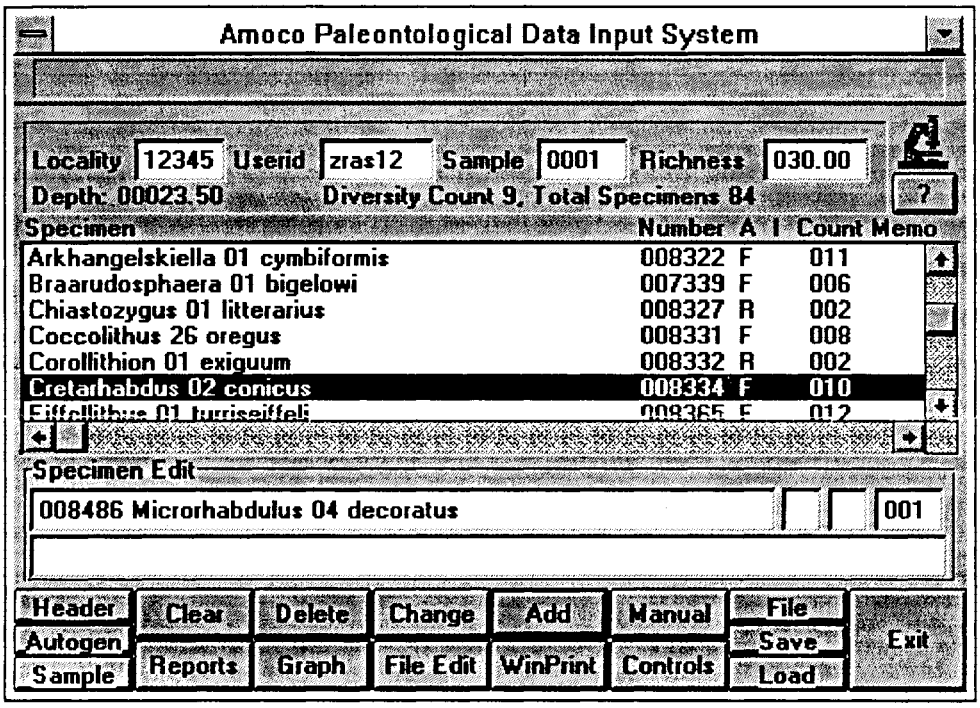

Figure 1. Illustration of the Wintaxon Main Palel showing nannofossil entries and associated taxon numbers , qualitative abundances, and specimen counts.

program to allow the user to "enter" data without having to direct attention away from the microscope. Speech synthesis is then used to repeat selected fossil taxon back to the user for confirmation of the transaction. Fossil taxa are stored in WinTaxon in the form of dictionaries using standard binominal nomenclature. Additionally, WinTaxon can be used for either specimen counts of individual taxa or qualitative abundance estimates. These data can then be integrated into range charts or species abundance/diversity plots. WinTaxon also accepts user input for Age/Zone, Palaeoenvironments, Lithology, Thermal Alteration Indices, and Kerogen Rank.

LIVING COCCOLITHOPHORE COMMUNITIES IN THE NORTHERN NORTH ATLANTIC

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Topics: Living, N. Atlantic, Ecol/oc

Since 1987 investigations of living coccolithophore communities have been carried out to record occurrence, distribution, and abundances of species in the northern North Atlantic. Up to now, a set of more than 200 plankton samples from about 80 stations have been examined. According to coccolithophore occurrences and abundances three species groups can be distinguished in the Norwegian-Greeenland Sea as a result of specific ecological preferences:

(1) A relatively varied "Atlantic Group" which, above all, contains species of the Syracosphaeraceae (*Syracosphaera borealis, S. corolla, S. molischii*) and holococcolith bearing forms (e.g. *Corisphaera gracilis*). They were found primarily at stations within the Norwegian Current at temperatures above 9-10°C. Only a few of these species tolerate slightly cooler conditions.

(2) An "Arctic Group" that is distinctly less varied also inhabits the relativly warm Norwegian Current but extends further westward into the area of Arctic mixed surface water. This group is heterogeneous as well and not equally distributed: While *Algirosphaera robusta* and *Ophiaster hydroideus* are found primarily in areas with prominent Atlantic water influence, *Emiliania huxleyi* , *Alisphaera unicornis*, and *Calciopappus caudatus* can be observed up to directly on the polar front.

(3) A "Polar Group" that is composed only of the two cold-adapted species, *Coccolithus pelagicus* and *Papposphaera sagittifera*. These species do occur in the Norwegian Current, but their primary area of distribution is within Arctic water which is colder than 6°C. *C. pelagicus* was almost always found in the resting stage as well as in the motile phase, the *Cristallolithus hyalinus* stage, without significant differences in cell numbers.

Moreover, south of the Iceland-Scotland Ridge there is a varied coccolithophore community of the North Atlantic which first of all contains *E. huxleyi*, species of the genus *Gephyrocapsa* (*G. muellerae, G. ericsonii*), *Syracosphaera* (e.g. *S. orbiculus, S. protrudens, S. pulchra*) and holococcolithophorid species (e.g. *Calyptrosphaera oblonga, Zygosphaera bannockii, Calyptrolithophora papillifera*). Parts of this group are drifted to the northern regions of the Norwegian-Greenland Sea in late summer.

The generally northward decrease in species number can primarily been explained by the limiting influence of water temperatures.

The coccolithophore communities are subject to strong seasonal variations that lead to big differences between summer and winter/spring. Thereby, the abundances of single species change within the regional groups, producing strong blooms mainly by the species *E. huxleyi* in summer (>3 mill. cells/liter). The seasonal variations of the species groups shift to the north/north-west with the drift of the Atlantic surface water masses. While south of Iceland first blooms occur in May/June, a high cell density is observed in the region of the Vøring Plateau in July, near Bear Island in August, and west of Jan Mayen not until September. The vertical flux of coccolithophorid material corresponds to these observations. In deep sediment traps in the Lofoten Basin and near Bear Island, sedimentation maxima of coccoliths are observed one month after the main production phases in surface waters.

