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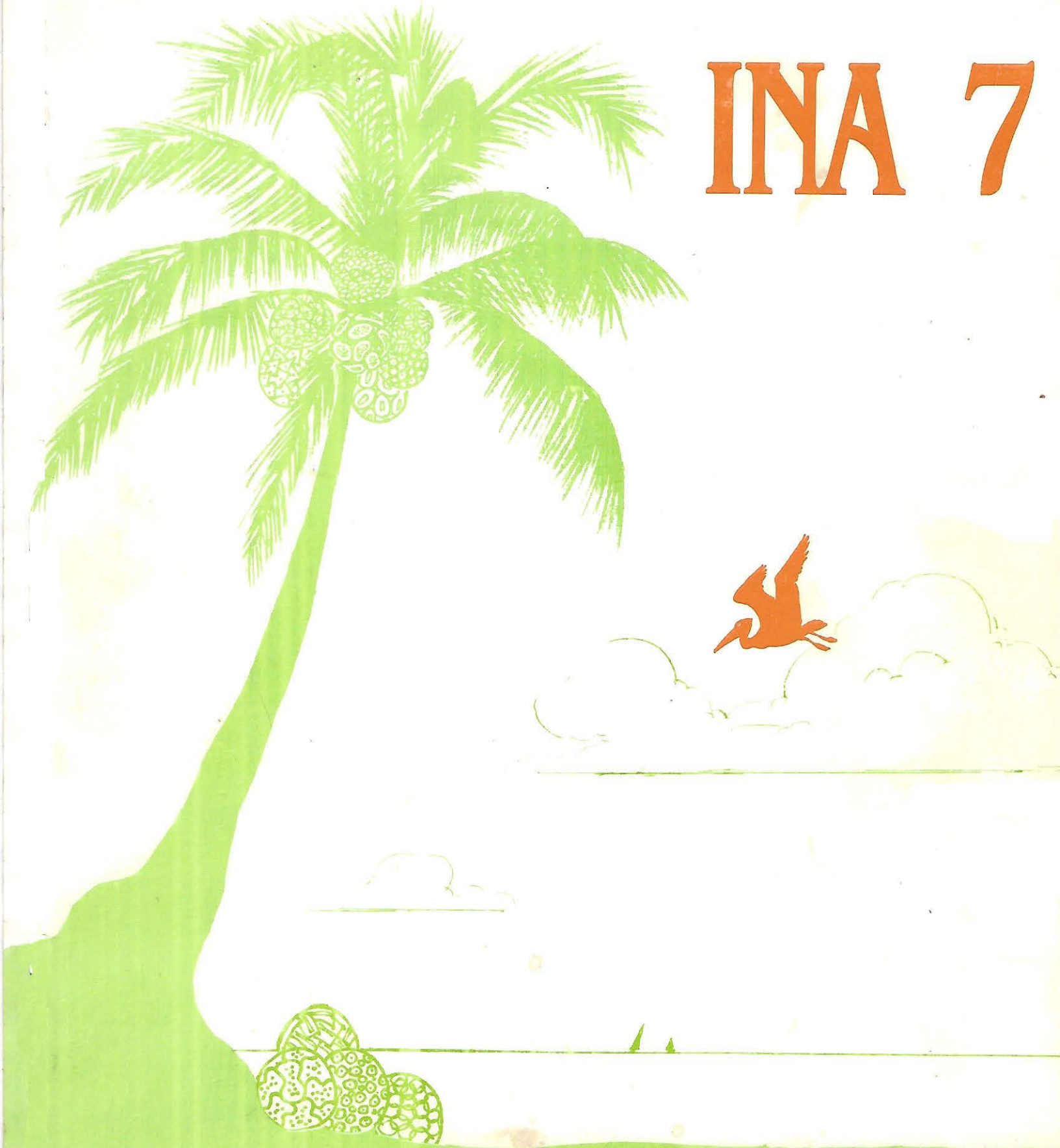

International Nannoplankton Association
La Parguera, Puerto Rico • February 10-13, 1998

Seventh International Nannoplankton Association

February 10-14, 1998 ✳ La Parguera, Puerto Rico

✳ Tuesday, February 10th,1998 ✳

07:30-08:30	Breakfast at Hotel
08:45-10:00	Workshop (Salón Bahía): **Nannofossil taxonomy and classification - general aspects and possibilities for encouraging consistency in taxonomy** Paul Bown & Jeremy Young
10:00-10:15	Coffee break
10:15-12:15	Workshops (Salón Bahía): **Mesozoic taxonomy revision proposals** Paul Bown & Jeremy Young **Cenozoic taxonomy revision proposals** Jeremy Young & Paul Bown **Living/Quaternary workshop on *Syracosphaera/Pontosphaera*** Ric Jordan
12:30-13:30	Lunch (on your own)
13:30-15:30	Workshops (Salón Bahía) **M94 filter - implications for estimating coccolithophore abundances** Amos Winter **Modeling the flux of coccolithophores to the ocean floor** Patrizia Ziveri
13:30-15:30	***POSTER SESSION I*** → (Salón Bahía)
16:00-17:00	Tour of Mangrove Channels
17:00-18:00	Reception, UPR Department of Marine Sciences (Isla Magueyes)
19:00-20:00	Dinner at Hotel

✳ Wednesday, February 11th, 1998 ✳

7:00-8:00 Breakfast at Hotel

8:00-8:30 Welcoming remarks

Talks session IA - **Large scale surveys and projects** - (Salón Bahía)
Shirley van Heck & William Siesser presiding

8:30-9:05 Hans R. Thiersten (and others)
Paleobiology of the Pelagic Realm.

9:05-9:40 Peter Westbroek
Modeling Biosphere-Geosphere Interactions.

9:40-10:05 Mario Cachão (and others)
CODENET - An European Research Network to Study Coccolithophorids.

10:05-10:20 Coffee break

Talks session IB - **Morphology and taxonomy**-(Salón Bahía)
Shirley van Heck and William Siesser presiding

10:20-10:45 Lluïsa Cros (and others)
New Examples of Holococcolith-Heterococcolith Combination Cells and their implications for Coccolithophorid Phylogeny.

10:45-11:10 Syed A. Jafar
Architecture of *Braarudosphaera bigelowii* (coccolithophorid): A Marine Planktonic Alga Holding Clues to Quasicrystalline Symmetry.

11:10-11:35 Paul Bown (and others)
The Morphology, Classification, Evolution and Morphometrics of the Late Cretaceous Coccolith Genus *Gartnerago* Bukry, 1969.

11:35-12: 00 Jeremy R. Young (and others)
Chirality and the K/T Boundary

12:00-12:25 Andy Howard (and others)
Morphometric Analysis of the Broinsonia parca plexus across the Santonian-Campanian Boundary.

12:30-13:30 Lunch at Hotel

Talks session II - **Jurassic**
Elisabetta Erba and Sherwood Wise presiding

13:35-14:00 Emmanuela Mattioli (and others)
The Eustatic and Climatic-orbital Signature on Phytoplankton and Geochemistry: Examples from the Early Toarcian in Central Italy.

14:00-14:20 Nicola Perilli (and others)
Calcareous Nannofossil Biostratigraphy of Early and Middle Toarcian from the Cordillera Iberica and Cuenca Vasco-Cantábrica (Spain).

14:20-14:40 Nicola Perilli
Early-Middle Toarcian Calcareous Nannofossils of San Andrés and Camino Sections (Cuenca Vasco-Cantábrica, Spain).

14:40-15:05 Elisabetta Erba (and others)
Isotope Fluctuations and Plankton Diversification in the Middle Jurassic of Western Tethys.

15:05-15:30 Richard Howe
A Preliminary Nannofossil Biostratigraphy of the Jurassic of the Rankin Platform and Dampier Sub-Basin on the North West Shelf of Western Australia.

15:30-15:45 Coffee break

15:45-16:30 INA Business Meeting (Salón Bahía)

16:30-18:45 ***POSTER SESSION II*** → (Salón Bahía)

19:00 Bus to Chancellor's residence University of Puerto Rico, Mayagüez

20:00-22:00 Reception and dinner at Chancellor's residence

✳Thursday, February 12th, 1998✳

07:00-08:00 Breakfast

Talks session III - **Cretaceous and Palaeogene** - (Salón Bahía)
Nicky Hine and Tim Bralower presiding

08:00-08:25 Christianne Street (and others)
Palaeobiology of Early Cretaceous Nannoplankton

08:25-08:50 Fabio Lottaroli (and others)
High resolution Biostratigraphy in the North Sea Chalk (Off-Shore Norwegian North Sea).

08:50-09:15 Jeremy R.Young (and others)
Cenomanian Nannofossils and Milankovitch Cyclicity.

09:15-09:40 Amina I.S. Karega
The Mid-Late Cretaceous and Early Tertiary Calcareous Nannofossils; Tanzania.

09:40-10:05 Timothy J. Bralower
Reworked Nannofossils Indicate Margin Collapse and Massive Sediment Gravity Flows in the Gulf of Mexico and Caribbean Triggered by the Cretaceous/Tertiary Boundary Chicxulub Impact

10:05-10:30 Yoram Eshet (and others)
Microfossils Help in Deciphering a Complex Metamorphic and Paleogeographic Enigma.

10:30-10:45 Coffee break

10:45-11:10 Simonetta Monechi (and others)
Statistical Analysis of Sequential Abundance Data: Paleo-Ecological Evidence from the Upper Eocene Massignano Section (Central Italy).

11:10-11:35 Tania Hildebrand-Habel (and others)
Variations in South Atlantic Calc-dinoflagellate Associations since the Late Cretaceous.

11:35-12:00 Alyssa M. Peleo-Alampay,
Unusual Oligocene *Braarudosphaera*-rich Layers of the South Atlantic and their Paleoceanographic Implications.

12:00-12:25 Jens Wendler (and others)
High Resolution Sequence Biostratigraphy with Calcareous Dinoflagellate Cysts, Coccoliths and Foraminifera.

12:25-13:25 Lunch at Hotel

Talks Session IV - **Neogene and Quaternary-** (Salón Bahía)
Jeremy Young and Jean Self-Trail presiding

13:25-13:50 Ting C. Huang
Nannofossils from the lower Miocene of Puerto Rico

13:50-14:15 Richard A. Denne
Calcareous Nannoplankton Dominance Shifts of the Plio-Pleistocene: Global Significance and Implications for Biostratigraphy.

14:15-14:40 Patrick Sean Quinn
Ceramic Nannopalaeontology

14:40-15:05 Mario Cachão (and others)
Coccolith Palaeoecological Interpretations from an Upwelling Region Off NW Africa (ODP 658C) During the Last 130 kyrs.

15:05-15:30 Christine Höll (and others)
On the Environmental Affinity of Calcareous Dinoflagellates in Late Quaternary Sediments of the Tropical Atlantic.

15:30-15:45 Coffee break

15:45-16:10 Elisabetta Erba (and others)
Response of calcareous nannofloras to paleoceanographic changes related to sapropels (Late Pleistocene, Eastern Mediterranean).

16:10-16:35 Hanno Kinkel (and others)
Coccolithophore Response to Changing Late Quaternary Paleoceanography in the Equatorial Atlantic Ocean.

16:35-19:00 ***POSTER SESSION III*** → (Salón Bahía)

19:00-20:00 Dinner at Hotel

20:30-23:00 Tropical Rhythm Dance Band → (Salón Bahía)

✳ Friday, February 15th, 1998 ✳

07:00-08:00 Breakfast at Hotel

Talks session V - **Modern nannoplankton, biological oceanography and ecology**
Hisatake Okada and Simonetta Monechi presiding
(Salón Tropical)

08:00-08:25 Open

08:25-08:50 Richard Jordan (and others)
Seasonal Changes in the Living Coccolithophorid Assemblages off the Puerto Rican Coast.

08:50-09:15 Mara Cortés (and others)
Coccolithophore Ecology at the Time-Series Station ALOHA, Hawaii.

09:15-09:40 Britta Karwath (and others)
Environmental Affinities of *Thoracosphaera heimii* in Field and Laboratory Studies - Preliminary Results.

09:40-10:05 Hisatake Okada (and others)
Seasonal Variation of Modern Coccolithophores in the Subarctic Pacific Ocean and Bering Sea.

10:05-10:30 Open

10:30-10:45 Coffee break

10:45-11:10 Mario Cachão (and others)
(Cocco)liths versus (Cocco)spheres: A Method to Approach the Ecology and the Biostratonomy of Coccolithophores.

11:10-11:35 Luc Beaufort (and others)
Coccolith Production and Sedimentation in the Vicinity of the North-Western African Upwelling.

11:35-12:00 Patrizia Ziveri
Export Production and Preservation of Coccolithophores from Upwelling and Oligotrophic Areas.

12:00-12:30 Yoram Eshet
The Virtual Paleontologist, OR: Children as Real Paleontologists

Lunch - on your own

Afternoon - recover; except CODENET participants who have workshop session (small conference room).

18:00-19:00 Tour of Phosphorescent Bay with our own Dr. Juan González

✳ Saturday, February 14th, 1998 ✳

08:00-15:00 Field trip (includes lunch somewhere)

POSTER SESSIONS

Tuesday, February 10th, 1998 **13:30 - 15:30**
Wednesday, February 11th, 1998 **16:30 - 18:45**
Thursday, February 12th, 1998 **16:35 - 19:00**

P1 DuVernay, Alvin. **Biosteering on 'Mars' - Reducing Uncertainties of Horizontal Drilling.**

P2 Antunes, Rogério Loureiro, Luiz Carlos Veiga de Oliveira, Seirin Shimabukuro and Armando Scarparo Cunha. **Calcareous Nannnofossil Biozones of the Brazilian Continental Margin: Evolution of a Concept.**

P3 Styzen, Michael J. and Terri Dunn. **Summary of the Nannofossil Gulf Coast Equivalency Project.**

P4 Siesser, William G. **Biostratigraphy of the Genus *Scyphosphaera*.**

P5 Hamrsmid, Bohumil and Yawoa da Costa. **Calcareous Nannoplankton Biostratigraphy of the Coast Basin of Togo, West Africa.**

P6 Walsworth-Bell, E. Benedict, Paul R. Bown, and Graham P. Weedon. **Jurassic Nannofossil Ecology and Environmental Cycles: Preliminary Results.**

P7 Mattioli, Emmanuela and Raffaella Bucefalo Palliani. **Lower Jurassic Integrated Biostratigraphy based on Calcareous Nannofossils and Dinoflagellate Cysts in the Tethyan Realm.**

P8 Burnett, Jackie A., Paul R. Bown, Jeremy R.Young and Jim B. Riding. **Phytoplankton Dynamics and Environmental Cycles in the Late Jurassic Kimmeridge Clay - Preliminary Results.**

P9 Geisen, Markus Jörg Mutterlose, and Jeremy R. Young. **Coccolith Biometrics: A High Resolution Case Study in the Hauterivian (early Cretaceous) and Planned Work in the CODENET Project.**

P10 Veiga de Oliveira, Luiz Carlos, René Rodrigues, Valesca Brasil Lemos, Ricardo Ayup-Zouain, and Ivanise Maria Wolff. **Multivariate Analysis of Calcareous Nannoplankton and Stable Isotopic Study in the Upper Campanian - Lower Maastrichtian of the Campos Basin (SE Brazil).**

P11 Švábenická, Lilian. **Evidence of the *Braarudosphaera*-rich Sediments in the Turonian of the Bohemian Cretaceous Basin, Czech Republic.**

P12 Self-Trail, Jean M. and Gregory S. Gohn. **Sequence Biostratigraphy of a Shallow Marine Environment: Campanian and Maastrichtian Sediments of South Carolina, U.S.A.**

P13 Eshet, Yoram and S. Moshkovitz. **Paleocene Calcareous Nannofossil Biostratigraphy in Israel - Preliminary Results.**

P14 Fukasawa, Kazue and Chikara Hiramatsu. **Biostratigraphic and Paleoceanographic Significance of the Late Middle Miocene - Early Pliocene Calcareous Nannofossils**

from the Coast of the Sea of Japan, Northeast Japan.

P15 Peleo-Alampay, Alyssa M. **Miocene Calcareous Nannofossil Magnetobiostratigraphy and Biochronology.**

P16 Huang, Ting C. **Nannofossils from a Lower Miocene Core of Puerto Rico.**

P17 Villa, G. and Wise, S. **Quaternary and Miocene *Thoracosphaera* in the Ross Sea (77 ° S Latitude).**

P18 Baumann, Karl-Heinz, Hanno Kinkel, Martin Cepek, and P.J. Müller. **Coccolithophore and Alkenone Changes in Late Quaternary Sediments of the South Atlantic.Miocene - Pliocene**

P19 Lototskaya Anna, Patrizia Ziveri, Gerald M. Ganssen, and Jan E. van Hinte. **Calcareous Nannoflora Response to Termination II at 45 °-53°N (Northeast Atlantic).**

P20 Tanaka, Yuichiro. **Late Quarternary Nannofossil Assemblages in the Transitional Northwestern Pacific Ocean.**

P21 Hine, Nicky. **Variations in Surface Water Mass Conditions Along the North East Atlantic Fringe as Evidenced by Late Quaternary Calcareous Nannoplankton.**

P22 Flores, José-Abel , F. Javier Sierro, Carles Pelejero, Joan Grimalt, Luejiang Wang and Michael Sarnthein. **Sea Surface Dynamics and Paleomonsoon Variability in the South China Sea for the Last 140,000 Years.**

P23 Flores, J.A., Bárcena, M. A. and Sierro, J. F. **Trade-Wind Effect in the Sea Surface Dynamic Off West-Africa (5 °N) During the Last Climatic Cycle.**

P24 Esper, Oliver, Karin Zonneveld and Helmut Willems. **Palaeoceanological reconstruction of the Late Quaternary Agulhas Current (South Atlantic) Based on Calcareous and Organic Walled Dinoflagellate Cysts.**

P25 Ziveri, Patrizia, Arrian Rutten, Cesare Corselli, and Gert de Lange. **Coccolith $CaCO_3$ Actuo and Paleo-fluxes from the Eastern Mediterranean.**

P26 Zeltner, Alexandra. **Coccolith fluxes in the central Arabian Sea. (14 °27,46'N, 64° 34,32'E).**

P27 Henderiks, J, J. Bollmann, T. Freudenthal, H. Meggers, C. Sprengel, and H.R. Thierstein. **Coccolith Assemblages Along an E-W Transect North of the Canary Islands (29 °N): Comparison Between Sediment, Sediment Trap and Plankton Samples.**

P28 Broerse, Alexandra T. C. **Coccolithophore ($CaCO_3$) Fluxes in the Sea of Okhotsk (North Pacific Ocean).**

P29 Broerse, Alexandra, T.C. **Coccolithophore Export Production from Equatorial to Sub-Polar Waters.**

P30 Andruleit, Harald. **Coccolithophore Sedimentation in the Nordic Seas: Findings from Three Trap Moorings.**

P31 Baumann, Karl-Heinz, and Sprengel, Claudia. **Seasonal and Interannual Variations of**

Coccolithophore Fluxes and Species Composition in Sediment Traps North of the Canary Islands.