In addition, distinct variations between the observation years have been revealed by our investigations. These differences include composition and species abundances of the regional species groups as well as time and intensity of production phases. However, there is always a close connection between the distribution of the regional species groups and the different water masses.

NEOGENE CALCAREOUS NANNOFOSSILS, AND PLANKTONIC AND BENTHIC FORAMINIFERA FROM FOUR LOCALITIES, SOUTHEASTERN MEXICO

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Topics: Late Oligocene- Pliocene, Mexico, Biostratigraphy

Calcareous nannoplankton, and planktonic and benthic foraminifera were analyzed from four geological sections in southeastern Mexico; Veracruz state (Achotal - Río La Soledad and Caobal - Puente Naranjo sections) and Chiapas state (Ostuacán and Nicapa sections). The alternant terrigenous sequence is similar for all four sections; it is formed mainly by shale, limolites and fine to medium grained sandstones. The fossil content indicates an Upper Oligocene-Lower Pliocene age.

The Upper Oligocene strata are 35 m thick, and are represented only at the Nicapa Section. The nannoplankton is characterized by *Sphenolithus ciperoensis, S. pseudoradians, Zygrhablithus bijugatus, Cyclicargolithus abisectus, Dictyococcites bisectus* and the planktonic foraminifera reported include *Globigerina ciperoensis angulisuturalis.*

The Lower Miocene, is 350 m thick and is reported for both the Ostuacan and Nicapa sections. Characteristic fossils include *Discoaster deflandrei, D. druggii, Sphenolithus heteromorphus, Helicosphaera ampliaperta* (nannofossils) and *Globigerinoides bisphericus, G. diminutus and Globigerinoides bisphericus, G. diminutus* and *Globoquadrina altispira altispira* (planktonic foraminifera) .

The Middle Miocene is about 1000 m thick at the Achotal - Rio La Soledad, Ostuacan and Nicapa sections, it is indicated by the presence of *Discoaster exilis, D. bolli, D. petaliformis, D. musicus, D. variabilis, D. kugleri, Coronocyclus nitescens, Catinaster coalitus* (nannofossils) and *Globorotalia fohsi praefohsi, G. fohsi lobata, G. fohsi fohsi* and *G. fohsi peripheroacuta.*

The Lower Pliocene is only represented by a 94 m thick section, although it is believed that this could be greater. The association is constituted by *Ceratolithus armatus, C. acutus, Amaurolithus delicatus, A. tricorniculatus, A. bizarrus, Discoaster brouweri, D. pentaradiatus, D. subsurculus* (nannofossils) and *Globorotalia margaritae, Neogloboquadrina dutertrei, Hastigerina pelagica* and *Sphaeroidinellopsis hancocki.*

The bathymetric value of different species of benthic foraminifera, the planktonic/benthic ratio, and sediment type were used to determine the sedimentary environments. These range from lower bathyal to upper bathyal - outer neritic; these latter corresponding to the Lower Pliocene.

Both the nannoflora and microfauna associations of the Ostuacan and Nicapa sections were affected by dissolution and recrystallization; the nannoplankton is more altered than the planktonic and benthic foraminifera.

Specific diversity analysis of the microfauna and microflora indicates that this depends mainly on the sediment type and diagenesis; nanno- and microfossils are more diverse and better preserved in fine grained friable sediments, such as shales and limolites; and scarce or absent in compacted or sandy sediments.

EVOLUTION OF PALAEOCENE AND EOCENE CALCAREOUS NANNOFOSSILS - AN EXAMPLE OF GRADUALISM

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Topics: Palaeocene-Eocene, USA (Coastal Plains), Evolution

Calcareous nannofossils from Palaeocene and Eocene marine sediments of the Atlantic and Gulf Coastal Plains of the United States were examined using both the scanning electron microscope and the light microscope. Samples were taken at closely-spaced intervals (usually 0.5m or less) from numerous cores and outcrops in New Jersey, Maryland, Virginia, and Alabama. Detailed morphological studies of these very well preserved microfossils document temporal morphological changes within individual species, as well as the evolution of one calcareous nannofossil species into another. All of the evolution that was observed consists of gradual morphological shifts within a species or between species. In most calcareous nannofossil species that we have documented to date, these evolutionary shifts can be tracked over a period of 3 to 8 million years. However, evolutionary rates and the number of species exhibiting morphologic change appears to increase significantly during times of significant worldwide climatic and oceanographic change,

such as the late Palaeocene event at approximately 55Ma. In our study area, the late Palaeocene event consists of a decrease in sediment grain size, a shift in clay mineral domination, a significant decrease in benthic foraminiferal diversity that suggests low-oxygen environments, and an increase in planktonic foraminiferal abundance.

There are several different types of morphological changes that characterize speciation events during the Palaeocene and Eocene. For example, the evolution of *Toweius eminens* into *Toweius occultatus* in upper Zone NP 9 (late Palaeocene) is marked by changes in the extensions into the central area. Typical specimens of *T. eminens* have both longitudinal and lateral extensions meeting in the central area. In somewhat younger sediments, the longitudinal extensions are thinner and no longer meet. Finally, most specimens have longitudinal extensions that are vestigial or absent entirely, and these are typical of *T. occultatus* s.s.

Campylosphaera dela represents a species that undergoes a gradual increase in size from the late Palaeocene to the early Eocene. When *C dela* first appears in mid Zone NP 9, specimens are typically 6-7μm in length. By lower Zone NP 14, specimens have increased in size to an average of 8-9μm. Throughout this interval the basic shape or structure of this species does not change.

In addition to changes in the extensions into the central area and increases in size, some of the other documented evolutionary changes in calcareous nannofossil morphology within Palaeocene and Eocene species include (1) an increase in the number and shape of pores in the central region (e.g., *Toweius pertusus*), (2) changes in the shape of the crossbar (e.g., *Neochiastiozygus concinnus, Chiasmolithus bidens*), (3) a lowering of the central perforate region relative to the distal shield (e.g., *T. pertusus*), and (4) an increase in the height and width of the rim (e.g., *Lophodolithus nascens, Transversopontis pulcher*).

THE SIGNIFICANCE OF SOME SUBTLE CHANGES IN THE COMPOSITION OF LATE CRETACEOUS AND EARLY TERTIARY NANNOFLORAS FROM AUSTRALIA

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Topics: Maas/Eoc/Olig, Australia, P'ecol/oc, Biogeography

Subtle changes in the composition of nannofloral assemblages from Australia have significant palaeoclimatic, palaeoceanographic and/or biostratigraphic ramifications. Three examples are given, from the late Maastrichtian, middle-late Eocene and late Oligocene. These raised some questions which with more data can be answered more clearly.

The late Maastrichtian assemblages come from three Australian marginal basins (the Great Australian Bight, Perth and Carnarvon Basins) where the distribution of key species, such as *Nephrolithus frequens, Cribrosphaerella daniae, Kamptnerius magnificus, C eratolithoides aculeus*, and *Micula murus*, has been used to distinguish two "biogeographic provinces": Austral and Extratropical. Assemblages in the Austral Province (Perth and Great Australian Bight Basins) generally lack *C. aculeus* and *M. murus*, but include common *N. frequens, C. daniae* and *K. magnificus*. Is the occasional presence of *C. aculeus* or, particularly, *M. murus* in these assemblages or their northern counterparts, of real palaeoclimatic significance or can it be ignored? Assemblages in the Extratropical Province (Carnarvon Basin) include both *C. aculeus* and *M. murus* as well as *N. frequens*, but the latter two are usually rare and easily missed during routine examination. The stratigraphic order of the earliest appearances of *N. frequens* and *M. murus* is not always the same throughout this wide province (which may have extended into, e.g., the South Atlantic Ocean, South Africa, Egypt, Tunisia and France). It can be related mostly to geographic location relative to the Austral/Boreal and Tropical Provinces and, therefore, should not be discarded as an aberration.

The mid to high latitude, middle to late Eocene assemblages from the southern margin of Australia contain rare *Helicosphaera heezenii, H. reticulata* and/or *Sphenolithus predistentus* in the Great Australian Bight Basin, but not in the Otway Basin to the east. These rare occurrences seem to be of real palaeoceanographic significance. They suggest a warm intermittent surface current the "proto-Leeuwin Current" flowing from the west into southern Australia. Stronger evidence, common *Sphenolithus distentus*, is present in late Oligocene assemblages from the Great Australian Bight Basin. The existence of the "proto-Leeuwin Current" is supported also by foraminiferal evidence.

The third example considers the FAD of *Isthmolithus recurvus* in the upper Eocene of the Otway Basin. This species has been recorded by two independent authors as having its earliest occurrence at Browns Creek, some five metres above the base of the calcareous planktic/marine section there. Recent re-examination of the lower part of the Browns Creek Clays has revealed the undeniable presence of *I. recurvus*, albeit rare, at the base of the section and within the lowermost two metres, in association with frequent *Neococcolithes dubius*. *Isthmolithus recurvus* is absent from the next three metres, reappearing in greater numbers above, but without the association of *N. dubius*. Does the level of this reappearance of *I. recurvus* correlate with the species' earliest appearance elsewhere, and is it therefore the species' FAD? Evidence suggests that it is. Should, therefore, the rare occurrences of the species at the base of the section be ignored, especially considering that the associated foraminiferal evidence, in cluding rare *Acarinina collactea*, suggests a late middle Eocene age at this level?

CALCAREOUS NANNOFOSSILS FROM THE PALAEOGENE DEPOSITS OF THE KAMCHATKA AREA

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Topics: Palaeogene, Arctic Russia, Biostratigraphy

Until recently nannofossils did not seem to be useful for Cenozoic stratigraphy of North-Eastern Russia, because favourable facies for the nannofossils are absent there. However our research has now revealed Palaeogene assemblages of nannofossils with moderate to good preservation in several localities of the eastern Kamchatka area: Govena Peninsula, Karaginskii I., Kronotzkii Peninsula, Kamchatskii Cape and Komandor Is. The Palaeogene deposits are generally composed of thick terrigenous-tuffaceous formations with igneous layers. Numerous faults distort the normal stratigraphic sequence of layers.

Some levels with nannofossils are established:

CP11 *Discoaster lodoensis* Zone (Kronotzkii Peninsula)

CP13 *Nannotetrina quadrata* Zone (Kronotzkii Peninsula)

CPI4 *Reticulofenestra umbilicus* Zone (Kronotzkii Peninsula,, Govena Peninsula, Karaginskii I., Komandor Is.)

CP15 *Discoaster barbadiensis* Zone,

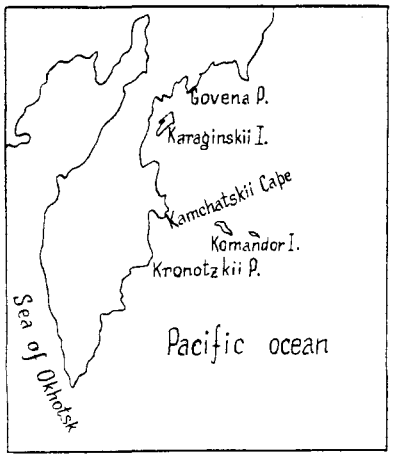
CPl5b *Isthmolithus recurvus* Subzone (Karaginskii I.).

In the Kamchatka Cape and several other parts of the area scarce nannofossil assemblages were found. They determine the age of deposits within the interval from the late Middle Eocene (CP14 Zone) to the earliest Oligocene (CP16 Zone).

Only in the Kronotzkii Peninsula localities are shallow water species present (*Pontosphaera, Transversopontis*). In the other sections the assemblages are typical of oceanic rises. Discoasters are common only in the Lower Eocene deposits.

Everywhere in the area the assemblages are rather poor. The principal reason for this impoverishment was probably not climate but unfavourable depositional environments, as is evidenced by abundant tuffaceous material in the host rocks.