P32 Baumann, K.H., H. Andruleit, and C. Samtleben. **Coccolithophores of the Nordic Seas: Comparison of Living Communities with Surface Sediment Assemblages.**

P33 Baumann, Karl-Heinz. **Variations in Morphometry of *Coccolithus pelagicus* Coccoliths in Plankton and Sediments of the Northern North Atlantic.**

P34 Vink, Annemiek, Karin Zonneveld and Helmut Willems. **Recent Distributions of Calcareous Dinoflagellates in the South Atlantic and Their Potential Use in Palaeoecology.**

P35 Cros, Lluïsa. **Variety of Exothecal Coccoliths of *Syracosphaera*.**

P36 Bollmann, Jorg, Hans Barth, Michaela Knoll, Bernd Lenz, Federico López Laatzen, Thomas Müller, Rainer Reuter, Gerold Siedler, Andrea Spies, Claudia Sprengel, Hans R. Thierstein, Oliver Zielinski **Distribution of Living Coccolithophores Along a Zonal Transect (29°N) North of the Canary Islands: Vertical, Seasonal and Interannual Variations.**

P37 Hagino, Kyoko. **Community Structure of Living Coccolithophore in the Central and Western Pacific.**

P38 Hernández-Becerril, David Uriel. **Cocolithophorids from the Subtropical Mexican Pacific (West Coast of Baja California, México).**

P39 Takahashi, Kyoma. **Modern Nannoflora from off the Coast of Western Australia.**

P40 Westbroek, Peter, Bas Kooijman, Jan van Hinte, Patrizia Ziveri. **Geobiology, Definition, Organization and Some Representative Research.**

Late Pleistocene-Holocene Palaeoclimatic Changes As Recorded By Caclcareous Nannofossils (Central Tyrrhenian Sea - Italy)

Filomena Ornella Amore and Paola Esposito

Dipartimento di Scienze della Terra
Università di Napoli "Federico II" Largo San Marcellino, 10 - 80138 NAPOLI, ITALY
E- mail: amore@unina.it

A quantitative analysis of the calcareous nannofossil assemblages from three Late Pleistocene-Holocene gravity cores from the Gaeta Bay continental shelf (Central TyrrhenianSea - Italy) was done. The core C5 (500 cm long, 111 mbsl, 41°05'41"N; 13°35'56"E) consists of two units separated by a discontinuity surface. The more distal cores C8 (362 cm long, 126 mbsl, 41°04'31"N, 13°32'18"E) and C9 (470 cm long, 212 mbsl, 41°02'46"N, 13°29'24"E) present a continuous sedimentary record. The analysis of the acoustic profiles (Senatore, 1996) identified a prograding wedge system with clinoforms increasing in dip seaward. Thus, the lower interval in the C5 is older than in the other cores. The interpretation of seismic profiles is also supported by nannofossils data: the *Emiliania huxley* Acme and *E. huxley* Zones (Gartner, 1977) have been identified in core C5. The boundary between the zones is at 270 cm. To detect this event the quantitative counting method of Rio et al., 1990 has been adopted. The C8 and C9 cores lower intervals should correspond to stage 2 partim. The upper parts of all the cores represent the Late Glacial-Holocene intervals. The quantitative analysis of the calcareous nannofossils assemblages was focused to recognize the Late Pleistocene - Holocene palaeoclimatic patterns of this area.

In this study in agreement with the climatic and palaeoclimatic meaning of coccolithophore *R. clavigera*, *U. sibogae*, *C. leptoporus* and *Pontosphaera spp*. have been considered warm species, instead *C. pelagicus* has been considered a cold water indicator. However in our cores we observed that *C. leptorus* and *C. pelagicus* are controlled also by nutrient enrichment. A palaeoclimatic curve using a formula already utilized for foraminifera was done. The basal units of all the cores correspond to episodes characterized by high percentages of *C. pelagicus* and by low percentages of the warm water species. A first increase of the warm taxa and a dramatic drop of *C. pelagicus* at the base of Late-Glacial interval have been observed. During this interval maximum value of *B. bigelowi* has been recorded. This species is generally absent or represented with very low percentages in our cores. However peaks of abundance, with maximum value in the nearshore cores, occur in all cores during this period and could suggest that the abundance of this species be linked to major wet and increased regional rainfall and runoff of this period. The YD is characterized by a slight decrease of warm waters species, a parallel increase in cold waters species and by some barren levels that show instead diatom blooms. The Holocene/Pleistocene boundary is characterized by low values of *C. pelagicus*, by a further increase of *U. sibogae*, *Rhabdosphaera spp*., by a dominance of *E. huxley* and an increase of *Ceratolithus spp*. Peaks of *C. leptoporus* and *H. carteri* are observed during the Holocene. Flores et al. (1997) recorded "maxima in the abundance of these taxa during interglacial periods". Pujos (1992) suggest that the higher values of these species may be linked to nutrient-rich waters. In our cores a relationship between peaks of these taxa and peaks of *C. pelagicus* has been observed. This species prefers cold water but also high concentration in nutrient (Cãchao & Moita 1995; Roth 1994). *Syracosphaera spp*. have been recorded in the cores and they occur

more frequently and with higher percentage in the Holocene part of the cores. Peaks in abundance of *Ceratolithus spp.* are also observed in all the cores. We observed that maximum value of *Ceratolithus spp.* is always associated with peaks of *R. clavigera* and maximum value of *Globigerinoides spp* (Amore et al., in press), which could testify a further warming within the Holocene.

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Coccolithophore Sedimentation in the Nordic Seas: Findings from Three Trap Moorings

Harald Andruleit

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR),
Stilleweg 2, 30655 HANOVER, GERMANY. e-mail: h.andruleit@bgr.de
(formerly at Sonderforschungsbereich 313, University of Kiel)

Coccolithophore fluxes were investigated by sediment trap studies at three sites in the Nordic Seas from 1990 to 1992 and 1994 to 1995. Each trap mooring comprised traps at three different water depths: at 300 to 500m, at 1000m water depth, and about 300m above the seafloor. All sites were characterized by a strong seasonality in coccolithophore fluxes. Highest fluxes were observed in the Norwegian Sea (NB 6) which were about 10 to 20 times higher than in the southern Greenland Sea (OG 4/5). Interestingly fluxes from the central Greenland Sea (GS 2) were lower than in the Norwegian Sea but clearly higher than in the southern Greenland Sea. Maximum fluxes ($13x10^6$ ind.$m^{-2}d^{-1}$ for the Norwegian Sea, $2.4x10^6$ ind.$m^{-2}d^{-1}$ for the southern Greenland Sea, and $12x10^6$ ind.$m^{-2}d^{-1}$ for the central Greenland Sea) were reached during high sedimentation phases in late summer and autumn.

The settling assemblages represented already highly altered remnants of the former living communities. However, only in the central Greenland Sea (GS2) dissolution seemed to be of major influence. Dominant species were *Emiliania huxleyi* in the Norwegian Sea and *Coccolithus pelagicus* in the Greenland Sea. Especially in the central Greenland Sea *C. pelagicus* dominated with more than 98%. Clear differences in the assemblage compositions are thought to reflect distinct signatures of the local oceanography.

The settling assemblages underwent only minor alterations during sinking from 500 to 1000m water depth. By contrast, resuspension and lateral advection within an extensive bottom nepheloid layer strongly influenced the assemblages of the deep sediment traps 300m above the seafloor, wiping out the distinct seasonality in coccolithophore fluxes and diminishing the differences in assemblage compositions between the three sites.

Calcareous Nannnofossil Biozones of the Brazilian Continental Margin: Evolution of a Concept

Rogério Loureiro Antunes, Luiz Carlos Veiga de Oliveira, Seirin Shimabukuro and Armando Scarparo Cunha

PETROBRAS/CENPES/DIVEX/SEBIPE, Pd. 20, Cid. Universitária, Quadra 7, 21949-900, RIO de JANEIRO, RJ, BRAZIL. E-mail: lcveiga@cenpes.petrobras.com.br.

In Brazil, the biostratigraphic research on the calcareous nannoplankton began in 1968, during the early phase of petroleum exploration on the continental margin. These initial studies lent support to the first biozonation, by Troelsen & Quadros (1971), comprises 22 biozones (5 of which in the Cretaceous and 17 in the Cenozoic). Subsequent research aimed at more precise age determinations of the biozones and more refined biostratigraphic frameworks. In 1993, Ricther et al. integrated all previous work in the Cenozoic section of the Brazilian continental margin and proposed a new biozonation. This scheme is nowadays in use and consists of 35 interval zones defined by last occurrences of selected taxons. Concerning the Cretaceous section, additional studies have provided the basis for an improved biozonation. Antunes (in press) critically reviewed all zones proposed until then for the Mesozoic section of the continental margin and constructed a preliminary biozonation to be tested in further investigations. This biostratigraphic framework has ever since been approved in the Sergipe/Alagoas, Potiguar, Santos and Campos basins. In 1997, new biozones were added to Cretaceous zonation of the Campos and Santos basins (Oliveira, 1997; Oliveira & Costa, 1997).

It has been demonstrated that Albian biozones differ markedly on the equatorial and southeast margins. Probably, this results from distinct oceanographic conditions prevalent during early developmental phases of the South Atlantic Ocean.

Isotope Fluctuations and Plankton Diversification in the Middle Jurassic of Western Tethys

A. Bartolini [1], E. Erba[2] and E. Mattioli[3]

[1] Institut de Paléontologie et Géologie, Université de Lausanne, LAUSANNE - SWITZERLAND
[2] Dipartimento di Scienze della Terra, Via Mangiagalli, MILANO - ITALIA. E-mail: Erba@imiucca.csi.unimi.it
[3] Dipartimento di Scienze della Terra, P.za Università, PERUGIA - ITALIA

An integrated biostratigraphy (calcareous nannofossils and radiolarians) and isotope stratigraphy study has been carried out in the Umbria-Marche-Sabina (central Italy) and Digne area (southern France), in the Aalenian to early Bathonian, with the aim to better understand the palaeoceanographic evolution of the western Tethys during this period. This integrated stratigraphycal approach has also allowed a better age determination in lithotypes, such as in central Italy, depleted or barren of ammonites. Although the absolute $\delta^{13}C$ values of the Digne marly limestones are offset by about 1‰ with respect to the Umbria-Marche-Sabina pelagic limestones, all major isotopic shifts can be correlated between the two areas. The $\delta^{13}C$ curves show a relative minimum in the upper Aalenian and a positive composite peak in the upper part of lower Bajocian-lower part of upper Bajocian interval.

At the Aalenian/Bajocian boundary a turnover of calcareous nannoplankton can be observed: the taxa characteristic of the early Jurassic, and mainly *Schizosphaerella* spp., tend to decrease in abundance, and Watznaueriaceae experienced a speciation event becoming the dominant taxon in the assemblage. This speciation marked the end of the "*Schizosphaerella* spp. age" (Noël et al, 1996) lasting the whole early Jurassic, and led to a long period of Watznaueria dominance, before the Nannoconus attain a lithogenetic importance in the terminal Jurassic. The diversification trend of the Family Watznaueriaceae parallels the $\delta^{13}C$ increase. Radiolarian assemblages followed partly the same trend as nannoplankton. From the base of the Bajocian, the radiolarian associations show a slight tendency towards the diversification, coincident with increasing $\delta^{13}C$ values. In the upper part of the early Bajocian, Last Appearances prevail over First Appearances associated with the peak of the $\delta^{13}C$ event. This may indicate maximum eutrophic conditions. Contemporaneously with the isotopic event, an increase of biosiliceous productivity is recorded as an increase in visible chert in the Umbria-Marche area. The plankton diversification, the isotope event and the increase in biosiliceous sedimentation may be related to deep palaeoenvironmental modification, such as climatic-eustatic changes, crisis of carbonate platforms, volcanism, modifying the ocean chemistry and opening new available niches for the plankton.

Variations in Morphometry of Coccolithus pelagicus Coccoliths in Plankton and Sediments of the Northern North Atlantic

Karl-Heinz Baumann

FB Geowissenschaften, Universität BREMEN, GERMANY.
E-mail: khb@mail.sedpal.uni-bremen.de.

Variations in the intra-specific morphometry of *Coccolithus pelagicus* (Wallich) Schiller were observed in late Pliocene/Pleistocene sediments of the North Atlantic and Nordic Seas. In general, the distal shield of *C. pelagicus* show a wide range of size variations, typically 8-16 µm in length and 6-14µm in width. Element count for the distal shield is 30-65. Length, width, and the number of distal shield elements are strongly correlated to each other. Investigation of plankton samples and surface sediments show that a decrease in mean size of the distal shields occurs towards the north with approximation to colder surface waters. *C. pelagicus* distal shield variation is much greater in the North Atlantic than observed in the Norwegian-Greenland Sea. In sediments of the Fram Strait small coccoliths (7-12µm) were exclusively observed. Thus, surface water temperature seems to be the primary control for the decrease in mean C. pelagicus size.

This species is a major component of high latitude assemblages although it occasionally occurs at much lower latitudes. Fluctuation in morphometry of *C. pelagicus* therefore are connected with variations in abundance. The coccolith assemblages in these sediments have been drastically influenced by glacial-interglacial climatic changes, especially in the Nordic Seas. However, several abundance peaks are present in the last 3.0 Ma. Most obvious are high numbers of C. pelagicus in sediments of the early Pleistocene, of part of oxygen isotope stage 7, and of the Holocene. Within all of these intervals an obvious (and drastic) decrease in size was observed, with coccoliths smaller than 10µm virtually appearing and longer specimens decreasing in abundance.

Coccolith size probably results from the interaction between coccolith biosynthesis and environment. Thus, variations in coccolith-size and abundance of C. pelagicus are due to ecological differences in the various interglacials, i.e. due to differences in the inflow of warm North Atlantic surface water. However, other factors such as nutrients/trophic level could also control assemblage variation and/or intraspecific variations rather than temperature alone.

Coccolithophores of the Nordic Seas: Comparison of Living Communities with Surface Sediment Assemblages

K.-H. Baumann[1], H. Andruleit[2], and C. Samtleben[3]

FB Geowissenschaften, Universität BREMEN, GERMANY.
E-mail: khb@mail.sedpal.uni-bremen.de; h.andruleit@bgr.de

Coccolithophores in the Norwegian-Greenland Sea have been investigated in both a high number of plankton samples of several cruises and in surface sediments of the entire area. Here, data of the living communities are compared with results of surface sediment assemblages. The distribution and frequency of individual species that are found in the surface sediments are shown in biogeographic maps. Living coccolithophore communities in the Norwegian-Greenland Sea can be classified in three regional groups tracing the corresponding surface water masses: (1) an Atlantic group, (2) an Atlantic-Arctic group, and (3) an Arctic group. These assemblages are decomposed and altered during descent in the water column. Destruction and solution of delicate heterococcoliths and of all the holococcoliths leave only few species at deeper water levels. These species are further influenced by differential dissolution and destruction at the sediment-water interface. As a result, the original composition of the living communities becomes increasingly obscured in the impoverished taphocoenoses. Samples from surface sediments contain significantly less coccolithophore species than those which are included in living communities of the same area. Of the identified 22 species in the surface waters only 7 are found in the surface sediments. The most frequently occurring species are *Emiliania huxleyi* and *Coccolithus pelagicus*. In addition, *Calcidiscus leptoporus* and *Gephyrocapsa muellerae* are regularly found in small amounts. This becomes even more remarkable when one consider the fact that these species are rarely found in the living communities. Based on the concentration and diversity of the species and the ratio changes between *E. huxleyi* and *C. pelagicus* it is possible to establish biogeographic zones. Thus, the coccolith distribution in surface sediments of the Norwegian Sea seems to give a good description of the various locations of various water masses in the area.

Coccolithophore and Alkenone Changes in Late Quaternary Sediments of the South Atlantic

Karl-Heinz Baumann, Hanno Kinkel, Martin Cepek, and P.J. Müller

FB Geowissenschaften, Universität BREMEN, GERMANY.
E-mail: khb@mail.sedpal.uni-bremen.de; hkinkel@mail.sedpal.uni-bremen.de.

Late Quaternary coccolithophore assemblages in three sediment cores were investigated to reconstruct changes in the surface water conditions and productivity. However, variations in the coccolithophore assemblages give only relative temperature changes. Thus, variations in species composition are compared to alkenone concentrations and alkenone-derived sea-surface temperature (SST) records. These SST estimates are usually based on a UK37'-temperature relationship which was quantified using data from clonal cultures of *Emiliania huxleyi*. Therefore this cosmopolitan species is believed to be the main producer of alkenones in the open ocean. Meanwhile it was shown that *Gephyrocapsa oceanica* synthesizes alkenones and it is believed that other species of *Gephyrocapsa* should also contain this biomarker. Nevertheless, SSTs derived from UK37' relationship may be biased if other coccolithophores with different temperature affinities have contributed to the sedimentary alkenone record. Therefore, in the present study, we focused on the correlation between occurrence and abundances of the most abundant species with both the normalized alkenone concentration as well as SSTs. It is, however, not yet proofed whether all of these species actually produce alkenones. By simply plotting the alkenone concentrations against the coccolith abundances of the dominant species, only few trends are apparent in the scattergrams. Carbon-normalized alkenone concentrations are inversely correlated to abundances of *E. huxleyi*. In contrast, abundances of *Gephyrocapsa oceanica* and of *G. ericsonii* (but not of *G. muellerae*) are directly related to normalized alkenone concentrations. Numbers and abundances of most of the other species do not correlate to the alkenone data. However, although abundances of *Gephyrocapsa* species best fit to alkenone concentrations, the calibration made by *E. huxleyi* yield the more reasonable SSTs even for periods when this species was absent from the record. In addition, the correlation of coccolith abundances to SSTs also give some general trends. Abundances of *G. ericsonii* and *U. sibogae* clearly show a correlation with increasing SSTs, while those of *G. muellerae*, *G. oceanica*, and *C. leptoporus* show a positive trend with cooler temperatures. In general, highest numbers of coccoliths in the sedimentary record are observed during relatively cold periods and most probably are indicative of relatively nutrient-rich waters.