The finding of nannofossils in the Kamchatka area allows us to determine the age of previously undated sequences and to trace the stratigraphic succession of layers in sections with complicated tectonics.



Locality Map

CALCAREOUS NANNOPLANKTON FROM THE NIEBYLEC SHALY MEMBER - POLISH CARPATHIANS.

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Topics: E. Miocene, Poland, Biostratigraphy

63 samples were taken from the section of the Niebylec Shaly Member (NSM), formerly proposed as a stratotype for Oligocene/Miocene boundary (Nowak *et al.* 1984). 36 of them contained calcareous nannofossils of variable abundance and preservation. 45 species were recognized (of which 26 were autochthonous and 19 reworked). Lower Miocene taxa were recognized through the section and were utilized for age determination. All samples contained also reworked Cretaceous and Palaeogene forms. The age of the lower boundary of the NSM was established at NN2 zone. In the upper part of the section, presence of *Helicosphaera walbersdorfensis* together with visible simultaneous quantity increase of *Sphenolithus belemnos* and *Helicosphaera carteri*, may suggests presence of the NN3 zone.

Using Paratethyan stratigraphic terminology this age determination implies Eggenburgian (in part). These data do not agree with those, based on poorly preserved planktonic foraminifera, of Nowak, *et al.* (1985) since they proposed the NSM section as the stratotype for the Oligocene/ Miocene boundary.

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CALCAREOUS NANNOPLANKTON STRATIGRAPHY OF THE TERMINAL FLYSCH DEPOSITS (SKOLE NAPPE, POLISH CARPATHIANS).

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Topics: Miocene, Poland, Biostratigraphy

The age of terminal flysch deposition in the Polish Carpathians was not precisely established until now. In the Skole Nappe the last flysch episode is connected with deposition of upper Krosno beds which are composed mainly of grey shales with rare thin sandstone intercalations. Sections for the study were carefully selected. They give the most complete possible outcrop profile in the Polish Carpathians, through all parts of the Krosno beds. Moreover, hitherto published data suggested the presence of the youngest flysch deposits there (Koszarski, 1963).

Samples were taken from shales and mudstones. Samples from turbidites were collected from the last deposited parts of the beds, i.e. from units E and F of the Bouma (1962) sequence. The quantity of autochthonous taxa in these parts of the sequence is highest. Standard preparation and counting techniques were used (cf. Perch-Nielsen, 1985). 560 samples were collected from the flysch sediments from 11 sections located within the Krzywe-Zyznow and Slonne Gory synclines (Skole Nappe, Krosno beds). The range of nannofossils found in the samples from these sections indicate a time interval from zone NN 2 to NN 5. The youngest nannofossils, belonging to zone NN 5, were found in samples from Lutcza-Zyznow profile. Continuous presence of *Sphenolithus heteromorphus* , first appearance of *Discoaster variabilis* and simultaneous disappearance of *Helicosphaera ampliaperta* in samples from the upper part of the section, suggests that these samples belong to zone NN 5. This gives a possible age for terminal flysch deposition in that part of the Polish Carpathians. This result is contrary to existing assignments (based mainly on foraminiferal assemblages) in which terminal flysch deposition of the Krosno beds in the Skole Nappe was interpreted as uppermost Oligocene and/or lowest Miocene.

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MIDDLE MIOCENE CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY IN THE MEDITERRANEAN REGION

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Topics: M. Miocene, Mediterranean, Zonation

The standard calcareous nannofossil zonations of Martini (1971) and Okada & Bukry (1980) provide a poor biostratigraphic resolution in the Mediterranean Middle Miocene. In particular, the interval between the LO of *Sphenolithus* and the FO of *Discoaster hamatus* (Zones NN6, NN7, NN8 of Martini, approximately between 13-14 Ma and 9.30 - 10 Ma can not be subdivided because *Discoaster kugleri* and *Catinaster coalitus* are virtually absent in the region.

In order to check the possibility of improving biostratigraphic resolution in the Mediterranean Middle Miocene, we have studied the calcareous nannofossil contents of numerous sections from widely separated areas (Balearic Sea, Malta, Sicily, Central and Northern Italy), indicative of vastly different depositional settings (shelf, hemipelagic and terrigenous deep basins).

We have established the quantitative distribution patterns of selected taxa and by using prominent frequency changes (first common occurrence, last common occurrence, absence intervals, reversals in abundances between taxa) it has been possible to correlate consistently the various sections with a resolution superior to that provided by the standard zonations. On the basis of these results a regional biostratigraphic scheme is proposed for the Mediterranean Middle Miocene.

QUANTITATIVE STUDIES OF CALCAREOUS NANNOFOSSIL ASSEMBLAGES FROM PLIOCENE-PLEISTOCENE SEDIMENTS OF THE NORTH ATLANTIC

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Topics: Plio-Pleistocene, N. Atlantic Ocean, Biostratigraphy, Techniques

Calcareous nannofossils found from the Pliocene to Pleistocene in the North Atlantic Ocean have been studied biostratigraphically for a long time. Being different from those works, this study deals with the quantitative analysis of the whole calcareous nannofossil assemblage from North Atlantic Ocean during the Pliocene and the Pleistocene, in order to investigate the relationships between various species in it and their development.

Calcareous nannofossils from the North and Central Atlantic (Sites 608, 609, 664) were counted using the light microscope. After comparison to other preparation methods, a modified method developed by Beaufort (1991) was employed for quantitative analysis of calcareous nannofossils. The result of absolute abundance (AA) counts of a given species can be given as the number of specimens of the given species per gram of sediment.

The quantitative analysis reveals that the components of the calcareous nannofossil assemblages varied with times and latitudes. They were dominated by different species in different periods. During the early Pliocene the assemblage was dominated by *Reticulofenestra pseudoumbilica* (AA: 1-7 x10^9 specimens/gram sediment, Relative Abundance RA: 20%-50% in Hole 608). This dominance was replaced later by the group of *R. haqii* and *R. minutula* (AA: 2-38 x10^9 specimens/gram sediment, RA: 20%-80%) from the middle to the late Pliocene. With the beginning of the Pleistocene, the assemblage was characterized by the dominance of *Gephyrocapsa* (AA: 6-150 x10^9 specimens/gram sediment, RA: 25%-96%).

MAASTRICHTIAN NANNOFOSSILS IN THE MATERIAL OF THE HIGH GOTHIC PAINTINGS IN BOHEMIA

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Topics: Maastrichtian, Czech Rep., Biostratigraphy, Gothic paintings

Data obtained from the study of calcareous nannoplankton may be used not only in geology, but also in some other branches, for instance in restoration work for medieval paintings. Perch-Nielsen (*in* Blindheim, *et al.* 1974) analyzed material from the 13th century Gothic painted altar

in the Norwegian church of Tingelstad. Using coccoliths, she deduced, that the chalk did not come originally from Norway.

The High Gothic panel pictures of Master Theodoricus from the 14th century, which decorate the chapel of the Holy Rood at Karlstejn Castle in Bohemia, have been studied and restored. The picture has a base of three thin layers: 1. A basal "grey" siliceous layer, directly on the beech board; 2. a "white" layer of so-called glue chalk foundation and 3. a final covering of white lead paint. The artist worked upon this base. Only the "white" layer contains coccoliths. The coccoliths were probably originally well preserved, but subsequently they were mostly broken to pieces as the sediment was very finely crushed. The assemblages contain a high diversity of species including *Nephrolithus frequens, Micula murus, Lithraphidites quadratus, Arkhangelskiella cymbiformis, Prediscosphaera stoveri, Eiffellithus gorkae* and *Placozygus sigmoides*, indicating an Late Maastrichtian age, Zone CC26. No sediments of Maastrichtian age are known from the Bohemian region. So like the Norwegian Master from Tingelstad, the Bohemian Master Theodoricus did not use for his work sediments from his home locality. The chalk material had to be imported into Bohemia probably from North West Europe.

REFORMATION OF THE SURFACE OCEANIC CIRCULATION DURING THE PALAEOGENE: CALCAREOUS NANNOPLANKTON AND OXYGEN ISOTOPE EVIDENCE

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Topics: Palaeogene, Global, P'ecol/oc

Calcareous nannoplankton evolutionary development during the Cenozoic has been studied on the basis of our investigation of DSDP/ODP sediment samples (Lisitsyn *et al.* 1983). An analysis of changes of nannoplankton morphotypes has been made. It has been established that the distribution of nannoplankton genera and species with different skeleton constructions is determined by density differences of the oceanic surface waters. Analogous investigations have been conducted with planktonic foraminifera. Nannofossil and foraminifera oxygen isotope study (Nikolaev, *et al.* 1989) has demonstrated that density fluctuations and surface water depth stratification from the end of the Palaeogene to the Neogene were due to water temperature changes adventurely. The $\partial^{18}O$ of Neogene nannoplankton and shallow-dwelling foraminifera species in all climatic zones was lighter then the $\partial^{18}O$ of deeper-dwelling foraminifera. This confirms that the surface waters thermotypic stratification during the Neogene was similar to the present.

For Palaeogene oceans "isotopic reverse" of nannofossils was typical. Their $\partial^{18}O$ was heavier than that of the deeper dwelling foraminifers. We equate this with expansion of oceanic surface water with strongly positive $\partial^{18}O_w$ values (i.e. dense high-salinity waters). The conversion from halotypic circulation into the galoterme-thermohalinic one took place in the Middle Eocene. This conclusion is confirmed by our planktonic foraminifera study (Nicolaev *et al.* 1987) and by data from research on Antarctic ODP samples (Kennett and Stott, 1990).

Analyzing the value and the intensity of the "isotopic reverse" and the development of nannoplankton morphotypes we have drawn the following conclusions on the water circulation peculiarities of the Palaeogene;

1) Relatively low salinity and cool waters of the Early Palaeocene converted into high salinity and warm waters of the Late Palaeocene. The former position is confirmed by relatively poorer complexes of minor nannoplankton forms and the latter position, by the appearance of massive warm-water discoasters.

2) At the Palaeocene-Eocene boundary salinity reduced slightly (nannoplankton calcification decreases and there is the beginning of development of late and thin discoasters and *Chiasmolithus*).

3) Distinct climatic zonation first appeared in the Middle Eocene, this was the beginning of thermohaline circulation.

4) The Late Eocene and the Early Oligocene oceans had similar conditions. There formed the constant thermohaline circulation. The obvious difference of the microfloras in high and low latitudes and low evolutionary activity of nannoplankton are noteworthy.

5) The Late Oligocene ecological space of nannoplankton narrowed in the low latitudes (poorer species complex and development of relatively big discoasters and delicate sphenoliths). This confirms our conclusion (Nikolaev *et al.* 1989) about the first appearance of the near surface upwelling waters in the equatorial divergence zone. At this time the distinct difference between low and high latitudes was formed.

6) During the Neogene cooling of surface oceanic waters and development of the thermotypic circulation occurred (Ushakova & Blyum, 1992).

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A REVIEW AND CLASSIFICATION OF FOSSIL DIDEMNID ASCIDIAN SPICULES FROM FINE-GRAINED SEDIMENTS

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Topics: ?-Living, Global, Taxonomy, Ascidian spicules

The first comprehensive discussion and classification of fossil didemnid spicules in sediments is presented. Three new fossil genera based on spicule morphology and nine new fossil species will be described.

In this study, four major types of rays were identified and this' led to the recognition of three new genera.

•*Micrascidites*-type rays (Fig.1) are rhomboid or kite-shaped in axial section, and the free parts of the rays are always conical.

•The second type of rays (Fig.2) are widest in a diameter along the jointed part of the rays; the free part, is always narrower and is conical or truncated conical.

•The third type of rays (Fig.3) resemble a sharpened pencil, their free lengths being cylindrical with a truncated peripheral end.