Seasonal and Interannual Variations of Coccolithophore Fluxes and Species Composition in Sediment Traps North of the Canary Islands

Karl-Heinz Baumann and Claudia Sprengel.

FB Geowissenschaften, Universitat BREMEN, GERMANY.
E-mail: khb@mail.sedpal.uni-bremen.de

The present investigation is part of the MAST III target program CANIGO (Canary Islands Azores Gibraltar Observation), subproject "Particle flux and Paleoceanography in the Eastern Boundary Current System". One of the main goals of this subproject is to quantitatively determine the influence of environmental variability on the magnitude and composition of seasonal and interannual particle flux in the Canary region, and to study the modification of particulate matter in the water column. At present, coccolithophore fluxes were investigated in sediment traps of the time-series station ESTOC (European Station for Time-series in the Ocean, Canary Islands), located 100 km north off Gran Canaria in the eastern subtropical North Atlantic gyre. The 20 cup particle traps (AQUATEC) were deployed at 1000m and 3000m below sea surface. The sampling intervals ranged from one to three weeks.

Results of four mooring intervals from April 1993 to October 1995 are presented. Total coccolithophore flux and the vertical flux of different species at various depths as well as the seasonal trend in species composition are shown. In general, coccolith and coccosphere fluxes (up to $5x10^9$ Ind./m^2/day) are characterized by a relatively strong seasonality, and maximum fluxes were reached during spring time. *Emiliania huxleyi* was the dominant species during most of the investigated time interval, followed by *Florisphaera profunda* and *Gephyrocapsa ericsonii.* Considerably higher fluxes observed in the lower traps (~1000m) in comparison to the upper ones (~3000m) are most probably due to lateral advection of particulate matter to the mooring location. Coccolithophore-$CaCO_3$ fluxes were calculated to determine the contribution to the total biogenic $CaCO_3$ flux.

Coccolith Production and Sedimentation in the Vicinity of the North-Western African Upwelling

Luc Beaufort, Dollfus, D., Buchet, N., and Bieda, S.
CNRS-CEREGE, BP80 13545 Aix-en-Provence cedex 4 FRANCE
E-mail:beaufort@cerege.fr

During the EUMELI experiment (JGOFS France) 6 sediment traps were deployed at two mooring sites off the Mauritania margin from February 1991 to November 1992. They provided time series of sedimentation at 3 different depths (250, 1000, 2500 m) with a time resolution ranging from 8 to 10 days for almost two years in both an oligotrophic area (21°N 31°W at about 2000 km from shore) and a mesotrophic area, in the vicinity of the Cap Blanc upwelling (18° N 21° W). We estimated coccolith, coccosphere and thoracosphere fluxes and compared these results to mass, organic carbon, terrigenous and carbonate fluxes. The coccolith contribution to the $CaCO_3$ flux has been estimated.

In the mesotrophic zone the coccolith fluxes range from 51 106 to 10 109 coccoliths m-2 d-1 whereas they range from 23 106 to 179 106 coccoliths m-2 d-1 in the oligotrophic zone. In the mesotrophic zone coccolith, coccopsphere and mass fluxes are highest during two short events in March and May 1991. *Emiliania huxleyi* represents 95% of the coccolithophore assemblages during these two events, while in the rest of the series the relative abundance of *E. huxleyi* is lower. These two events are recorded at the three depths in almost perfect synchroneity, implying sinking speed higher than 500 m d-1 which is particularly high. At 2500 m the percentage of $CaCO_3$ due to coccoliths is high (about 85%) during these events, sharply decreases thereafter down to values around 40% and latter progressively re-increases. These decreases are possibly due to post bloom grazing.

In the oligotrophic zone fluxes are also closely related to total mass flux. The flux variations of rare species such as *Thocosphaera heimii* or *Ceratolithus cristatus* also follow mass flux variations. We discuss the different possibilities of production/sedimentation which could explain such relation and in particular those linked to biological aggregation.

Distribution of Living Coccolithophores Along a Zonal Transect (29°N) North of the Canary Islands: Vertical, Seasonal and Interannual Variations

Jörg Bollmann[1], Hans Barth[2], Michaela Knoll[3], Bernd Lenz[3], Federico Lopez Laatzen[4], Thomas Müller[3], Rainer Reuter[2], Gerold Siedler[3], Andrea Spies[5], Claudia Sprengel[5], Hans R. Thierstein[1], Oliver Zielinski[2]

1Geological Institute, ETHZ, 8092 ZURICH, SWITZERLAND. E-mail: thiersten@erdw.ethz.ch
[2]Physics Faculty, University of OLDENBURG, GERMANY
[3]Institute of Marine Research, Kiel University , KIEL, GERMANY
[4]Instituto Español de Ciencias de Mar, SANTA CRUZ de TENERIFE y MADRID, SPAIN
[5]Geoscience Department, University of BREMEN, GERMANY

The production and burial of calcitic coccoliths in upwelling and oligotrophic ocean areas is still poorly known, despite the potentially important role they may play in the global carbon cycle. We are analyzing their production along a pronounced E-W fertility gradient in the Canary Current system, as a contribution towards assessing their role in the geosphere-biosphere system. Our general scientific goals are (a) to obtain a better understanding of the seasonal and interannual interaction between coccolithophores and the physical and chemical environment and (b) to compare this interaction with the long-term variability of coccolith composition and flux into the sedimentary archives.

Towards this general goal cell density and taxonomic composition of living coccolithophore associations were analyzed along an East-West temperature and productivity gradient in the North Atlantic Eastern Boundary Current at three locations near the mooring stations LP1 (29°45.7N, 17° 57.3W), JGOFS Time-series Station ESTOC (29°10.0N, 15°30.0W) and EBC2 (28°42.5, 13°9.3W). At these stations, water samples taken at 11 different water depth levels (0-300m) during several seasonal cruises from September 1995 to September 1997 were filtered on Nucleopore® membranes in order to determine coccolithophore cell densities and taxonomic composition of the assemblages. In addition, in situ CTD and fluorometer measurements were done and samples for nutrient and oxygen content were collected from the same water depth levels at all stations.

The strongest gradient in sea surface temperature and salinity along the zonal transect occurred during late summer (September) and ranged from 24°C and 37.1psu at station LP1 to about 20.2°C and 36.5psu at station EBC2. The weakest gradient occurred during winter (January) and ranged from 19.5°C and 36.8psu at station LP1 to 19.1°C and 36.7psu at station EBC2.

Total coccolithophore cell densities showed a strong gradient from the open ocean location LP1(~ 20'000 cells/l) to the near-shore location EBC2 (~ 65'000 cells/l) during winter as well as during late summer (~ 18'000 cells/l to ~ 45'000 cells/l). Maximum cell densities usually occurred in the upper photic zone above the deep chlorophyll maximum which was generally located between 50 and 125m water depth.

Five coccolithophore species dominated all assemblages analysed so far. The most abundant species was *G. ericsonii* which dominated the upper photic zone during the whole year at the near-shore station EBC2. At the open ocean station LP1 and ESTOC *G. ericsonii* was the most abundant species only from 0m to 50m during winter and from 50m to 100m during late summer. *U. tenuis* dominated only during late summer from 0 to 50m water depth at LP1 and ESTOC and is of minor importance at the EBC2 station. *Florisphaera profunda* is the third most abundant species during all analysed seasons at all stations below the deep chlorophyll maximum. *Emiliania huxleyi* was only found to dominate from 50 to 100m during winter time at the open ocean stations LP1 and ESTOC.

The Morphology, Classification, Evolution and Morphometrics of the Late Cretaceous Coccolith Genus *Gartnerago* Bukry, 1969

Paul Bown[1], Matthew Hampton[2] and Jackie Burnett[1]

[1] Department of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, UK.
Email: p.bown@ucl.ac.uk; j.burnett@ucl.ac.uk
[2] Network Stratigraphic Consulting Ltd., Cranbourne Road, Potters Bar, EN6 3DQ, UK

The Cretaceous family Arkhangelskiellaceae has recently been revised (Bown and Hampton in Bown and Young, 1997: JNR, 19/1, p. 32) following re-evaluation of the morphology and phylogeny of the genus *Gartnerago* (and closely allied *Kamptnerius*). An order-level grouping, the Arkhangelskiales, has been proposed incorporating two families, the Kamptneriaceae and Arkhangelskiellaceae sensu stricto. The rationale behind this revision will be discussed.

The new order incorporates typically tiered 'placolith' coccoliths, with 3-5 closely appressed 'shields' and central-area structures which include transverse bars with proximal net; axial or sub-axial crosses with proximal net; and perforate plates crossed by axial or sub-axial sutures. The two families, however, display significant variations in light-microscope appearance, from predominantly dark images in the Kamptneriaceae, to predominantly bright images in the Arkhangelskiellaceae. The phylogeny of the Kamptneriaceae also appears to be distinct from the Arkhangelskiellaceae, and incorporates a number of complex and interesting morphological innovations. The oldest Kamptneriaceae representatives actually possess loxolith rim morphologies, although in a somewhat modified form. Albian to early Cenomanian species retained this rim structure, and it was not until the appearance of *G. segmentatum* (*G. obliquum* of many authors) that the typical multi-shielded 'arkhangelskiellid' rim structure was developed. In fact, this rim structure is not strictly placolith (i.e. discrete, subhorizontal shields separated by a tube), but rather a modified loxolith structure in which folding of the rim-wall produces shield-like protrusions. While this rim morphology evolution substantially modifies the surfical appearance of the rim (from loxolith-like wall to placolith-like shields) the LM appearance (reflecting the crystallographic architecture) remains remarkably constant.

We will also present the results of a morphometric study of *Gartnerago*, which has aided taxonomic clarification and provided useful biostratigraphic information.

Reworked Nannofossils Indicate Margin Collapse and Massive Sediment Gravity Flows in the Gulf of Mexico and Caribbean Triggered by the Cretaceous/Tertiary Boundary Chicxulub Impact

Timothy J. Bralower

Geology Dept., University of North Carolina, Chapel Hill, NC 27599, USA
bralower@email.unc.edu

Detailed biostratigraphic and lithologic investigations were conducted on Cretaceous/ Tertiary boundary (KTB) sections in eleven Deep Sea Drilling Project and Ocean Drilling Program sites ranging from the Yucatan continental margin to the Caribbean Sea. In several sites, a mixture of older, reworked nannofossil assemblages are found with late Maastrichtian nannofossil taxa (e.g., *Micula murus* and *Lithraphidites quadratus*). Reworked assemblages contain markers that are diagnostic of the late Campanian to early Maastrichtian (*Aspidolithus parcus* subsp. *parcus, A. parcus* subsp. *constrictus*, *Eiffellithus eximius*, *Quadrum gothicum, Q. trifidum*, *Reinhardtites anthophorus, R. levis*, *Lithastrinus grillii*, and *Tranolithus orionatus*), and Barremian to earliest Aptian (*Nannoconus steinmannii*, *N. elongatus, N. minutus,* and *Hayesites radiatus*). Some of these sites also contain a combination of late Maastrichtian and older planktic foraminifers. Pervasive reworking and winnowing, and the paucity of pelagic sediment components complicates the identification of the KTB level from biostratigraphic data which can only provide maximum ages in some cases and minimum ages in others. Because a suite of facies and a considerable thickness of sediments may be related to the KTB impact, we use impact-derived materials (including spherules, shocked quartz and Ir anomalies) to identify KTB units.

Angular polymict clasts and fining-upwards sedimentary structures indicate that KTB deposits were laid down by sediment gravity flows, including turbidity currents and debris flows. In several sites where KTB sediments are missing, there is a distinct unconformity between Cretaceous and lowermost Paleocene sediments. Scouring by the gravity flows appears to be responsible for the hiatus at these sites. The reworked nannofossils and lithologically-distinct clasts suggest the gravity flows were initiated by massive collapse of surrounding continental margins presumably as a result of the Chicxulub impact. The gravity flow deposits are aerially extensive and vertically expansive. Sites up to 1000 km from a potential gravity-flow source contain the same reworked nannofossil taxa in the KTB deposits as observed in more proximal sites. Presence of reworked deposits on Cretaceous topographic highs shows that the gravity flows engulfed a significant part of the lower water column as they moved down slope. Because thick sequences of reworked KTB sediments were rapidly deposited (in hours to a few years), strict use of traditional biostratigraphic techniques yields erroneous age interpretations.

Coccolithophore Export Production from Equatorial to Sub-Polar Waters

Alexandra T. C. Broerse

Geomarine Center, Faculty of Earth Sciences, Vrije Universiteit, de Boelelaan 1085, 1081 HV AMSTERDAM, THE NETHERLANDS. E-mail: bros@geo.vu.nl

The *Emiliania* Modelling Initiative (GEM) investigates the impact of coccolithophores on the ocean carbon cycle. In 1994 a project within GEM has been started in order to quantify and map on a global scale the variety of coccolithophore communities in the recent ocean by month, season and year and to determine the coccolithophore-$CaCO_3$ export fluxes. A few key stations were selected in a wide range of oceanic settings. I will present a compilation of coccolithophore export production from stations in the subtropical (34°N 21°W) and the temperate Northeast Atlantic (48°N 21°W), in the Equatorial Pacific (5°S 139°W and 12°S 135°W), in the tropical northwestern Indian Ocean off Somalia (10°N 53°E), and in the sub-polar Sea of Okhotsk (53°N 149°E) in the extreme north-west of the Pacific Ocean, in addition with available data on coccolithophore export production from literature.

In the equatorial Pacific coccolithophores showed little seasonal fluctuations in fluxes and species composition. Mean daily fluxes at 5°S were about $2.1x10^8$ and at 12°S $2.5x10^8$ coccoliths/m^2/day. The two most abundant species throughout the year were *Gladiolithus flabellatus* and *Gephyrocapsa oceanica*. The fine fraction (<32 μm) $CaCO_3$ is used as an estimation for maximum coccolithophore carbonate fluxes. At 5°S the annual fine fraction $CaCO_3$ flux was 3.2 g/m^2/year, presenting only 22% of the total $CaCO_3$ flux, while at 12°S the fine fraction $CaCO_3$ contribution was 68% with 4.2 g/m^2/year.

The production in the tropical station off Somalia in the northwestern Indian Ocean is influenced by upwelling during the SW monsoon. The average daily coccolith flux was $4.7x10^8$/m^2/day and the average flux was 3 times higher during the SW monsoon than during the inter-monsoonal period. *Florisphaera profunda* dominated the assemblage during the start of the upwelling season, while *G. oceanica* and *Emiliania huxleyi*, were dominant in the SW monsoon and the inter-monsoonal period. The fine fraction $CaCO_3$ flux was 7.8 g/m^2/year, and consisted only 34% of the total $CaCO_3$ flux.

In the subtropical Atlantic station the average coccolith flux was highest with $1.1x10^9$/m^2/day. The spring bloom started in January, and fluxes were about 15 times higher than in other seasons. *F. profunda* was the dominant species with 50% during pre-bloom conditions, and *E. huxleyi* dominated the rest of year between 40-80%. The average fine fraction $CaCO_3$ flux was 8.1 g/m^2/year and contributed 62% to the total $CaCO_3$ flux.

In the temperate Atlantic the average daily flux was $3.9x10^8$ coccoliths/m^2/day. The spring bloom was in April/May with fluxes about 10 times higher than during the rest of the year. *E. huxleyi* dominated the coccolith assemblage continuously with 60-80%. The fine fraction $CaCO_3$ flux was 4.6 g/m^2/year and contributed only 41% to the total $CaCO_3$ flux.

In the sub-polar Sea of Okhotsk, which is covered with ice during the winter, the average flux was $1.6x10^7$ coccoliths/m^2/day, with *Coccolithus pelagicus* dominating during the autumn bloom in November and *E. huxleyi* dominating during the beginning of the spring bloom in March-April 1991, while maximum mass and biogenic silica fluxes were found in June. Besides *E. huxleyi* and *C. pelagicus* no other species were significant. The <32 μm $CaCO_3$ flux was only 1.5 g/m^2/year, representing 14% of the total $CaCO_3$ flux.

Coccolithophore ($CaCO_3$) Fluxes in the Sea of Okhotsk (North Pacific Ocean)

Alexandra T. C. Broerse

Geomarine Center, Faculty of Earth Sciences, Vrije Universiteit, de Boelelaan 1085, 1081 HV AMSTERDAM, THE NETHERLANDS. E-mail: bros@geo.vu.nl

Coccolithophore fluxes, and its calcium carbonate contribution were determined in the Sea of Okhotsk, a subpolar zone in the extreme north-west of the Pacific Ocean. It is, after the Bering Sea, the largest marginal sea in the world, covered for 80% with first year sea-ice during an average winter. A sediment trap mooring, deployed in the center of the Sea of Okhotsk at 53°N 150°E (Shoyo station), collected material at 258 m and 1061 m depth from August 1990 to August 1991. Two distinct particle blooms in spring and autumn were observed, alternating with a summer and winter slack period. There was an unusually large export production of organic carbon (mainly in spring) and inorganic carbon (mainly in autumn) to the interior of the Sea of Okhotsk, with a very extended phytoplankton bloom. The two most dominant coccolithophore species were *Coccolithus pelagicus* and *Emiliania huxleyi*, showing an increase in fluxes at 258 m depth during both spring and autumn blooms. *C. pelagicus* was more abundant during the autumn bloom, while *E. huxleyi* reached maximum fluxes during the spring bloom. Maximum fluxes of *C. pelagicus* were reached two weeks after the peak mass flux at 1.6×10^6 coccospheres/m^2/day in mid- November, and maximum coccolith fluxes in November-December at 6.6×10^7/m^2/day, one months after peak mass fluxes. *E. huxleyi* was most abundant in the beginning of the spring bloom in March-April 1991, while maximum mass and biogenic silica fluxes were found in June. Peak coccolith and coccosphere fluxes were reached at respectively 3.7×10^7 and 1.2×10^4/m^2/day, respectively. The time weighted mean daily fluxes of all species at 258 m depth were 1.6×10^7 coccoliths/m^2/day and 2.5×10^5 coccospheres/m^2/day. The coccolithophore export production at 1061 m depth was not correlated to that at 258 m.