• The fourth type of rays (Fig.4) are needle-like and unequal in length, forming bundle-like structure with or without a free part.

Recognising these distinctive fossil didemnid spicules in fine-grained sediments should provide invaluable palaeoenvironmental information and also may stimulate interest in their biostratigraphical applications.

Ascidians, often called sea squirts, are sessile, filter feeding tunicates (subphylum Urochordata) which are important members of marine benthonic communities throughout shelf seas. Living ascidians have attracted a widespread interest from biologists because of their imagined evolutionary position as a probable vertebrate ancestor.

Although most ascidians are soft-bodied, some species secrete calcareous aragonitic spicules of distinctive-shape. Spicules secreted by didemnid ascidians, are often found in slides prepared for calcareous nannofossil examination. These stellate or spherical-shaped spicules range in size between 10 and 70 μm and, more rarely up to 125μm. Although living didemnid ascidians are well known from continental shelves throughout the world, fossilized didemnid ascidian spicules are very rarely reported by palaeontologists and therefore at present, are of little use as palaeoenvironmental and/or biostratigraphic markers.

This study summarizes the present knowledge of ascidians in relation to didemnid ascidians and fossil ascidian spicules. It should help stimulate research interest, hopefully among nannofossil specialists. Only after extensive reporting can the stratigraphic ranges of such spicules be

properly established and their true stratigraphic values be fully understood.

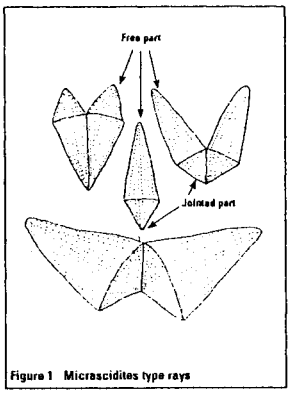

Figure 1 Micrascidites type rays

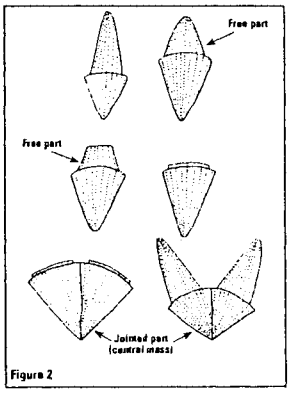

Figure 2

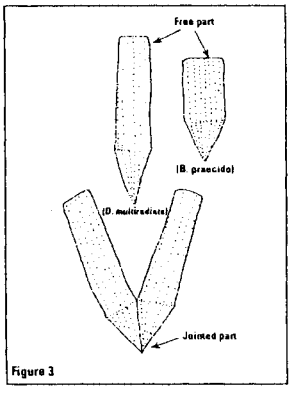

Figure 3

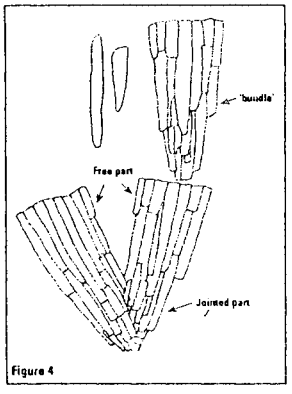

Figure 4

ALBIAN NANNOFOSSILS FROM MELARASUR, TIRUCHIRAPALLI, TAMIL NADU, INDIA.

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Topics: Albian; India; Biostratigraphy

Cretaceous rocks of Tiruchirapalli, southern India, have gained palaeontological significance owing to their diverse fossil content. Earlier investigators suggested that the Dalmiapuram Formation is older than the Utatur Group; however, their field relationship is unclear. Based on calcareous nannofossils, Jafar & Rai (1989) and Kale & Phansalkar (1992), assigned a Middle to Late Albian age to the Dalmiapuram Formation.

In order to determine the age of the Utatur Group, we investigated the using calcareous nannofossils of the marls exposed in a quarry at Melarasur, which is part of the Utatur group. Melarasur is located about 2 km north of the Kallakudi Quarry II, which is the type area of Dalmiapuram Formation. Microscopic examination of the marl samples collected in the 3m thick exposures of the limestone quarry revealed the presence of abundant, but moderately preserved calcareous nannofossils. 31 species belonging to 21 genera have been identified in the marls.
The fossils recorded are: *Axopodorhabdus albianus, Biscutum constans, Biscutum supracretaceum, Chiastozygus litterarius, Corollithion achylosum, Cretarhabdus crenulatus, Cyclagelosphaera margereli, Eprolithus floralis, Hayesites albiensis, Hayesites* sp., *Lithraphidites carniolensis, Lithraphidites* cf. *L. alatus, Loxolithus armilla, Manivitella pemmatoidea, Prediscosphaera* cf. *P. columnata, Podorhabdus albianus, Rhagodiscus splendens, Rhagodiscus* sp., *Rucinolithus irregularis, Thoracosphaera operculata, Tranolithus exiguus, Tranolithus gabalus, Tranolithus phacelosus, Tubodiscus verenae, Vagalapilla matalosa, Watznaueria barnesae, Watznaueria biporta, Watznaueria communis, Zeuqrhabdotus emberqeri, Zygodiscus diplogrammus* and *Zygodiscus elegans.*

Based on the presence of *Hayesites albiensis, Prediscosphaera* cf. *P. columnata, Tranolithus exiguus, Tranolithus phacelosus* and *Rucinolithus irregularis*, the marls have been assigned to the uppermost part of *Prediscosphaera columnata* CC8 Zone of Middle to Upper Albian age.

The present study on Melarasur clearly reflects that certain rock units of the Utatur Group are the same age as those of the Dalmiapuram Formation and hence considering Dalmiapuram Formation as being older than the Utatur Group is not justified.