Due to carbonate dissolution at greater depth *E. huxleyi* was almost absent and *C. pelagicus* showed a decrease in fluxes, while the percentage of corroded specimens increased dramatically. C. pelagicus showed two peaks at 1061 m, in January-February 1991, and in April-May 1991, with maximum coccolith and coccosphere fluxes of 1.3×10^7 and 1.8×10^5. Time weighted mean fluxes at 1061 m were 2.2×10^6 coccoliths and 2.1×10^4 coccospheres/m^2/day. To determine coccolithophore contribution to the total $CaCO_3$ flux, the carbonate flux in the fine fraction (<32 μm) was measured. Time weighted mean $CaCO_3$ fluxes in the fine fraction decreased from 4.0 mg/m^2/day at 258 m to 2.6 mg/m^2/day at 1061m, contributing 14 and 10%, respectively to the total carbonate flux. The fine fraction carbonate fluxes included coccolithophore-$CaCO_3$, but also other carbonate sources (biogenic and detrital) were contributing significantly.

Phytoplankton Dynamics and Environmental Cycles in the Late Jurassic Kimmeridge Clay - Preliminary Results

Jackie A. Burnett[1], Paul R. Bown[1], Jeremy R.Young[2] and Jim B. Riding[3]

[1] Dept. of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, UK. E-mail: j.burnett@ucl.ac.uk; p.bown@ucl.ac.uk

[2] Palaeontology Dept., The Natural History Museum, Cromwell Road, London, SW7 5BD, UK. E-mail: jy@nhm.ac.uk

[3] British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.

The preliminary results of our study of virtually monogeneric nannofossil assemblages, in tandem with dinoflagellate assemblages, from the Kimmeridge Clay Formation (KCF) of England will be presented. The KCF is an unusual sedimentary package, comprising mostly mudstones which contain variably preserved nannofossil assemblages, but including three episodes of concentrated, laminated coccolith sedimentation: the so-called white stone bands. The nannofloras in the limestone laminations of the white stone bands are extremely well-preserved, including coccospheres of delicate taxa such as Polypodorhabdus, Truncatoscaphus and Stradnerlithus, among the almost overwhelming numbers of Watznaueria coccospheres. The dark laminations are Corg-rich mudstones and almost devoid of coccoliths, although imprints of Watznaueria's can be seen on some bedding surfaces.

The study of the KCF is multilayered, and forms part of a wider project which will incorporate geochemical and sedimentary analyses and which aims to provide an overall environmental model of the formation. The virtually monogeneric nature of the KCF means that it has a low biostratigraphic resolution compared to the same interval elsewhere. Relative abundance and biometric studies of the Watznaueria species has allowed us to improve this situation, as well as make some comments on the palaeobiogeography of the region, and these results will be presented. The enigmatic nature of the light/dark laminations, representing a switch from coccolith to dinoflagellate dominance in the water-column, is the current focus of our investigation. The timing of these switches is presently unknown but could represent seasonal blooms. There is also an indication of Milankovitch cyclicity in the sequence.

(Cocco)liths *versus* (cocco)spheres: a method to approach the ecology and the biostratonomy of Coccolithophores

M. Cachão[1] and A. Oliveira[2]

[1] Dep. Geology Faculty Sciences Univ. Lisbon, Rua Escola Politécnica, nº 58, P-1294 Lisboa Codex, PORTUGAL. E-mail: mcachao@fc.ul.pt
[2] JNICT, Univ. Algarve / Portuguese Navy Hidrog. Institute, Rua das Trinas, nº 49, P-1200 Lisboa, PORTUGAL

Most of the micropaleontological oriented works performed upon coccolithophore communities developing on the upper layers of the water column routinely include the counting of coccospheres (here after referred to as spheres, for simplicity) and heterococcoliths (here after simply referred as liths) both structures found in the same filters. Subsequently, the coccolith data is either forgotten or converted to coccospheres by defining, species by species, a certain and constant number of coccoliths per cell (coccosphere). By doing so a significative (and probably very important) part of the information may be eliminated not to mention introducing an additional error source for our data.

In most of the biological research developing upon phytoplankton in general and coccolithophores in particular an important aspect is to recognize when a particular species is blooming, in a steady developing state or in a decaying process. But how to access this type of questions if most of the data is gathered along sections in which a station is rarely sampled twice, or at least within a time interval of the same order of magnitude of the developmental process of these microalga ?

Coccolithophores have the particular feature of producing so many complex structures (the liths) which are released by the cells in certain conditions (growing, cell division or grazing processes). Due to their quite small dimensions (generally between 2 to 15 μm) and their resilient (calcite) nature, liths may persist for a while in the upper layers of the water column. In these circumstances, the amount of liths present in the water column, related to the number of cells, may be considered as an additional source of information. Some sort of "memory" of the system.

In the present work we decided to explore this approach. We kept coccolith distinct from coccosphere data and by means of simple lith versus sphere bivariate graphs and their linear (or not) correlations to tried to analyse distinct coccolithophore developing or decaying situations.

Our data was gathered offshore from Portugal where, during winters, an Iberian poleward slope current (the Portuguese Coastal Countercurrent - PCC) develops bringing northwards subtropical coccolithophore assemblages which normally dwell in waters south of the Azores Front (Cachão *et al.*, 1998). This data was subsequently used to produce a computer algorithm which simulates several possible situations.

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CODENET - An European Research Network to Study Cocolithophorids

M. Cachao [1]; J. Young [2]; H. Thierstein [3]; J. van Hinte [4];
C. Billard [5]; L. Medlin[6]; M. Estrada [7]; and, S. Damste [8]

[1] Museu Nacional de Historia Natural, University of LISBON, PORTUGAL; E-mail: mcachao@fc.ul.pt
[2] Paleontology Department, The Natural History Museum, LONDON, ENGLAND; E-mail: jy@nhm.ac.uk
[3] Geological Institute, Swiss Federal Inst.Technology, ZURICH, SWITZERLAND;
E-mail: thierstein@erdw.ethz.ch
[4] Earth Sciences Faculty, Free University of AMSTERDAM, NETHERLANDS; E-mail: hinj@geo.vu.nl
[5] Laboratoire Biol. Biotechn. Marines, Univ. Caen, BASSE-NORMANDIE, FRANCE;
E-mail: Billard@ibba.unicaen.fr
[6] Alfred-Wegener-Inst. Polar & Marine Research, BREMERHAVEN, GERMANY;
E-mail: lmedlin@awi-bremerhaven.de
[7] Instituto de Ciencias del Mar, Spanish Council for Scientific Research, BARCELONA, SPAIN;
E-mail: marta@icm.csic.es
[8] Netherlands Institute for Sea Reseach, NETHERLANDS; E-mail: daamste@nioz.nl

Coccolithophorid Evolutionary Biodiversity and Ecology Network (CODENET) is a recently created research network, funded by EC TMR program, bringing together eight first rate geological, marine biological, molecular genetic and organic geochemical research groups from seven European countries. Multidisciplinarity is essential for investigation of the open ocean primary production, global carbon, carbonate and sulphur cycles and to interpret global change in the geological record, with vital importance for marine biologists, biogeochemists and micropaleontologists.

Coccolithophorids are ideal for such study and since this potential has previously been exploited via research on the single species *Emiliania huxleyi*, we believe that to develop it further a broader taxonomic approach is desirable.

The CODENET research strategy is to take six species spanning the evolutionary diversity of coccolithophorids. They will be used to: (1) probe high level diversity in key aspects of its biology; (2) build a representative suite of case studies in species-level diversity and microevolutionary processes; (3) study their ecology, quantify their impact on the carbonate system and study the relationship between coccolithophorid evolution and global change through the last 20 Ma. To accomplish these goals a unique combination of experimental study of laboratory cultures with ecological and evolutionary studies based on plankton, sediment trap, and geological samples will be carried out.

In what concerns evolutionary diversity the CODENET objectives are: (1) to determine the major patterns of biodiversity in coccolithophorid life-cycles, biomarker composition, photosynthetic pigments, cytology and plastid genome; (2) to re-evaluate the phylogeny of the coccolithophorids using separate and combined analyses of molecular, genetic, morphological and biochemical data and compare this with the paleontological record of coccolithophorid evolution; (3) to calculate divergence times of groups and rates of evolution, including molecular clock calibrations; (4) to reconstruct the sequence of major evolutionary steps in coccolithogenesis, lipid biochemistry, plastid evolution, and life cycle differentiation.

To approach microevolution and species level variation the CODENET objectives are: (1) to evaluate which aspects of variation represent genotipic vs. ecophenotipic or ontogenetic variation; (2) to determine whether intra-specific variability in morphology, physiology and biochemistry are correlated, defining discrete sub-species; (3) to determine whether physiological adaptation occurs within local sub-populations independently of other genotypic characters; (4) to determine whether microevolution occurs by (sub)-species selection or effectively simpatric evolution within ocean-scale populations.

To access coccolithophorid ecology CODENET objectives are: (1) to determine whether coccolithophorids as a group occupy a distinctive ecological niche, and if so characterise it; (2) - to determine which aspects of intra- or inter-specific assemblage variation are most valuable for palaeoecological calibrations and develop palaeoecological proxies; (3) to determine the extend to which coccolithophorid carbonate accumulation rate is affected by species composition and evolution.

We hope this comprehensive interdisciplinary study will afford a major breakthrough in understanding the evolution and ecology of coccolithophorids and the role they play in structuring biodiversity and processes in the modern ocean and in the past.

Biostratigraphy of Zanclian Deposits in Periadriatic Depression (Western Albania), Based on Calcareous Nannofossils

L. Cobaj[1], Xh Islami[2] and Sh. Cobaj[1]

[1] Oil and Gas Institute, Fier, ALBANIA
[2] Alpetrol, Fier, ALBANIA

The Pliocene deposits have a large distribution in Preadriatic Depression. They are represented by Helmesi and Rrogozhina formations. The first one is dominate by clays with silts and sandstone intercalations. Rrogozhina formation is composed by massive sandstones and conglomerates. The deposits of Currila and Kavaja sections (Western Albania) are analyzed in this study. The abundance, diversity of nannoflora, the presence and/or absence of some index species such as *T. rugosus, C. acutus, D. quinqueramus*, etc. permit us to make some conclusions. In terms of Okada and Bukry (1980) the following zones and subzones, *A. tricorniculatus* (CN10), *T. rugosus* (CN10/a), *C. acutus* (CN10/b) and *C. rugosus* (CN10/c) are determined. The scarcity of *D. quinqueramus* in the upper part of the late Miocene makes it rather difficult to define the Miocene-Pliocene boundary. The representatives of *Ceratolithus* are rare, also. The quantity of *Discoaster* fluctuates with climatic changes. An impoverishment of assemblages toward the top of the Zanclian deposits is evident. Above all this phenomenon is observed in Kavaja section where the sandstones and conglomerated are present. In order to make a correlation between nannofossils and forams the samples have been observed. Both data have helped to give a fine biostratigraphy.

Calcareous Nannofossil Age-Constrains of Anoxic Pliensbachian Deposits from the Cuenca Vasco-Cantábrica (Spain)

María José Comas-Rengifo[1] and Nicola Perilli[2]

[1] Departamento de Paleontología, Universidad Complutense de MADRID, SPAIN
[2] Dipartimento di Scienze della Terra, PISA, ITALY. E- mail: perilli@dst.unipi.it

This work deals with ammonite and calcareous nannofossil integrated biostratigraphy on two anoxic Pliensbachian intervals well-exposed in the western sector of the Cuenca Vasco-Cantábrica (northern Spain). The study sections (San Andrés, Camino and Tudanca) are located in the Santander Province of the Cantabria Community.

The sampled carbonate ramp deposits consist of marlstones, marly limestones and limestones with intercalation of black organic-rich laminated marly and silty claystones. These deposits provide age-diagnostic ammonite assemblages, that allow us to recognize Jamesoni, Ibex, Davoei, Stokesi, Margaritatus and Spinatum Zones. The anoxic events, with TOC values ranging from 1.48 to 11.80, are Carixian (Ibex Zone) and Domerian (Margaritatus Zone) in age.

The calcareous nannofossil biostratigraphy is based on more than 100 closely-spaced samples, mainly collected from marlstones and marly limestones. Semiquantitative analysis was performed with a light polarizing microscope. The total abundance of nannofossil assemblages ranges from rare to few/common and preservation from poor to moderate. The ammonite and calcareous nannofossil biohorizons identified allow to correlate these organic-rich deposits to the coeval ones from both Boreal and Tethyan Domains.

Coccolithophore Ecology at the Time-Series Station ALOHA, Hawaii

Mara Cortés and Hans R. Thierstein

Geological Institute, ETH-Zentrum, CH-8092 ZURICH, SWITZERLAND
E-mails: mara@erdw.ethz.ch; thierstein@erdw.ethz.ch

Cell densities of total coccolithophores and main taxa were determined in 127 samples from the upper 200m at about monthly intervals between January 1994 and November 1995 at the time-series station ALOHA, Hawaii. The generally low, but seasonally dynamic coccolithophore cell density variability is compared with in-situ measurements of environmental parameters.

A principal components analysis to test for covariance among environmental parameters separated the data set (limited to the 79 samples with statistically significant cell densities) into two groups, representing samples from the upper and lower photic zones. Correlation analyses between cell density variability of the five dominant taxa and potentially controlling environmental parameters in these separate data sets showed significant improvement of correlation coefficients compared to analyses for the entire photic zone.

In the upper photic zone the cell densities of all dominant taxa are most highly correlated with temperature variability (Pearson product-moment correlation $r>|0.6|$), *E. huxleyi* and *U. tenuis* negatively and *U. irregularis* and small gephyrocapsids positively. Multiple regression analyses increased these correlations by about 10% for *E. huxleyi* with the addition of phospate and for *U. irregularis* with the addition of light (PAR).

F. profunda cell densities are highly negatively correlated with light ($r=-0.76$) and positively correlated with nitrates ($r=0.65$), which corresponds to the maximum bottom-up control (i.e. by physical forcing) of any species encountered.

The surprisingly low correlations of cell densities with nitrate and phosphate may be caused by insufficient sampling resolution, nutrient levels close to detection limits, or both.

A comparison of the optima of all encountered taxa indicates that they occupy the multivariate environmental space continuously but in a consistent sequence.

Variety of Exothecal Coccoliths of *Syracosphaera*

Lluïsa Cros

Institut de Ciències del Mar (CSIC), Passeig Joan de Borbó s/n, 08039 BARCELONA, SPAIN.
E-mail: lluisa@icm.csic.es

The characteristic coccoliths of the genus *Syracosphaera* are the caneoliths; they constitute the monothecate coccolith cases and the endotheca of the dithecate coccospheres of this genus (Jordan et al. 1995). Frequently these coccoliths show little differences between species, sometimes it is even difficult to distinguish them clearly. However, the exothecal coccoliths present a high morphological variety and has different patterns of distribution on the endotheca; even the name "deviating coccoliths" (Heimdal & Gaarder, 1981; Jordan et al., 1995) is applie to one kind of coccolith distribution only, around the apical pole. Furthermore the frequency of exothecal coccoliths is variable. In some species they rarely occur and sometimes never. This study shows for the first time eight instances of exothecal coccoliths not recognized before; some of them are cyrtoliths, but some are clearly caneoliths (for terminology see Braarud et al. 1955; Heimdal, 1993 and Jordan et al. 1995). Moreover, a tentative classification of the exothecal coccoliths of the Syracosphaera species found in the NW Mediterranean is presented. Those different exothecal coccolith morphologies and distributions may be related to the phylogenetic proximity between the *Syracosphaera* species.

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New Examples of Holococcolith-Heterococcolith Combination Cells and Their Implications for Coccolithophorid Phylogeny

Lluïsa Cros[1], Annelies Kleijne[2], and Jeremy R. Young[3]

[1] Institut de Ciències del Mar (CSIC), Passeig Joan de Borbó s/n., 08039 BARCELONA, SPAIN.
Email: lluisa@icm.csic.es
[2] Earth Sciences, Amsterdam Free University, 1081HV AMSTERDAM, THE NETHERLANDS.
[3] Palaeontology Dept., The Natural History Museum, LONDON SW7 5BD, UK. E-mail: jy@nhm.ac.uk

Combination cells can provide invaluable clues to life cycle transitions within coccolithophorids. As described by Thomsen et al. (1991), these are cells with composite coccospheres including two partial layers of coccoliths which normally occur on separate coccospheres. Three new examples of combination cells bearing both heterococcoliths and holococcoliths have recently been observed during study of samples from the NW Mediterranean and are presented here for the first time. The cells comprise: *Syracosphaera anthos* (Lohmann) Janin with *Periphyllophora mirabilis* (Schiller) Kamptner, *Helicosphaera carteri* (Wallich) Kamptner with *Syracolithus catilliferus* (Kamptner) Deflandre and *Syracosphaera sp.* type K Kleijne (1993) with *Corisphaera sp.* type A Kleijne (1991). Two further combination cell types previously reported have been observed again: *Coronosphaera mediterranea* with *Calyptrolithina wettsteinii*, found previously by Kamptner (1941); and *Syracosphaera sp.* type A with heterococcoliths and holococcoliths, found previously by Kleijne (1991). *Helicosphaera carteri*, which has been selected as a key species in the CODENET network, and *Syracolithus catilliferus* are sufficiently abundant in the NW Mediterranean samples, to have reliable data on their distribution in the water column.

Usually these monomorphic species co-occurred at the same stations, with *S. catilliferus* closer to the surface (0-20 m.) and *H. carteri* below 30 m. depth. It is likely that the holo-heterococcolith combination cells represent a transition between two different stages in the same life-cycle and so the different distributions in the water column of the involved "species" are likely to be an expression of the ecological strategy of the some coccolithophorids. In addition the association recently presented by Alcober and Jordan (1997) involving the heterococcolithophorid, Neosphaera coccolithomorpha Lecal-Schlauder with the nannolith bearing species *Ceratolithus cristatus* Kamptner, was found. There was no obvious ecological separation between these species, they usually co-occurred in the same stations but both in the surface water samples. Previously holo-heterococcolith combination cells were only well documented from the Coccolithaceae and Pappospheraceae. Our results confirm previous tentative observations of combination cells in the Syracosphaeraceae and for the first time document them in the Helicosphaeraceae (order Zygodiscales). As a result it now becomes reasonable to predict that this is a widespread pattern in coccolithophorids, with heterococcoliths occurring on diploid phases and holococcoliths on haploid phases (see also Billard, 1994; Young and Bown, 1997). The modern nannoflora include about 50 holococcolithophorid species and 40 species of Zygodiscales and Syracosphaerales, simple life-cycle pairing of these species is a likely outcome of future research.