THE AUSTRALASIAN IMPACT EVENT: BIOLOGICAL/CLIMATIC EFFECTS AND IMPLICATIONS FOR CALCAREOUS NANNOPLANKTON EXTINCTIONS

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Topics: Pleistocene, Indian Ocean, P'ecol/oc, Meteorites

What is the minimum size of an extraterrestrial impactor necessary to cause calcareous nannoplankton extinctions? One way to establish this is to detect, if possible, the effects of known impacts on the fossil record. A good candidate for study would be the Australasian microtektites, which are now generally accepted to be the products of extraterrestrial impacts. These microtektites occur near the Brunhes/Matuyama boundary at about 0.75 Ma and have a wide distribution (~10% of the earth's surface). This impact event is the second largest in the Cenozoic, and the impact crater has been estimated to be about 17 km. In order to better understand the role of this impact in shaping life and climate on earth, we carried out a detailed study of nannofossils across the Australasian microtektite interval at ODP Site 758 in the equatorial Indian Ocean. We also compiled high-resolution stable isotope and carbonate data from this site and others to infer paleoclimate conditions across this interval. Our study indicates that there are no calcareous nannoplankton extinctions associated with the impact horizon. There is also no significant change in the abundance of *Florisphaera profunda*, an environmentally sensitive species. Carbonate content shows little variation across the impact horizon, which suggests that ocean productivity did not change significantly. Oxygen isotope data show typical Pleistocene glacial-interglacial cycles, which were generally caused by the Milankovitch cycles. The impact horizon is located slightly after the glacial maximum in oxygen isotope stage 20. In other words, the impact was within a warming trend from glacial stage 20 to interglacial stage 19. We conclude that, within the resolution of our geologic record (~1000 yrs), the Australasian impact had insignificant effects on life and climate. This study, therefore, helps establish a lower limit on the size of an impactor that could cause extinctions among calcareous nannoplankton.

CORRELATION OF NEOGENE NANNOFOSSIL DATUMS WITH OXYGEN ISOTOPE STRATIGRAPHY AND MAGNETOSTRATIGRAPHY AT ODP SITES 714 AND 758

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Topics: Pliocene-Pleistocene, Indian Ocean, Zonation

The abrupt increase in abundance of *Emiliania huxleyi* is recorded in oxygen isotope upper stage 5 at ODP Site 714, as in a number of sites reported previously. It is proposed here that this event is used as a stratigraphic marker rather than the reversal in dominance between *Gephyrocapsa caribbeanica* because of two main reasons: (1) It is difficult if not impossible to count *G. caribbeanica* as there are major taxonomic problems associated with this species (e.g., Matsuoka & Okada, 1990); (2) the abundance of *E. huxleyi* often does not exceed that of *G. caribbeanica* or *Gephyrocapsa* larger than 4 μm. *Reticulofenestra asanoi* is rare and has a significantly shorter stratigraphic range in the equatorial Indian Ocean. Correlations of other upper Pliocene-Pleistocene nannofossil datums with oxygen isotope stratigraphy have so far been determined within several stages (~0.1 Ma) and will be refined to individual stages in this study. Correlations of upper Miocene-lower Pliocene datums with magnetostratigraphy result in different age estimates than those compiled in Berggren (1985). In particular, the last occurrences of *Reticulofenestra pseudoumbilicus* and *Discoaster quinqueramus* are about 10% older and younger, respectively, than those given in Berggren *et al.* (1985).

THE AUSTRALASIAN IMPACT EVENT: BIOLOGICAL/CLIMATIC EFFECTS AND IMPLICATIONS FOR CALCAREOUS NANNOPLANKTON EXTINCTIONS

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CENOMANIAN HIGH RESOLUTION STRATIGRAPHY AND PALAEOCEANOGRAPHY

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Topics: Cenomanian, England/France, P'ecol/oc, Milankovitch

Recent research on the Cenomanian sequences (chalks and marls) of the Anglo-Paris basin (Gale 1990) has revealed the presence of Milankovitch-frequency cyclicity. Secular variations in bed thickness and lithology, related to oceanographic trends can be recognized and individual beds representing ca.20,000 year (precession) time intervals can be correlated across the basin, as confirmed by ammonite faunas. Work in the Vocontian Trough (S.France) and Umbrian Basin (Gubbio, Italy) suggests that such correlations can be also extended across a very wide geographical area.

As pelagic rhythmic carbonates consist mainly of calcareous nannofossils, nannofloral assemblages provide a basic tool in the investigation of cyclicity. Nannofloras are sensitive to physical and chemical changes in surface water masses, and nannofloral distribution in the Cenomanian is believed to have been affected by such variations. The lithological signal observed must therefore represent, primarily a record of variable nannoplankton productivity, which in itself reflects the oceanographical conditions in Mid Cretaceous seas. Orbital perturbations, in particular changes in the axial obliquity, influence the Earth's insolation and seasonality, triggering fluctuations in climate which in turn affect the physical and chemical properties of the water mass.

Preliminary quantitative nannofossil study has revealed the presence of significant cyclical variations in the relative abundance of a number of key nannofossil species. Two of these species, *Biscutum constans* and *Zeugrhabdotus noeliae*, have been identified as **high** fertility indices (Roth 1981, 1986 & 1989 & Erba 1986). This is the first time such a signal has been observed in Cenomanian chalks and marls.

Fluctuations in abundance of both high fertility (*B.constans, Z.noeliae & Z.erectus*) and low fertility (*W.barnesae*) indices (Erba 1992) are in phase with lithological cyclicity and are thought to reflect systematic variations in nutrient concentration which in turn is thought to be the result of orbitally driven oceanographic/climatic changes

COCCOLITHOPHORE PHYLOGENY RESEARCH

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Topics: Jurassic-Recent, Global, Evolution

The recent conference on Prymnesiophyte Biology (Plymouth March 1993, see also report in INA Newsletter 15/1) highlighted the fact that prymnesiophyte phylogeny is currently being actively reviewed as a result of research by numerous different groups using quite different approaches - including detailed revision of living coccolithophore taxonomy, revitalised study of non-calcified and weakly calcifying prymnesiophytes, application of molecular biological studies to these groups, and new data coming from comparative studies of cytological and biochemical features (e.g. flagellar ultrastructure and lipid chemistry). Our contribution to this study consists of synthesis and reassessment of the fossil record, using in particular the V/R model (Young et al 1992) as a means of investigating homology and testing phylogenetic interpretations.