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Calcareous Nannoplankton Dominance Shifts of the Plio-Pleistocene: Global Significance and Implications for Biostratigraphy

Richard A. Denne

Applied Biostratigraphix, 2 Treescape Circle, The Woodlands, TEXAS, USA 77381.
E-mail: RichDenne@aol.com

Due to the relatively low number of genera and species of calcareous nannoplankton, extinction theorists have generally relegated their Plio-Pleistocene extinction patterns to being merely "background extinctions". Quantitative examination of material from the Gulf of Mexico and Caribbean areas, however, indicates that a series of rapid assemblage turnovers during the Plio-Pleistocene caused the dominant Miocene genera (comprising up to 95% of the nannoflora) to become either extinct or extremely rare. It was also found that the dominant genera of the Pleistocene (comprising up to 99% of the nannoflora) evolved during the Plio-Pleistocene.

Six genera dominated the upper Miocene calcareous nannoplankton assemblage. *Reticulofenestra* was found to be the most dominant genus from the lower Miocene until the upper Pliocene, comprising from 40 – 80% of the nannoplankton assemblage. Other common upper Miocene genera include *Dictyococcites* (up to 40%), *Sphenolithus* (up to 15%), *Discoaster* (up to 10%), *Helicosphaera*, and *Calcidiscus* (both under 5%).

The Pliocene is characterized by a series of generic abundance changes, as opposed to the stability of the upper Miocene. *Sphenolithus* dropped precipitously in abundance during the lower Pliocene (NN14), and became extinct by the upper Pliocene (NN16). *Discoaster*, a genus common throughout most of the Tertiary decreased in abundance during the upper Miocene (NN11) and again in the upper Pliocene (NN16), and was extinct by the end of the Pliocene (NN18). *Reticulofenestra* nearly doubled in abundance above the Plio-Miocene boundary (NN12), and remained abundant throughout most of the Pliocene. However, near the top of the Pliocene (NN16) the genus nearly went extinct, being reduced to very rare occurrences in the Pleistocene. This is also true for *Dictyococcites*, which became very rare after the middle Pliocene (NN15).

Four genera were found to be dominant during the Pleistocene. Both *Pseudoemiliania* and *Gephyrocapsa* evolved during the middle Pliocene (NN15) and rapidly became common. During the lower Pleistocene (NN19) *Pseudoemiliania* comprised up to 35% of the calcareous nannoflora assemblage, but dropped rapidly in abundance in the middle of this zone and was extinct by its end. *Gephyrocapsa* became the dominant genus (40 – 99%) during the upper Pliocene (NN16), and remained so until the uppermost Pleistocene (NN21), when the recently evolved genus *Emiliania* became dominant (up to 80% of the assemblage). *Helicosphaera* comprised approximately 5% of the assemblage during the lower Pleistocene, but dropped to only 1% by the middle Pleistocene.

As many of the Plio-Pleistocene dominance shifts occurred over a very short period of time, they represent extremely useful biostratigraphic horizons. When taken to the species level, as many as 16 abundance shifts are found within the dominant genera of the Plio-Pleistocene, a significant increase over the nine horizons derived from first and last occurrences.

Biosteering on 'Mars' - Reducing Uncertainties of Horizontal Drilling

Alvin DuVernay

Mississippi Canyon Block 807 #A-1 ST, Gulf of Mexico - USA
E-mail: alduv@shellus.com.

Biosteering is a geosteering tool for adjusting well track orientation while horizontal drilling. It reduces uncertainties of other enabling technologies by utilizing real-time biostratigraphic interpretation. Discrimination of specific sands and shales is achieved by the continuous analyses of ditch cuttings.

Biosteering is a proven technology by Shell and other international Companies but is rarely utilized by Gulf of Mexico operators. Deposition rates are perceived to be too rapid for the development of unique reproducible paleontologic signals within reservoir seal pairs. Successful biosteering of the Pink sand horizontal well (MC 807 #A-1 ST, Shell USA GOM) at Shell's Mars Field was facilitated by creating and rigorously implementing a feasibility study. Ample lead time, high resolution biostratigraphy on multiple control wells and a robust sampling program of conventional core through the reservoir and bounding shales were key success factors to this study.

The Mars Pink interval (including bounding shales) was deposited in approximately 600,000 yrs. The Pink sand is interpreted to be a lowstand depositional event between the NPM 4 maximum flooding surface (LAD *D.challengeri, E. Zanclian*) and the NPM 4.3 lowstand system tract (LAD *D.bergrennii, L. Messinian*). Real-time determination of the bottom hole assembly position was established by on-site nannofossil sample exam and interpretation of these system tract fossil assemblages.

The Virtual Paleontologist, or: Children as Real Paleontologists

Yoram Eshet

Geological Survey of Israel, 30 Malkhei Israel St., JERUSALEM, 95501, ISRAEL
E-mail: yoram@mail.gsi.gov.il

Paleontology can be best described as a discipline of science, in which fossil evidence is collected, identified, analyzed, and interpreted in order to build models that reconstruct the world as it was in ancient times. We know from our work how complex this process, of data collection, analysis and reconstruction can be. But, could you believe that a small elementary-school kid can fill the boots of a paleontologist, and come up with high-level reconstructions of the ancient world, that are not much different than yours - the "big" paleontologist? Well, if you still doubt it, Message In A Fossil may just convince you. Message in A Fossil is an educational multimedia simulation for elementary-school students, that was developed under the author's scientific supervision. The aim of the program is to allow students to play the "real"role of a paleontologist and experience the methods of data collection, analysis, and synthesis that scientists use in scientific investigations. In the program, the students dig in a virtual paleontological excavation and discover fossils. They use an on-line fossil reference collection to identify and interpret their finds. The students even put together broken fossils and reconstruct complete skeletons.

At the end of their investigation, the students build a museum-diorama of the ancient habitat that matches the evidence they found. Many schools in the United States are currently using this program as part of their earth science and life science curriculum. It is currently used by schools in Texas as part of an innovative curriculum or as a component of a thematically-based curriculum.

Paleocene Calcareous Nannofossil Biostratigraphy in Israel - Preliminary Results

Yoram Eshet and S. Moshkovitz

Geological Survey of Israel, 30 Malkhei Israel St., JERUSALEM, 95501, ISRAEL
E-mail: yoram@mail.gsi.gov.il

The Paleocene sequence of Israel is composed of about 70 meters of marls and chalks that were deposited in hemipelagic environments. The calcareous nannofossils biostratigraphy of these sequences is investigated as part of a multidisciplinary correlation study of the Paleocene in Israel. The present paper includes the preliminary calcareous nannofossil zonation and correlation for the Maastrichtian to Early Eocene. Except for minor modifications, the nannofossil zonation scheme of Martini (1971) was found applicable in the Israeli sections. The following nannofossil zonation was defined: 1. *Micula prinsii* Zone (latest Cretaceous): The interval from the First Occurrence (FO) of *M. prinsii* to the FO of abundant acme of small *Biscutum* spp. 2. *Markalius inversus* Zone - NP1 (Early Paleocene): The lower zonal boundary is placed according to the first bloom of an assemblage dominated by small *Biscutum* species, as *B. romeinii* and *B. parvulum*, that form an acme slightly above the K-T boundary, and are considered to be the earliest Paleocene markers (Perch-Nielsen, 1985). The FO of the Paleocene Cruciplacolithus primus occurs slightly above the *Biscutum* acme. The top of the zone is determined by the FO of *Cruciplacolithus tenuis*. Cretaceous forms continue to be prominent in this zone, a phenomenon which is well known from most K-T boundary sections worldwide. 3. *Cruciplacolithus tenuis* Zone - NP2 (Early Paleocene): From the FO of *C. tenuis* to the FO of *Cruciplacolithus danicus*. 4. *Cruciplacolithus danicus* Zone - NP 3 (Early Paleocene): from the FO of *C. danicus* to the FO of *Ellipsolithus macellus*. 5. *Ellipsolithus macellus* Zone - NP 4 (Early Paleocene): From the FO of *E. macellus* to the FO of *Fasciculithus tympaniformis*. Cretaceous forms disappear almost completely from this zone and upwards. 6. *Fasciculithus tympaniformis* Zone - NP 5 (Late Paleocene): From the FO of *F. tympaniformis* to the FO of *Heliolithus kleinpelli*. The first occurrence of the genus *Discoaster* occurs at the top of this zone, with the FO of a multi-rayed taxon, tentatively named here *Discoaster* sp. A, which has about 40 rays. 7. *Heliolithus kleinpellii* Zone - NP 6 (Late Paleocene): From the FO of *H. kleinpellii* to the FO of *Discoaster mohleri*. 8. *Discoaster mohleri* Zone - NP 7 (Late Paleocene): From the FO of *D. mohleri* to the FO of *Heliolithus riedelii*. Since H. riedelii is missing in the studied sections, NP 7 and NP 8 were combined into a NP 7-8 Zone, from the FO of *D. mohleri* to the FO of *D. multiradiatus*. 9. *Heliolithus riedelii* Zone - NP 8 (Late Paleocene): From the FO of *H. riedelii* to the FO of *Discoaster multiradiatus*. Because *H. riedelii* is missing in the present study we combined NP 7 and NP 8 into a NP7-8 interval, as done by most authors who faced the same problem. 10. *Discoaster multiradiatus* Zone - NP 9 (Late Paleocene): From the FO of *D. multiradiatus* to the FO of *Tribrachiatus bramlettei*. In the transition from NP 7-8 to NP 9, *Discoasters* reduce the number of rays from about 40 (*Discoaster* type A) to about 18-30 rays. This change marks a world-wide ray-reduction trend (Moshkovitz, 1967; Romein, 1979; Wei and Wise, 1989) that continues well into the Early Eocene. 11. *Tribrachiatus contortus* Zone - NP 10 (latest Paleocene-Early Eocene): From the FO of *Tribrachiatus bramlettei* to the LO of *Tribrachiatus contortus*. The Paleocene-Eocene boundary is drawn within the lower part of NP 10, at the top of the planktic foraminifera *Morozovella velascoensis* Zone (P6a). The FO of T. contortus is found close to the top of NP 10. In some of the sections, the LO of *T. contortus* could not be defined with certainty, and the FO of *Tribrachiatus orthostylus* Type B was used to mark the top of the zone, following Perch-Nielsen, 1985). *T. orthostylus* Type A first appears slightly below the FO of *T. orthostylus* Type B, within NP 10. 12. *Tribrachiatus binodosus* Zone - NP 11 (Early Eocene): From the LO of *T. contortus* to the FO of *Discoaster lodoensis*. In the present study, the FO of *T. orthostylus* Type B was found useful to determine the base of the zone.

Palaeoceanological Reconstruction of the Late Quaternary Agulhas Current (South Atlantic) Based on Calcareous and Organic Walled Dinoflagellate Cysts

Oliver Esper, Karin Zonneveld and Helmut Willems

Fachbereich 5 - Geowissenschaften, Universität Bremen, Postfach 33 04 40, 28334 BREMEN, GERMANY
E-mails: esper@zfn.uni-bremen.de; willems@micropal.uni-bremen.de

In the last decades it has become apparent that climatic change is greatly influenced by changes in the global ocean current systems. One of the most important systems is the thermohaline circulation of the Atlantic Ocean, which transports cold, higher saline water from the northern Atlantic to the southern hemisphere and in return transports warmer water of the South Atlantic to the north, positively influencing the northern continental climate. To understand the fluctuations in the heat flux through glacial/interglacial changes in the Late Quaternary, it is necessary to study several key areas. One of such areas is the eastern South Atlantic, where warmer Indian Ocean water is carried around the cape of South Africa through the Agulhas Current into the Atlantic Ocean. The aim of the present study is to reconstruct the palaeoceanology of this region.

Changes in ocean currents can be detected through the analysis of different constituents of the seafloor sediments. One useful tool are dinoflagellate cysts. These micro-organisms possess a life cycle with a planktonic thecate stage, sensitive to environmental parameters like water temperature, salinity, and nutrient supply, and a corresponding resting cyst stage. Depending on the species, there are two different groups of fossilisable dinoflagellate cysts (dinocysts) distinguishable through the nature of their wall material: organic walled and calcareous dinocysts.

In this study, an approach is made to correlate and compare results of the analysis of organic walled dinocyst assemblages with calcareous walled dinocyst assemblages and the calcareous vegetative stage of *Thoracosphaera heimii*. Samples are taken from sediments of core GeoB 3603-2 located in the southern Cape Basin offshore South Africa, and cover the time interval from oxygen isotope stage 6 (150.000y BP) to the Recent, thereby including the last three deglaciations. The results are used to reconstruct the palaeoenvironment and palaeoceanography of the Agulhas Current during glacial and interglacial times in order to gain more knowledge on the role of the thermohaline circulation on global climatic change.

Trade-Wind Effect in the Sea Surface dynamic Off West-Africa (5°N) During the Last Climatic Cycle

J.A. Flores, M.A. Bárcena, and J.F. Sierro

Dpto. Geología. Fac. Ciencias. Universidad de Salamanca. 37008- SALAMANCA, SPAIN
E-mail: flores@rs6000.usal.es

The Camel-1 gravity core was recovered during the CAMEL-93 BIO Hesperides cruise (Mid-oceanic Equatorial Canyon-93) in Sierra Leone Rise (Equatorial Atlantic) at 5°6'25S/21°2'36W. Water depth at the core location is 2686 m. The total length of Camel-1 is 446 cm. The stratigraphic control, based on the $\delta^{18}O$ record of the planktic foraminifer *Globigerinoides ruber*, as well as with the $CaCO_3$ content and weight percentage of those foraminifers < 63 μm, allowed the identification of isotopic stages (IS) 6 to 1, in the uppermost 160 cm of the core. Additional stratigraphic control data were obtained from the nannofossil record. Two reversals between *E. huxleyi* and medium sized *Gephyrocapsa* (MG) were observed at 83 and 40 cm core depth, and dated at 80,000 and 40,000 years respectively.

Freshwater diatoms (*Aulacosira* sp.) in eolian sediments come from erosion of diatomaceous deposits in dry lake beds, while opal phytoliths are injected into the atmosphere by fires and wind storms during dry seasons. IS's 6, 5.4/5.3, 4 and 2 have been interpreted as arid periods, with desiccation of lakes and a migration of the grass belt bordering the western Sahara. The maximum in opal phytoliths at the IS 3 has been interpreted as an intense humid period, with higher grass-brush biomass which develops during the raining seasons.

At the core location of Camel-1, surface waters are mesotrophic. Under this conditions, coccolithophorids are the most important primary producers. The dominant taxa is *F. profunda* (75 to 95 %). This coccolithophorid is related with a deep nutricline and therefore with low nutrient concentration at the surface. During IS 6, 5.4, 5.2, 4 and 2, minimum values of *F. profunda* were recorded and related with a shallower nutricline position. If during glacial episodes, the a trade-winds were intensified, it were insufficient to break at all the water column stability.

Other taxa, such as MG, *Helicosphaera* spp., *Syracosphaera* spp., *C. leptoporus* show a similar trend than the $\delta^{18}O$ curve.

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Sea Surface Dynamics and Paleomonsoon Variability in the South China Sea for the last 140,000 years

José-Abel Flores[1], F. Javier Sierro[1], Carles Pelejero[2], Joan Grimalt[2], Luejiang Wang[3] and Michael Sarnthein[3]

[1] Universidad de SALAMANCA. SPAIN. Email: flores@rs6000.usal.es
[2] CSIC. BARCELONA. CATALONIA. SPAIN.
[3] University of KIEL. GERMANY

The South China Sea (SCS) is a marginal sea with a climate and hydrography mainly affected by monsoon activity and sea level changes. Here we report Coccolithophores and molecular records from core 17961-2 (8°30.4' N/ 112°19.9'E, 1968 m depth) obtained during the R/V SONNE cruise in April-June 1994 (Sarnthein et al., 1994).

Core 17961-2 is located on a plateau in front of the Sunda shelf, an area affected during glacial periods by fluvial sediment discharge of the Molengraaff/Paleo-Sunda River. This river entered the SCS north of Western Borneo. A detailed study based on molecular biomarkers was already presented by Pelejero et. al (1996).

Combined $\delta^{18}O$ data from the planktic foraminifera *Globigerinoides ruber* and AMS radiocarbon ages provide a precise age control. Regarding the coccolithophore record, the bottom of the *Emiliania huxleyi* acme is placed at about 85 ky B.P. An increase in the relative abundance of *E. huxleyi* is observed near 30 ky B.P. Below 100 ky a drastic increase in the *Gephyrocapsa* < 3μm is observed. The interval between 40 and 7 ky B.P. is characterized by an increase in the abundance of *Emiliania* > 4.5 μm. The near-bottom section of the core is compacted by the core technique with the consequent reduction in the sedimentation rate.

Sea Surface Temperature (SST) values were obtained using the relative composition of di- and triunsaturated C_{37} alkenones, the U^{k}_{37} index, and the calibration recently established for the South China Sea (Pelejero and Grimalt, 1997). For comparison, we also plotted SST obtained with the commonly used calibration derived by Prahl and Wakeham, 1987, which only leads minor differences (0.2°C at the most). The SST profiles follow a typical glacial-to-interglacial pattern, with a 2.5°C difference between today and the Last Glacial Maximum (LGM). This difference is larger than that reported for the low-latitude open Pacific, showing a different record of this marginal sea with respect to the open ocean at the same latitudes. The SST estimates for stage 5e are relatively high (28.8°C) as compared to modern temperature estimates of 27.7°C, which approximately match the actual annually averaged SST value measured in this region. Hence we infer a 1.1°C warming of stage 5e versus Holocene. The warmer episodes, when dilution by fluvial mud has been low, are characterized by high concentrations of (total) coccolithophores and good preservation. This is especially significant during stages 1 and 3. Stages 5c and 5e show less significant peaks. Minimum values of coccolithophores are observed during stages 2 and 4. The general trend of % $CaCO_3$ parallels the coccolithophore concentrations.

Florisphaera profunda show a reduction in their proportion during stages 2, between stages 5a and 5b, and during 5d. Differences in SST between IS 1, 3, 4 and 5 suggests that the *F.*

profunda dynamics are mainly linked to the nutricline stability rather than to other factors. This is most evident comparing the lower photic layer inhabitants with the upper and medium photic layer inhabitants (excluding in both groups those species that are not exclusive of one of the layers). According with these data, stages 2, 4, 5b and 5c were characterized by a shallower nutricline, with a higher vertical mixing in the water column.