Reassuringly data from "new" sources, particularly molecular biology, tends to support traditional interpretations based on coccolith morphology and the fossil record. This highlights the fact that the database of available information from the fossil record, accumulated by painstaking biostratigraphical research, is enormous and should make study of Prymnesiophyte phylogeny particularly rewarding. This should provide motivation for sorting out some of the taxonomic chaos that currently affects much of nannofossil nomenclature.

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IMAGE ANALYSIS AND STORAGE IN NANNOFOSSIL RESEARCH - AN EXAMPLE USING *E. HUXLEYI*

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Topics: Techniques, Video microscopy

A large EC funded interdisciplinary study of *Emiliania huxleyi*, is currently underway, (Westbroek et al in press). This provides an ideal framework for well-constrained study of intra-specific variation of coccolith morphology in this species. Building on previous work this will hopefully form a useful case study of more general application. There are, however, significant methodological problems - electron microscopy is too time-consuming for routine study of the large number of samples available; whilst quantitative observations are difficult using light microscopy, particularly on the very small coccoliths of *E. huxleyi*. The approach which has been adopted is to use image capture from the light microscope to a computer. This allows high-precision analysis of size variation as a rapid first level screening technique.

The equipment needed for this type of research, (CCD video camera, frame-grabber board, image handling software and a fast microcomputer), is now readily available at reasonable cost - significantly less than that of the research microscope itself. In addition the same equipment can be used for image acquisition and storage for at least two other purposes. First, good quality images can be stored for incorporation in taxonomic reference databases. Second, effectively instant storage of images allows us to overcome one of the fundamental problems of nannofossil research - the fact that nannofossils, unlike forams or larger fossils, cannot be manipulated or sorted. Collections of images of species in standard orientation can rapidly be made, which greatly aids traditional, qualitative, study of variation, as well as quantitative study. Consequently this type of equipment is now worth considering as a standard component of any well-found nannofossil research centre.

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NEOGENE CALCAREOUS NANNOFOSSILS FROM THE WESTERN PACIFIC OCEAN AND THEIR PALAEOCEANOGRAPHICAL SIGNIFICANCE

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Topics: Miocene-Pliocene, Pacific Ocean, P'ecol/oc

The study area named Bonin Basin was located in the north of the Philippine Sea. The Bonin area is made up of a complex series of arcs and basins formed since the start of the westward subduction of Pacific lithosphere in the Eocene. This paper addresses the nannofossil stratigraphy of Miocene-Pliocene sediments, and these materials were collected from two holes, 782A and 786A, Ocean Drilling Program, Leg 125.

Based on Okada and Bukry's zonation, 13 zones (or subzones) can be divided, and Zones CN1-3, Zone CN8 and Subzone CN10a are missing. This indicates, therefore, that three hiatuses were detected as follows: between upper Oligocene/middle Miocene, within late Miocene, and between late Miocene/early Pliocene.

The relative abundance of *Reticulofenestra pseudoumbilicus* and *R.haqii* is very high and may make up 40% of the total content of calcareous nannoplankton in the Miocene. It indicates that the assemblages are typical of mid-latitude. In the Neogene of this area we can divide four relatively warm stages, and four relatively cool stages, based on the relative abundance of *Discoaster* + *Sphenolithus*; the ratio of abundance of *Discoaster/Coccolithus* ; the ratio of abundance of *Discoaster pentaradiatus* + *D. brouweri/ D.intercalaris* + *D.surculus*; the relative abundance of *Coccolithus pelagicus*; and the change of complex diversity (D). The four relatively warm stages coincide basically with high calcium carbonate content. The warmest stage in the Neogene is middle middle Miocene (Subzone CN5a) from the study area.

The hiatus between the late Oligocene/Miocene is common everywhere in the Philippine Basin, and it can also be found in the East China Sea, South China Sea and west or east of Taiwan.

However, the number of nannofossil zones which are missing varies in different regions.

In the abyssal region the hiatus may be formed by the scouring of bottom currents, but the hiatuses on the continental shelf of the China Sea and areas near Taiwan are definitely related to the regression of Northern Hemisphere in this time. The hiatus between the Miocene/Pliocene is common in the Western Pacific Ocean and the continental shelf of China Sea.

SEASONAL DISTRIBUTION OF CALCAREOUS NANNOPLANKTON IN AN UPWELLING REGION: RESULTS FROM SEDIMENT TRAPPING AND WATER SAMPLING IN THE SAN PEDRO BASIN, SOUTHERN CALIFORNIA BIGHT

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Topics: Living, offshore California, P'ecol/oc, Upwelling

The seasonal production and distribution of extant coccolithophores have been investigated in the San Pedro Basin (33°33'N, 118°30"W), an upwelling region of the Southern California borderlands. The sampling program included sediment trapping and surface water sampling. The sediment trap, positioned at about 500m water depth, collected consecutive one-week samples from January to July 1988. The surface water samples were collected every two or three weeks over a year-long period from October 1991 to September 1992. The study site is typically affected by upwelling events that are most intense during the spring and early summer months.

Both polarizing light microscopy and scanning electron microscopy have been used in the present study.

Emiliana huxleyi is the most common species in both the water and sediment trap samples. *Florisphaera profunda*, *Gephyrocapsa ericsonii* and *G.muellerae* are also very common in the trap samples. For the surface water samples, *Calciopappus caudatus* and *Rhabdosphaera xiphos* are seasonally important.

The highest surface water coccolithophorid densities were found from February to June, with a maximum value of $63x10^3/l$ in early March. The maximum coccolith and coccosphere fluxes recorded by the sediment trap study were 8.6x108/m^2/day and 7.9x106/m^2/day respectively, with both maxima occuring in mid January. A comparison of seasonal trends in coccolithophorid fluxes with that previously determined for diatoms (Sautter and Sancetta, 1992) and planktonic foraminifera (Thunell and Sautter, 1992) will also be shown.

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NOTES