Sarnthein et al (1996) ascribed the $\delta^{18}O$ minima at 300 and 450 cm to low-salinity events for time periods corresponding close the Heinrich events H3 and H4. A further important peak occurs near 40 ky These low salinity events are linked to maxima in *Syracosphaera* spp. *D. tubifera* and *G. oceanica.* Other species, such as *N. coccolithomorpha*, seem to show an opposite pattern.

Concentrations (ng/g) of terrestrially derived nonacosane and hexacosan-1-ol are also presented. These profiles show a high sensitivity of the South China Sea to the influence of continental waters, tracing the probable inundation of the Sunda Shelf around 12-13 cal kyr B.P. This catastrophic event parallels an abrupt increase in *F. profunda* abundances, probably reflecting a change from shallow to deep nutricline, and/or an increase in turbidity.

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Biostratigraphic and Paleoceanographic Significance of the Late Middle Miocene - Early Pliocene Calcareous Nannofossils from the Coast of the Sea of Japan, Northeast Japan

Kazue Fukasawa[1] and Chikara Hiramatsu[2]

JAPEX Research Center, 1 - 2 - 1, Hamada, Mihama-ku, Chiba, JAPAN, 261
E-mail: kazue@rc.japex.co.jp Phone:+81-43-275-9311Fax:+81-43-275-9316

The Sea of Japan located between the Asian Continent and Japanese Islands, is thought to have appeared during late Oligocene to early Miocene, and has developed as a back-arc basin of Japan. From late Middle Miocene to early Pliocene, the calcareous microfossils are extremely rare in the coast of the Sea of Japan because of it's own characteristic environment ; stagnant and quiet waters. Therefore, it is difficult to apply the standard Neogene nannofossil zones (Okada and Bukry, 1980) to that region.

In order to contribute to the further understanding of the Neogene calcareous nannofossil occurrence, marine sediments in the coast of the Sea of Japan were examined in detail. Four types of calcareous nannofossil assemblages were recognized. Supplementary biostratigraphic analyses of planktonic foraminifers, diatoms and radiolarians have been carried out. The integrated biostratigraphic studies allowed us to recognize, at least, the four calcareous nannofossil occurrence intervals which are correlative with CN5a-b, CN8, CN9 and CN10-11, respectively.

The marker species of CN9, *Discoaster quinqueramus* regarded as a warm water indicator, was recognized from Yamagata to Hokkaido(Okada, 1988). *Discoaster* species was also found for the CN8 and CN5a-b intervals as well. Moreover, tropical and warm water planktonic foraminifers were identified in the same samples assigned to the CN5a-b(Inoue, 1995) and CN10-11 intervals.

The planktonic foraminiferal fauna from the late Middle Miocene to early Pliocene in the coast of the Sea of Japan consists of cold water species in general(Matoba, 1984). But the above results suggest the intermittent warm water inflows to that region.

According to Barron and Baldauf (1990), the time intervals of CN5b-6 and CN8-9 were correlated with their Climatic Optima 2 and 3, respectively. Therefore, CN5a-b, CN8 and CN9 intervals in the Sea of Japan indicate that the inflows are possibly related to the global climatic changes. Additionally, the results are useful to the correlation of the late Middle Miocene to early Pliocene marine sediments of the coast of the Sea of Japan, in which correlative markers were few.

Further analyses of calcareous nannofossil in the region will become applicable data for more detailed correlation and reconstruction of paleoceanographic changes.

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Coccolith biometrics: A High Resolution Case Study in the Hauterivian (early Cretaceous) and Planned Work in the CODENET Project

Markus Geisen,[1] Jörg Mutterlose,[1] and Jeremy R. Young[2]

[1] Institut für Geologie, Ruhr-Universität Bochum, Universitätsstrasse 150, Bochum, FRG.
E-mail: marcus.geisen@ruhr-uni-bochum.de
[2] The Natural History Museum, Cromwell Road, London, GB. E-mail: jy@nhm.ac.uk

Coccolith morphology and morphological variation in the fossil record may provide signals of both evolutionary change and ecological control. Within the CODENET (Coccolithophorid Evolutionary Biodiversity and Ecology Network) the nature and interaction of these effects will be investigated for selected genera. A series of constrained case studies will include: (1) Study of culture populations from different strains of single species in combination with molecular genetic and physiological data on other aspects of variation; (2) study of culture samples from single strains grown under varying ecological conditions; (3) study of water column samples; (4) study of broad geological time series and (5) study of high resolution geological sample sets with well constrained independent evidence of ecological variation. In all cases morphological variation will be studied using image analysis based on morphometric techniques. This poster outlines the basic methodology to be employed and illustrates a directly comparable case study recently undertaken by the first author.

In order to investigate the intensity of ecological control on the morphology of *Watznaueria* coccoliths a high resolution study was carried out. The material is derived from a section in NW Germany (Frielingen clay-pit, NW Hannover), which exposes clay-marl bedding rhythms on the scale of Milankovitch cycles (Mutterlose & Ruffell 1997). 27 samples from a 2.7 m thick sequence, consisting of four clay-marl bedding rhythms, were examined. 60 coccoliths in each sample have been analyzed biometrically, using a light microscope and digital image capture techniques, in order to gain size and shape parameters. The following sediment geochemical data were also considered : $CaCO_3$, C_{org}, total carbon and sediment color.

Results

Despite the strong micropalaeontological, lithological and geochemical signals of ecological changes throughout the section, there is remarkably little variation in coccolith size and shape. Virtually all assemblages have mean coccolith lengths within the range of 5.5-6.2 microns. This suggests that the size distribution of *Watznaueria* is not strongly influenced by ecology, which reinforces the value of study of long term, evolutionary variability. Nonetheless when examined in detail some consistent morphological variation is detectable in the data set:

- In pale beds the range of measured lengths is greater than in dark beds.
- Pale beds show a dominance of coccoliths with a large outer shield.
- Compared to the dark beds pale beds show a dominance of mature (sensu Young & Bown 1991) and relatively large coccoliths.

These results seem to represent autecological variations in coccolith size and shape distribution, with a strong influence of variable ontogenetic development, and they appear to correlate with the sediment geochemical data.

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Comparison of theWatznaueria Genus Signal Recorded in Tethyan and Boreal Areas During the Middle and Upper Jurassic

F. Giraud[1], E. Mattioli[2], B. Pittet[3], F. Atrops[1] and B. Courtinat[1]

[1] Université Lyon I, Centre des Sciences de la Terre, UMR 5565, 27-43 boulevard du 11 novembre, 69622 VILLEURBANNE CEDEX, FRANCE

[2] Università degli Studi di Perugia, Dipartimento di Scienze della Terra, Piazza Università, 06100 PERUGIA, ITALY

[3] Université de Fribourg, Institut de géologie et paléontologie, Pérolles, CH-1700 FRIBOURG, SWITZERLAND

The Family of the Watznaueriaceae represents one of the most important planktonic carbonate producer in the Middle-Upper Jurassic sediments. The dominance of this Family over other coccoliths began at the Aalenian/Bajocian boundary, when Watznaueriaceae experienced a significant evolutive radiation. The Watznaueriaceae substituted at this stage the calcareous dinoflagellate cyst *Schizosphaerella* spp. as carbonate producer, while the abundance of *Schizosphaerella* spp sensibly decreased. This speciation is probably related to a crisis in the coccolithophorid community, as species diversity is overall low and the assemblages are worldwide dominated by the genus *Watznaueria*. As it is observed in Middle to Late Jurassic sections presenting variable lithotypes and located in different palaeogeographical domains, the dominance of *Watznaueria* spp. seems not to be a consequence of a selective diagenesis.

The Middle-Upper Jurassic limestone-marl alternations from several localities in south-eastern France, central Italy and southern Germany, are selected for study the space and time distribution of different species of the genus *Watznaueria*. The south-eastern France sections are on the Ardèche margin and in the Dauphiné basin. In central Italy, basinal sections close to a carbonate platform margin are studied. The southern Germany sections are located on a carbonate ramp. The location of the sections, from shelf to the basin, enable the spatial variation of the nannofloral assemblages to be compared. Stratigraphic control of the studied sections is based on ammonites biozonations and in south-east of France, integrated ammonites and dinoflagellates biostratigraphy.

In the studied sections the oligotypic assemblage is dominated by a half dozen of specimens of the genus *Watznaueria*. The most significant abundance fluctuations are observed for *W. barnesae*, *W. britannica* and *W. manivitae*. As these species are very diagenesis resistant, we believe their fluctuations reflect primary palaeoceanographic variations. Statistical analyses applied to the abundances and distributions of the most common species will allow the main factors influencing nannoplankton distribution during the Middle-Late Jurassic to be depicted, such as sea level fluctuations, changes in productivity of the oceans and more general global environment changes.

Community Structure of Living Coccolithophore in the Central and Western Pacific

Kyoko Hagino

Division of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University
North 10, West 8, Kita-ku, SAPPORO, 060 JAPAN.
E-mail: hagino@strati.sci.hokudai.ac.jp. Tel. +81 (0)11 716 2111 (ex. 3519)

Vertical distribution of coccolithophores was investigated at 17 stations in the central and western Pacific Ocean. A total of 146 taxa, including a new species, was identified from 139 water samples studied.

Many species exhibited vertically constrained distribution, and the floral composition was strongly controlled by the stratification of the water column. In the well stratified water column, the floral structure was stratified to three vertical zones. *Umbillicosphaera* spp., *Discosphaera tubifera*, *Rhabdosphaera clavigera*, *Umbellosphaera* spp. and many holococcolith-bearing species were the major components of the upper photic zone. *Emiliania huxleyi*, *Gephyrocapsa ericsonii* and *Gephyrocapsa oceanica* were common throughout the entire photic zone, but were particularly abundant at the thermocline, thus defining the middle photic zone. *Oolithos fragilis* that dwells in the middle to lower photic zone, was more concentrated in the thermocline. On the other hand, *Algirosphaera* spp., *Florisphaera profunda* and *Gladiolithus flabellatus* occurred exclusively below the thermocline. In the weekly stratified water column, the flora was divided into two vertical zones. *O. fragilis*, *E. huxleyi* and *G. oceanica* were abundant in the upper photic zone, and *F. profunda*, *Algirosphaera* spp. and *G. flabellatus* were constrained below the thermocline.

In the well mixed water column where no thermocline could be observed, the floral stratification was very weak, and some of lower-photic inhabitants occurred in the shallow depth (up to 30m).

Calcareous Nannoplankton Biostratigraphy of the Coast Basin of Togo, West Africa

Bohumil Hamrsmid[1] and Yawoa da Costa[2]

[1] CZECH REPUBLIC. E-mail: hamrsmid@mnd.cz
[2] TOGO.

The Coast Basin of Togo with the territory of 33.00km2 lies in the southern part of Togo (West Africa) and extends into the offshore part of the Atlantic. Calcareous nannoplankton assemblages from 10 wells drilled in the onshore part of the basin down to the depth of 160 m were analyzed for the first time. Despite of the frequent lack of markers and very bad preservation of nannofossils, three sedimentary cycles were clearly recognized., The oldest sediments contained *Arkhangelskiella cybiformis*, *Ceratolithoides aculeus* <90°, *Lithraphidites quadratus*... documenting their Maastrichtian age. Next transgression started in the Upper Paleocene (NP 7 - with *Discoster mohleri*, *Biantolithus sparsus*, *Cruciplacolithus frequens*, *Fasciculithus tympaniformis*, *Heliolithus cantabriae*, etc.) and continued till above the Paleocene/Eocene boundary (lower part of NP 10 - *Tribrachiatus bramlettei*, *Rhomboaster cuspis*, *Discoaster binodosus*, *Discoaster salisburgensis*...). The next transgression reached the area under study in the middle Eocene (NP 15 - *Nannotetrina cristata*, *Chiasmolithus gigas*, *Discoaster barbadiensis*, *Helicosphaera seminulum*...) and went on till the Middle/Upper Eocene boundary (NP 17/NP 18 - *Helicosphaera compacta*, *Reticulofenestra umbilicus*, *Helicosphaera reticulata*, *Cribrocentrum reticulatum*, *Discoaster saipanensis*...). The above laying sediments (mostly continental sands, sandstones and siltstones) were barren and their stratigraphical position has not been documented.

Coccolith Assemblages Along an E-W Transect North of the Canary Islands (29°N): Comparison Between Sediment, Sediment Trap and Plankton Samples

J. Henderiks[1], J. Bollmann[1], T. Freudenthal[2], H. Meggers[2], C. Sprengel[2], and H.R. Thierstein[1]

[1]Geological Institute, ETH-Zentrum, CH-8092 ZURICH, SWITZERLAND. E-mail: thiersten@erdw.ethz.ch
[2]Geoscience Department, University of Bremen, Postfach 330440, D-28334 BREMEN, GERMANY

Coccoliths, as a major component of carbon deposited in the North Atlantic Eastern Boundary Current system, are investigated to quantify fluxes and to reconstruct paleoceanographic and paleoclimatic changes in this area.

The quantitative changes in species composition of coccolith assemblages may be indicative of changes in temperature, surface water fertility and preservation. In the Eastern Boundary Current system, the major gradients of fertility, the gradient of temperature, and the possibly disturbing influence of carbonate dissolution will be investigated on a dispersed set of surface sediment assemblages. Preservational effects should be identifiable by a comparison with assemblages collected in sediment traps of the nearby ESTOC mooring and plankton standing stock studies. Downcore analyses of coccolith assemblages in 3 gravity cores (GeoB 4242, 29°40.5N, 17°53.3W; GeoB 4241, 29°10.0N, 15°27.2W; GeoB 4240, 28°53.3N, 13°13.5W) taken along a 500km long E-W transect north of the Canary Islands will be used to assess temporal and spatial changes of the crucial oceanographic parameters over the past 125ka. This will be attempted by population counts and morphometric measurements of keystone taxa. The morphometric measurements may reveal highly accurate temperature or fertility correlations, if they can be calibrated in plankton samples, which were taken seasonally at different depth levels.

Current results of abundance determinations of coccoliths in surface sediments reveal a general dominance of *Emiliania huxleyi*, followed by *Florispaera profunda*. The E-W fertility gradient is represented by changes in the morphology of the gephyrocapsid-group. Size and bridge angle increase towards the coastal area.

Assemblage compositions recorded in sediment traps at 976m water depth (ESTOC station; September 1994 - October 1995) are similar to the observations in the surface sediment below. *E. huxleyi* coccoliths dominate throughout the sample period, with a seasonal variability of the total fluxes.

The plankton samples analyzed so far, show seasonally highly variable compositions with perennial dominance of *G. ericsonii*, and seasonal fluctuations of *E. huxleyi* and *U. tenuis* in the upper photic zone (0-100m water depth), and *F. profunda* in the lower photic zone (100-200m water depth).

Cocolithophorids from the Subtropical Mexican Pacific (West Coast of Baja California, México)

David Uriel Hernández-Becerril, Y. Ramirez and E. Bravo-Sierra

Laboratorio de Ecologia de Pesquerias, Instituto del Mar y Limnologia (ICMyL)
UNAM, Apto. Postal 70-305, MEXICO. E-mail: duhb@hp.fciencias.unam.mx

Studies on coccolithophorids in Mexico are rather scarce, mainly due to lack of training in species identification, and the traditional methods for studying marine phytoplankton (e.g. collection, preservation and analysis). There are a couple of papers on floristics of this group, one made in the Gulf of Mexico and the other is a list of species from the Gulf of California. Bottle samples (4 lt.) were taken various depths, in perpendicular transects along the west coast of Baja, California and Magdalena Bay, Mexico, considering neritic, intermediate and oceanic zones. Environmental variables were measured, such as dissolved oxygen, temperature and pH. A total of 32 samples were studied by optical and scanning electron microscopy, yielding 20 species identified and another 4 taxa not fully identified. The coccolithophorid flora is typical tropical - subtropical. The highest richness of taxa was observed in intermediate and oceanic stations. *Gephyrocapsa* spp. Dominated in number at most stations. We report seven new records for the Mexican Pacific.

Variations in South Atlantic Calcdinoflagellate Associations Since the Late Cretaceous

Tania Hildebrand-Habel & Helmut Willems

Department of Earth Sciences, University of BREMEN, GERMANY
E-mail: hiha@micropal.uni-bremen.de; willems@micropal.uni-bremen.de

For the first time, Maastrichtian to Miocene calcdinoflagellate associations of several South Atlantic DSDP/ODP sites have been examined. The assemblages mainly consist of long-ranging forms, fluctuating qualitatively and quantitatively in distinct stratigraphic patterns.

Generally, the Maastrichtian is characterized by stable calcdinoflagellate associations, exhibiting high percentage occurrences of obliquely and radially structured calcareous dinoflagellate cysts. Although no accelerated rates of extinctions are evident at the Cretaceous-Tertiary boundary, the broad species spectrum is modified by an extreme dominance of the tangentially structured *Operculodinella operculata*, which occurs in high abundances especially in NP1-NP3. The bloom of this species has been reported from numerous localities and apparently had a world-wide distribution. Comparable changes concerning the nature of the assemblage across the Cretaceous-Tertiary boundary had been described by Fütterer (1990) from the Weddell Sea and by Kienel (1994) from the Boreal of Europe. During Paleocene and partly Eocene, the dominance of various species of tangentially structured calcareous dinoflagellates persists. Only in the course of Oligocene and Miocene, oblique and radial wall structures become prominent again. Other than in the Recent, significant percentage occurrences of *Thoracosphaera* have not been recognized in the examined stratigraphic interval.

Although the particular factors controlling the stratigraphic differentiation of calcdinoflagellate associations remain ambiguous, changes evidently correspond to variations in the environmental conditions.

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Variations in Surface Water Mass Conditions Along the North East Atlantic Fringe as Evidenced by Late Quaternary Calcareous Nannoplankton

Nicky Hine

Earth Sciences Department, University of Sheffield, Sheffield, S3 7HF, UK.
E-mail: n.m.hine@sheffield.ac.uk

Calcareous nannoplankton from Late Quaternary sediment cores have been analyzed. Cores are sited along the northeastern Atlantic margin of the British Isles and follow a north-easterly to south-westerly trend from the Faeroe-Shetland Channel in the north, along the Hebridean Platform and into the Rockall Trough in the south.

All samples are assigned a Late Quaternary age based on their calcareous nannoplankton assemblages together with additional foraminifera and dinoflagellate cyst data. There has been no absolute dating of the cores.

The calcareous nannoplankton assemblages are of low diversity and range in abundance form rich to barren. The cores are characterized by a succession of calcareous nannoplankton assemblages which are alternately dominated by a single species or are barren. Commonly recorded species include *Emiliania huxleyi*, *Coccolithus pelagicus*, *Calcidiscus leptoporus*, *Syracosphaera* spp. and large and small *Gephyrocapsa*. Not all cores are considered to contain a complete record with hiatuses developed to varying degrees.

The down-core variations in the nannoplankton assemblages reflect the dynamic oceanographic conditions which prevailed throughout the Late Quaternary period. They suggest a number of fluctuations in the strength of the North Atlantic Current during the time the cores were deposited with a consequent change in the oceanographic regime of the North East Atlantic Ocean. These changes are associated with mass wastage of the North East Atlantic margin.

On the Environmental Affinity of Calcareous Dinoflagellates in Late Quaternary Sediments of the Tropical Atlantic

C. Höll, B. Karwath, C. Rühlemann, K.A.F. Zonneveld,and H. Willems

Fachbereich Geowissenschaften, Universität BREMEN, GERMANY
E-mail: hoell@micropal.uni-bremen.de; karwath@zfn.uni-bremen.de; willems@micropal.uni-bremen.de

Environmental affinities of calcareous dinoflagellates have been investigated for the last 140 ka by comparing two sediment cores: one from the highly productive eastern Atlantic equatorial divergence zone and the other one from the low productivity western tropical Atlantic. Pronounced differences in palaeoproductivity between the two sediment cores are indicated by high and variable organic carbon accumulation rates in the east, in contrast to relatively constant and low values in the west. Calcareous dinoflagellates show just the opposite pattern: high abundances in the west and lower in the east. At the equatorial divergence zone, temporal variations of calcareous dinoflagellate abundance and organic carbon accumulation rates show, for the most part, an inverse relationship. High calcareous dinoflagellate contents coincide with low organic carbon accumulation rates and vice versa. In the investigated region and time interval, enhanced production of calcareous dinoflagellates can be correlated to periods of reduced palaeoproductivity related to relatively stratified conditions of the upper water column.

Morphometric Analysis of the *Broinsonia parca plexus* Across the Santonian-Campanian Boundary

A. Howard[1,2], P.R. Bown[1], J.A. Burnett[1] and J.R. Young[2]

[1] Department of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, UK. E-mail: a.howard@ucl.ac.uk
[2] Palaeontology Department, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK. E-mail: jy@nhm.ac.uk

Calcareous nannofossil biostratigraphy and palaeoceanography is fundamentally reliant upon practical, precise and reproducible taxonomic definition. Most established phylogenetic models and biostratigraphic datum events are based on subjective observations of gross morphology, despite the well illustrated problems of intraspecific variation and gradualistic change from the fossil record. Recently, relatively simple measurements of coccolith morphology have been utilized to provide effective quantitative approaches to taxonomy and aid in the recognition of biostratigraphic datum events (e.g. Young, 1990; Bralower and Parrow 1996; Knappertsbusch et al., 1997).

Introduced here is the application of light-microscope-based image-capture techniques (see Young et al., 1996) to perform a detailed morphometric analysis of the *Broinsonia parca plexus* and associated Arkhangelskiellaceae across the Santonian/Campanian boundary from two geographically disparate sites; ODP Leg 119, hole 738C, Kerguelen Plateau and Scratchells Bay, Isle of Wight, UK. The FO of *Broinsonia parca parca* is an important biostratigraphic datum utilized in both low latitude (e.g. Bralower et al., 1995), high latitude (e.g. Watkins, et al. 1996) and global (Burnett in Bown, in press) calcareous nannofossil zonation schemes. Currently, precise definition of the species concept of *B. parca parca* is lacking in practice despite a varied literature (e.g. Hattner et al., 1980; Crux, 1982; Wise, 1983). Morphometric techniques are applied to provide a quantitative taxonomic and stratigraphic framework for the evolution of the *Broinsonia parca plexus* across the Santonian-Campanian boundary. Work herein represents preliminary results of Ph.D. research.

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A Preliminary Nannofossil Biostratigraphy of the Jurassic of the Rankin Platform and Dampier Sub-basin on the North West Shelf of Western Australia

Richard Howe

AUSTRALIA. E-mail: rhowe@cyllene.uwa.edu.au

Preliminary analysis of sidewall cores from two petroleum exploration wells on the Rankin Platform (Brigadier #1 and Gandara #1) and one well in the Dampier Sub-basin (North Rankin #4) has revealed that the Lower to Middle Jurassic sequence in these wells contains low to moderate abundance assemblages of poorly to moderately preserved calcareous nannofossils. These assemblages represent the first record of in situ Early and Middle Jurassic nannofossils from Australia, other than the early Bajocian assemblage recorded from the Newmarracarra Limestone in the onshore Perth Basin by Shafik (1994).

Nannofossil diversity is moderate, with more than 40 species recorded. Most of the assemblages are dominated by *Schizosphaerella punctulata* and species of *Lotharingius*. The oldest assemblages belong to Subzone NJ4a, of early Pliensbachian age, according to the correlations of de Kaenel et al. (1996) and Bown (1996). These assemblages are distinctly Tethyan in character, as they contain *Mitrolithus elegans* and *M. lenticularis*. An unconformity related to the onset of rifting on the North West Shelf separates these assemblages from overlying assemblages belonging to NJ6-9, of Toarcian to Bajocian age. *Mitrolithus jansae* is present in assemblages belonging to Zone NJ6, but declines in abundance upwards, suggesting a progressive decline in Tethyan influence.

Discovery of these assemblages will hopefully add significantly to the sparse record of Lower and Middle Jurassic nannofossils from the southern hemisphere, and the Australian region in particular.

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Nannofossils from a Lower Miocene Core of Puerto Rico

Ting C. Huang

EEC/Biostratigraphy GP3-307C Houston, Texas USA
E-mail: tchuang@earthlink.net

In search for more useful nannofossil events to enhance biostratigraphic resolution of the lower Miocene, Core NC-4 drilled by USGS in north Puerto Rico was studied for nannofossils. The studied section is lower Miocene in the Sphenolithus belemnos Zone (NN 3) and lower. Further subdivision of the section into NN 2 and NN 1 is very difficult using standard zonal events of Martini (1971). The last occurrence datum of Triquetrorhabdulus carinatus, which defines the top of NN 2, has not been well calibrated with paleomagnetic stratigraphy (Berggren et al., 1995), and a recent study (Olafsson, 1989) proved that it actually occurs higher at a stratigraphical level correlative with the top of NN 3 or even higher. The top of NN 2, defined by the first occurrence of Discoaster druggii, has been hard to place as well, because this marker is genetically closely related and morphologically gradational to Discoaster calculosus and Discoaster deflandrei.

Despite the difficulty in assigning standard zones for the section, the following events were identified in this study. They are considered useful for subdivision of the section. These in downhole order are:

- Last occurrence of Orthorhabdus serratus at 1357' (in NN 3).
- Last occurrence of Sphenolithus cf. S. heteromorphus at 1386'.
- Last occurrence of Triquetrorhabdulus auritus at 1450' (in NN 2).
- Last common occurrence of Sphenolithus cf. S. heteromorphus at 1450'.
- First occurrence of Sphenolithus cf. S. heteromorphus at 1518'.
- First occurrence of Orthorhabdus serratus at 1548'.
- Last occurrence of Helicosphaera recta at 1732' (in NN 1 ?).

Throughout this study, an object of uncertain origin was found rare but persistent below 1532' to 1750'. The "UFO" has five segments of crystallite, which are dark in polarized light. Four of them are connected to form a rectangle, and the fifth one is a bar that runs parallel to the short axis of the rectangle and divides the object into two equal halves. Its taxonomic affinities are unknown.

Another interesting form, Sphenolithus cf. S. heteromorphus, appears to have a short range in the lower Miocene. It occurs rarely near its top occurrence at 1386', but commonly and persistently from 1450' to 1518'. This species is different from Sphenolithus heteromorphus in being slightly asymmetrical and having a longer cone. A similar form has been documented by Peleo-Alampay and Wei (1995, plate 1, figs. 14-15, 18-19) from the north Atlantic DSDP site 563, and by Jiang and Watkins (1992, plate 3, figs. 16-18) from the Gulf of Mexico. Although it occurs sporadically in both regions, these occurrences were recorded about the same stratigraphic position as noted in this core. It may be a potential age marker, which has been under-documented.

Architecture of *Braarudosphaera bigelowii* (coccolithophorid): A Marine Planktonic Alga Holding Clues to Quasicrystalline Symmetry

Syed A. Jafar

Birbal Sahni Institute of Palaeobotany, 53, University Road,
Lucknow 226 007, INDIA

The cysts of golden-brown alga *Braarudosphaera bigelowii*, representing the resting phase with biomineralized Calcite skeleton, display quasicrystalline dodecahedral symmetry (Euclidean = flat, Elliptic= convex, Hyperbolic = concave)[1-3] with radial pentalith suture-intercepts closely oscillating across golden mean ratio: (sq.rt 5 + 1)/2. Studies under the light- and scanning electron microscope reveal finely laminated nature of each of the 12 regular pentalith plates consisting of microcystallites of mineral Calcite ($CaCO_3$) with Penrose pentagonal rotational symmetry [4], in terms of C-axis orientation of five optically distinct units (Fig.1). Dodecahedral symmetry is expected to be discovered among metallic alloys, which sofar have only revealed fivefold icosahedral symmetry.

The dodecahedral cyst of *B.bigelowii*, represent one of the most perfectly known Platonic bodies (**Universe**) of ancient mathematicians[5-6]. The quasiperiodic tiling of the three-dimensional space is also known from different organizational level of a variety of biologic entities using a vast array of building material, viz., radiolaria (hydrous- silica), coccoliths (biogenic Calcite), pollen-spores (organic polymers)[7-8], viruses (nucleoprotein) including more recent and remarkable quasicrystalloid 5-fold symmetry discovered in low density-high strength Mn-Al alloys, optically condensed matter and all-carbon Buckminsterfullerene molecules [9].

Thermodynamics of quasiperiodic symmetry in living and non-living system has yet to be fully understood[10], but in case of abundant quasicrystalline microbiogenic particles invisible to naked eye, the golden mean seems to control the aesthetically harmonizing icosahedral-dodecahedral patterns and forms, produced under subdued gravitational force, but major influence of surface tension, brownian movement and electrical forces. Does nonperiodicity signifies dominant feature of living and an exceptional trait of non-living system ?

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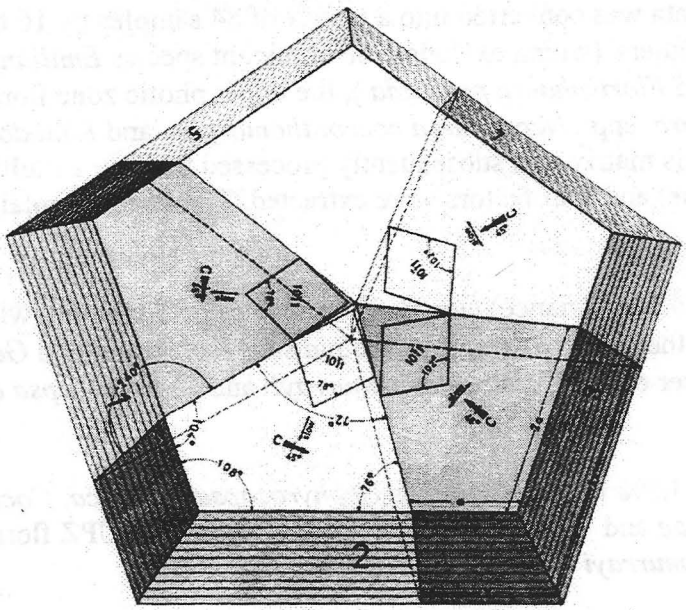
Fig. 1. A model of an isolated pentalith plate of *B. bigelowii* (proximal view, tilted away from observer; diameter ca.5μ). The most commonly observed optic orientation of Calcite microcrystallites is shown in sectors 1 & 2 and rare one in sectors 3 & 4. The dip and orientation of C-axis is indicated for each pentalith segment behaving as a single crystal and normal lattice of Calcite. After initial nucleation of dodecahedral framework, the plates are permitted to grow in thickness only inwards, to maintain constant relativity of growth and similar line segment ratios on both proximal and distal face (Sector 3; a : 2a = x : 2x). Each of the five polyhedral Calcite units (sectors 1-5) could be conceived to have been produced by truncation of a larger Penrose golden rhombus with angles of 108° - 72°.



Coccolith Palaeoecological Interpretations from an Upwelling Region Off NW Africa (ODP 658C) During the Last 130 kyrs

R.W. Jordan [1] and M. Cachão [2]

[1] Dept. of Earth & Environmental Sciences, Fac. Science, Yamagata Univ., Yamagata, 990 JAPAN.
E-mail: sh081@kdsal.kj.yamagata-u.ac.jp
[2] Dep. Geology, Fac. Sciences Lisbon Univ., Rua Escola Politecnica, nº 58, P-1294 Lisboa, Codex, PORTUGAL
E-mail: mcachao@fc.ul.pt

Sediments beneath a permanent upwelling cell were drilled and recovered for the first time during ODP Leg 108 and provide a long term record of upwelling history off NW Africa. Previous studies on samples from site 658C used the coccolithophorid-based U^{k}_{37} proxy to recognize Heinrich events and characterize the SST regime during isotope stages 1 to 6 in these sediments off Cap Blanc (JORDAN *et al.*, 1996; ZHAO *et al.*, in press).

The coccolith data was converted into a matrix of 84 samples by 16 taxa + 3 parameters. The parameters were 'Others' (which excluded the dominant species *Emiliania huxleyi*, *Gephyrocapsa* spp. and *Florisphaera profunda*), the upper photic zone flora (UPZ; which included *Umbellosphaera* spp., *Neosphaera coccolithomorpha*, and *Rhabdosphaera* spp.) and U^{k}_{37}-estimated SST. This matrix was subsequently processed through a multivariate statistical method (Factor Analysis) and four factors were extracted. The factors explain 60.5 % of the total variance.

Factor 1 (with 29.6% variance) clearly distinguishes SST together with *F. profunda* and *Syracosphaera* spp. on the positive axis, from *Calcidiscus leptoporus* and *Gephyrocapsa muellerae* (and to a lesser extent *Calciosolenia murrayi* and *Gephyrocapsa aperta*) on the negative axis.

Factor 2 (with 13.3% variance) defines *Gephyrocapsa oceanica*, *Coccolithus pelagicus, Umbilicosphaera sibogae* and 'Others' on the positive axis, and the UPZ flora, *Umbellosphaera* spp. and *Calciosolenia murrayi* on the negative axis.

Factor 3 (with 8.5% variance) distinguishes between *E. huxleyi*, *G. oceanica*, *Syracosphaera* spp., *Helicosphaera* spp., *C. pelagicus*, *C. murrayi*, *N. coccolithomorpha*, *U. sibogae* var. *foliosa* and SST on its positive axis from *G. aperta, G. muellerae* and *C. leptoporus* on its negative axis.

Factor 4 (with 8.1% variance) distinguishes the UPZ flora, *U. sibogae* var. *foliosa*, *N. coccolithomorpha*, *Umbellosphaera* spp., *C. murrayi* and *G. oceanica* on its positive axis from *Helicosphaera* spp., *C. pelagicus* and *G. muellerae* on its negative axis.

These assemblages are not so easy to interpret, but there are a few patterns which may be explained. There seems to be a clear distinction between subtropical and temperate floras. For instance, *G. muellerae, G. aperta* and *C. leptoporus* do not appear on the same side of the analysis as the subtropical species. This may be based on simple warm / cold water preferences, as clearly seen in JORDAN *et al.* (1996) in their plots of $U^{k'}_{37}$-derived SST against the relative

percentages of various species.

We believe that the downcore distributions of these assemblages result from changes in the offshore extent of the upwelling cell, in association with the periodic southward migration of temperate species (*e.g. G. muellerae*) during cooler periods (and during most Heinrich events). It is our opinion that different assemblages exist at varying distances from the upwelling centre, and that changes in the strength and direction of the prevailing winds (i.e. upwelling intensity) control which assemblage sediments out over the core site. The species composition of these zones will be discussed in our presentation.

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Seasonality of Living Coccolithophorids off the Puerto Rican Coast

Ric W. Jordan[1] and Amos Winter[2]

[1] Dept. of Earth & Environmental Sciences, Fac. Science, Yamagata Univ., Yamagata, 990 JAPAN.
E-mail: sh081@kdsal.kj.yamagata-u.ac.jp
[2] University of Puerto Rico, Marine Sciences Dept., Mayaguez, PR, 00681 USA.
E-mail: a_winter@rumac.upr.clu.edu

Phytoplankton samples were collected biweekly from a number of depths at a fixed station off the coast of Puerto Rico over a four year period (1992-1995). Here the results from 1995 (samples taken only between Jan.-May) are presented, although observations from other years will also be discussed. For each filter sample the microplankton composition was counted and the coccolithophorid species assemblages identified. The 1995 results show that the diatom contribution was highest during January and February, but from March-May the diatoms (especially the centrics) decreased in relative abundance whilst the coccolithophorids increased. However, the coccolithophorids always maintained a dominant or co-dominant assemblage in the middle to lower photic waters regardless of what was happening in the surface waters above. On the other hand, dinoflagellates never constituted more than 10% at any depth, which is a little surprising considering that near to the coast is a region famous for exceedingly high numbers of dinoflagellates. There is also evidence that material (e.g. epiphytic diatoms, chrysophyte cysts, pollen) from the Puerto Rican coast or mainland has been transported to the shelf area at particular times of the year.

The coccolithophorid community was distributed vertically into the three classical photic zones, including an easily recognizable middle photic zone. The revised zonal assemblages will be discussed in detail during the presentation. The general trend is a change from an assemblage dominated by either *E. huxleyi* or *G. oceanica* (without a collar) in the January to early March samples, to one dominated by *D. tubifera*, *U. irregularis* and holococcolithophorids in the upper photic zone, *M. elegans* and *A. quadricornu* in the middle photic zone, and *F. profunda* var. *profunda* in the lower photic zone from late March to May. In this latter period *G. oceanica* almost completely disappears from the counts (= <1% in May), although *E. huxleyi* also markedly declines at all depths its highest numbers are at the base of the upper photic zone (around 60-75m). *F. profunda* was the dominant species between 100-125m on only three sampling occasions (on 13th February, 24th March and 10th May). The absence/low percentage of this species (and other lower photic species) in the other deep samples, probably indicates that a deepening of the nutricline occurred, as in all cases there are significant amounts of middle photic zone species present.

These results show that the Puerto Rican shelf waters may still exhibit seasonality even though they are considered oligotrophic and permanently stratified. Observations from other samples within the four year sample has shed light on the seasonality and annual cyclicity of the phytoplankton from this subtropical area.

The Mid-Late Cretaceous and Early Tertiary Calcareous Nannofossils; Tanzania

Amina I. S. Karega

Tanzania Petroleum Development Corporation, Box 5233, Dar Es Salaam, TANZANIA.
E-mail: tpdcexploration@raha.com

Fifty-three species of nannofossils were recovered from eleven uphole samples collected during the running of seismic surveys in Ruvuma Basin Southern, Tanzania. Samples were subjected to standard nannofossils preparations. Smear and centrifuged slides were prepared for each sample. Samples were studied under light (LM) and Scanning Electron Microscope (SEM) for nannofossil assemblages.

The samples were found to contain a significant amount of nannofossils, ranging in age from Mid-Late Cretaceous and Tertiary. SEM and LM of well preserved specimens were taken. A number of zones were identified based on the presence of zonal marker species. The claystones and shales of the studied Cretaceous interval have a high diversity of calcareous nannofossils. While the studied Tertiary section consisted of argillaceous and carbonate deposits a high influx of calcareous nannofossils were observed.

Environmental Affinities of *Thoracosphaera heimii* in Field and Laboratory Studies - Preliminary Results

Britta Karwath, Dorothea Janofske and Helmut Willems

University of BREMEN, GERMANY. E-mail: karwath@zfn.uni-bremen.de; janofske@micropal.uni-bremen.de; willems@micropal.uni-bremen.de

Thoracosphaera heimii is a marine, planktonic dinophyte. It is phototrophic and the only dinoflagellate known to have a predominant calcareous coccoid stage in its vegetative life phase. The association of calcareous dinoflagellates in the plankton and in sediment cores is characterized by the overwhelming dominance of *T. heimii*. Recent work on sediment cores from the tropical Atlantic hints at a possible relationship between an increased abundance of *T. heimii* in sediment core material and decreased productivity under oligotrophic stratified conditions of the upper water column. To gain a better insight into the environmental affinities of this species, the spatial distribution of *T. heimii* was studied on a cruise from Las Palmas (Canaries) to Recife (Brazil) (26th January to 1st March). Samples were collected from the water column, ranging from 10 m to 50 m depth. Additionally to the field studies, a clone of *T. heimii* (CCMP 1071) has been cultured under controlled laboratory conditions. To this end, the clone was held in a temperature gradient from 35.5 to 7.5 °C. Cultures were also tested on their salinity tolerance.

Coccolithophore Response to Changing Late Quaternary Paleoceanography in the Equatorial Atlantic Ocean

Hanno Kinkel and Karl Heinz-Baumann

FB Geowissenschaften, Universität BREMEN, GERMANY.
E-mail: hkinkel@mail.sedpal.uni-bremen.de; khb@mail.sedpal.uni-bremen.de

In order to reconstruct the response of coccolithophores to changing paleoceanographic conditions, we investigated a set of surface sediment samples and three sediment cores from the Equatorial Atlantic. Present day surface water oceanography in this area is characterized by seasonal upwelling between 5°N and 10°S which stretches out from 10°E to 25°W. The driving mechanism for the upwelling is the strength of the tropical easterlies which are modulated by annual and long term insolation variations. Strong tropical easterlies shallowing of both thermocline and nutricline in the East resulting in a large nutrient flux to the upper photic zone and increased phytoplankton productivity. Outside the upwelling area, the thermocline and nutricline are deep resulting in a oligotrophic well stratified surface layer. The biogeographical distribution of coccolithophores in surface sediments reflect the situation of the overlying water masses, although the coccolithophore assemblages are heavily altered when settling through the water column. Eutrophic conditions in the photic zone are relatively well represented in surface sediments with highest abundances of *E. huxley* beneath the upwelling area where they also dominate the living assemblages. In contrast surface sediments underneath oligotrophic areas are dominated by the Lower Photic Zone taxa (LPZ) F. profunda and *G. flabellatus* due to strong dissolution of *U. irregularis* and *U. tenuis*, whose abundances are reduced from up to 100 % of the living assemblage to about 5 % of the surface sediment assemblages. The abundance of the LPZ taxa therefore enables us to reconstruct paleo - thermocline and nutricline depth and productivity. We present a reconstruction of surface water structure and productivity with coccolithophores for three sediment cores from the southern, central, and western Equatorial Atlantic of the last 140,000 years. The coccolithophore records in the southern and central Equatorial Atlantic show a strong cyclicity within the precession band of orbital forcing as the tropical easterlies are negatively correlated to the insolation at 15° N. Basin wide tilting causes a deepening of thermocline and nutricline in the west when a shallowing due to increased wind is reached in the east. Therefore the western sediment core shows an opposite trend in the coccolithophore record in comparison to the southern and central Equatorial Atlantic.

Calcareous Nannoflora Response to Termination II at 45°-53°N (Northeast Atlantic)

Anna Lototskaya, Patrizia Ziveri, Gerald M. Ganssen, and Jan E. van Hinte

Geomarine Centre, Faculty of Earth Sciences, Free University, De Boelelaan 1085, 1081 HV Amsterdam, THE NETHERLANDS. E-mail: lota@geo.vu.nl.

Termination II (glacial to interglacial transition from oxygen isotope stage 6 to stage 5) is considered to be one of the most rapid and abrupt climatic changes during the Late Quaternary. Our high resolution geochemical and floral study of the 140-100 ka BP interval in the northeast Atlantic cores T90-9P (45°N, 25°W) and T90-2P (53°N, 20°W) shows that Termination II (135-125 ka BP) occurred in two steps of drastic changes, interrupted by a short period of stability, and followed by at least 25 ka of relatively stable, interglacial conditions, traditionally referred to as the Eemian age (substage 5.5).

For the core T90-9P, an export production proxy based on coccolith accumulation rate (number/cm^2 ka), and supported by carbon isotope record of planktic foraminifera *Gs. ruber*, shows higher values during the Eemian than during glacial stage 6 and interglacial substage 5.4, with the maximum values (70x10^9 coccoliths/cm^2 ka) at 123-122 ka BP. The coccolith assemblage was dominated by two size-morphotypes of *Gephyrocapsa* alternating in dominance under different climatic conditions: *Gephyrocapsa muellerae* was more abundant in colder periods, whereas "small *Gephyrocapsa*" dominated in the Eemian. *Emiliania huxleyi*, *Syracosphaera pulchra* and *Florisphaera profunda* increased in the Eemian whereas *Coccolithus pelagicus* and *Helicosphaera carteri* decreased. Small *Gephyrocapsa* together with *Emiliania huxleyi* are associated with periods of higher productivity. The *E. huxleyi*/(*E. huxleyi* + *G. muellerae*) ratio is used as a proxy for paleoclimate changes in this region.

At 53°N (core T90-2P), 8° to the north, *G. muellerae* dominated the calcareous nannoplankton assemblage throughout the whole interval. During the Eemian its relative abundance decreased down to 40 % at the Eemian maximum (125 ka BP). At this site small *Gephyrocapsa* was always present but never dominated the assemblage.

The pelagic sedimentary record of Termination II in the northeast Atlantic includes a 5-15 cm thick layer enriched in ice-rafted material, a so called Heinrich layer. In contrast to Termination I, where such a Heinrich layer (H1) is associated with the first meltwater pulse of the deglaciation, the Heinrich event of Termination II (H11) occurred during the second stage of deglaciation (129.4-127.1 ka BP). It is characterized by accumulation of ice-rafted debris and low coccolithophore diversity. The coincident drop in coccolith accumulation rate could be explained either by changes in primary productivity due to reduction in salinity and light, or by dilution by ice-rafted material. It further could be an artifact resulting from low dating precision and incorrect thickness definition of the Heinrich layer. Five models are applied for the deposition of the Heinrich layer with changing thickness (3 cm) and duration (1000, 500 and 250 years). These scenarios result in a lowered, constant or even slightly increased primary productivity during this event.

High ResolutionBbiostratigraphy in the North Sea Chalk

Fabio Lottaroli and Donata Catrullo

AGIP. PO Box 12096 - 20120 MILANO, ITALY. E-mail: fabio.lottaroli@agip.it

INTRODUCTION

Chalk cored sections of twelve selected wells of the Greater Ekofisk area (Central North Sea) were studied for biostratigraphical purposes by means of calcareous nannofossils. The studied interval is developed in the uppermost Tor Formation (Maastrichtian) and Ekofisk Formation (Danian). Wells from Edda, Tor, Ekofisk and Eldfisk have been studied, among others. The high resolution biostratigraphy, together with the results of sedimentological description, was intended to form the base for a sequence statigraphic framework suitable for this area.

MATERIALS AND METHODS

Wells 2/5-7, 2/4-8, 2/5-2, 2/5-3, 2/4b-19A, 2/7-4, 2/7-3 and 2/8-2 were first studied in great details and the biostratigraphic approach was, as far as possible, quantitative. Eighty-four cores for a total length of 780 m have been studied in this first phase. The cores were sampled for biostratigraphy simultaneously with the visual core description. Therefore, samples (tot. 450) are representative of facies variations and stratigraphic development and their frequency is strictly related to facies interpretation. Anyway, the samples spacing rarely exceed 1 meter in Ekofisk Formation; only in the coarse reworked facies of Tor Formation the samples are more scattered. The biostratigraphic analyses were performed on smear-slides with an optical microscope (x1250). Three hundred specimens of calcareous nannofossils were counted in each sample and for the Danian sediments an additional count (50 specimens) was performed in order to estimate the evolutional degree of the *Cruciplacolithus-Chiasmolithus* assemblage (Van Haeck & Prins, 1987). The Maastrichtian sediments of Tor Formation were often so depleted of calcareous nannofossils to prevent from reaching 300 specimens counted. Available published biozonations developed in this specific area were chosen as reference both for the Cretaceous (Mortimer, 1987) and Danian. For the latter the maximum detail was obtained combining the biozonations of Perch Nielsen (1979) and Van Haeck & Prins (1987). In a second phase Fifty-two Core samples from wells 2/1-1, 2/4-7, 2/5-1 and 2/5-5 were studied to implement the regional biostratigraphic framework arising from phase I.

RESULTS

Biostratigraphy provided an extremely detailed subdivision mainly for the Danian sediments, where rapid evolution and appearances of new marker species make refined subdivision possible. So a good correlative framework between studied wells have been obtained, and even minor hiatuses were pointed out and consistently recorded at the regional scale. Moreover biostratigraphic analysis supported facies characterization pointing out reworked intervals. As already outlined for Chalk Group in this area, also for the studied interval the history of sedimentation is a complex interplay of autochthonous and allochthonous deposition, where redeposition represents the norm rather than the exception. Cretaceous reworked assemblages mixed with *in situ* Danian was rarely found. More frequently, intervals containing only Maastrichtian nannoflora were found embedded in the Danian sequence (2/5-7). Often, due

to the good biostratigraphic resolution, lower Danian interval have been recognized reworked into younger Danian sediments (2/4-B19a). - The cored interval of 2/5-7 well has been referred to lowermost Danian (D1) based on the nannofloral content of two centimetric clay-rich layers. The rest of the core, also the intervals identified as "pelagic chalk", contains only late Maastrichtian nannoflora. The presence of the K/T boundary at the base of this core is corroborated by the occurrence of *Prediscosphaera stoveri* acme (Posphical & Wise, 1990). - A hiatus or a very condensed section between sediments referred to D1 and upper D4 Biozones was detected in almost all the wells corresponding to a hard ground level (2/4-8) or to a clay-rich interval. - Hard ground were found to correspond to hiatuses also at higher stratigraphic levels (2/4-8). - Also the time span corresponding to D5-D9 Biozones seems poorly represented in some wells, even if, the lithological expression of this event is less clear.

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Onset of "Helminthoid Flysch" Sedimentation in the Western Tethys: Evidence from Antola Fm. (Northern Apennines, Italy)

Michele Marroni, Luca Pandolfi and Nicola Perilli

Dipartimento di Scienze della Terra, Università degli Studi di PISA, ITALIA
E-mail: marroni@dst.unipi.it; perilli@dst.unipi.it

In the Northern Apennines (Italy), spectacular, thick and widespread "Helminthoid Flysch" deposits crop out. These successions, consisting of fine-grained nannofossil-rich calcareous turbidites, sedimented in the Western Tethys Domain during the Late Cretaceous-Early Tertiary intraoceanic subduction and the following Europe-Adria collision. Similar deposits characterized by *helminthoidea* trace fossils crop out in French and Italian Maritime Alps, Swiss Pre-Alps, Central Switzerland, Bavarian Alps and Wienerwald of Austria. In the Northern Apennines, the "Helminthoid Flysch" represents the huge part of different tectonic units such as Antola, Cassio and Caio Units.

This work deals with calcareous nannofossils biostratigraphy of the lower portion of Antola Fm. cropping out northeast of Genova (Italy). The onset age of Helminthoid Flysch sedimentation represents an important starting-point to enlighten the tectono-sedimentary evolution of the Ligure-Piemontese Domain.

The Antola Unit includes a "basal complex" (Montoggio Shale) and the overlying Antola Fm. Made up of a 2000m thick calcareous turbidite sequence, the Antola Fm. is characterized by medium to thick calcareous beds and minor siliciclastic medium to thin beds. The sedimentological features of a calcareous turbidite sequence and the presence of thin hemipelagic $CaCO_3$-free claystones indicate a basin plain environment located below the local CCD.

The Helminthoid Flysch dating is problematic because of both the intense reworking of these deposits and the impoverishing of the calcareous nannofossil assemblages due to the tectonic stress, which affected the lower part of the tectonic unit.

In total, 110 samples were investigated: 29 of them were collected from the basal portion of the Antola Fm. and 91 from the 400 m thick overlying succession. The first group is characterized by poor to medium preserved calcareous nannofossil assemblages, with total abundance ranging from few to common and the number of species ranging from 10 to 20. The second group provide more abundant, diversified and the best preserved assemblages with a number of species ranging from 20 and 30.

The nannofloras are dominated by *Watznaueria barnesae* and *Micula decussata*, together with *Calculites obscurus*, *Cribrosphaerella erhenbergii*, *Lucianorhabdus cayeuxii*, *Micula staurophora* and *Prediscosphaerea cretacea*. Other frequent taxa are *Ceratholitoides aculeus*, *Cretarhabdus crenulatus*, *Eiffellithus turriseiffelii* and *Microrhabdulus decoratus*. The nannofossil assemblages from the lowermost calcareous turbidites of the Antola Fm. are characterized by the presence of *Ceratholitoides aculeus*, *Quadrum gothicum*, *Quadrum trifidum* and *Reinhardtites levis* and are referable to the *Quadrum trifidum* Zone (late Campanian-early Maastrichtian).

Lower Jurassic Integrated Biostratigraphy Based on Calcareous Nannofossils and DinoflagellateCcysts in the Tethyan Realm

Emanuela Mattioli & Raffaella Bucefalo Palliani

Dipartimento di Scienze della Terra, Università di Perugia, P.za Università, PERUGIA - ITALIA

Well preserved calcareous nannofossil and dinoflagellate cyst assemblages were collected from numerous successions outcropping in Tethyan localities. The reference area for this study is central Italy, where continuous sections well dated by ammonites are particularly suitable for an integrated biostratigraphical approach. Comparisons were carried out with the phytoplanktonic assemblages from Greece, southern France, Hungary, Portugal and southern Germany. This study is focused on the Lower Jurassic, period characterized by numerous global palaeoecological and palaeogegraphical events (speciations, transgressions, anoxia, etc.). In the Lower Jurassic marine phytoplankton producing fossilizable remains is mainly represented by calcareous nannoplankton and dinoflagellates. During this time interval, both groups experienced an evolutive radiation and colonized oceans and epicontinental seas.

The integration of selected calcareous nannofossil and dinoflagellate cyst events produced a very detailed biostratigraphical framework. This may represent an important parachronology to ammonite zonation. The integration of the two phytoplanktonic groups enables sediments to be dated even when lithologies unfavorable to the preservation of one fossil group are present. The light diachroneity between the Early Jurassic radiation of nannoplankton and dinoflagellates ensures that this approach has a good biostratigraphic potential. The biostratigraphic framework obtained in the present work yielded greater detail than that provided by ammonites and it is generally independent from the sedimentary facies.

The Eustatic andClimatic-orbital Sinature on Phytoplankton and Geochemistry: Examples from the Early Toarcian in Central Italy

E. Mattioli[1], R. Bucefalo Palliani[1], S. Cirilli S.[1] and B. Pittet [2]

[1] Dipartimento di Scienze della Terra, Università di Perugia, P.za Università, 06100 PERUGIA, ITALIA.
[2] Université de Fribourg, Institut de Géologie et Paléontologie, Pérolloes, CH-1700 FRIBOURG, SWITZERLAND

In central Italy (Umbria and southern Tuscany) the Early Toarcian consists of monotonous mixed carbonate-siliciclastic lithologies, rich in organic matter and with a scarcity of sedimentary structures. Six profiles were investigated in detail with a multidisciplinary approach. Quantitative and multifactorial analyses were applied to calcareous nannofossils, dinoflagellate cysts, organic constituents of palynofacies, and geochemical parameters (TOC, HI, OI, $CaCO_3$). The aim of this research is to emphasize the potential of phytoplanktonic and geochemical parameters as palaeoenvironmental indexes. Factor analysis evidences the existence of three main factors controlling the phytoplankton distribution, which are related to climatic-eustatic fluctuations.

- The calcareous dinoflagellate *Schizosphaerella* spp. is present everywhere in the studied lithotypes, its abundance is controlled by variations of the other groups, but blooms occur when carbonate rich layers are deposited;
- Biscutaceae and *Lotharingius* spp. are generally abundant in highly diversified assemblages; they dominate under good trophic conditions;
- Crepidolithaceae probably represent the deepest specimens living in the water column or off-shore taxa. Their abundance is probably dependent on the nutricline depth;
- *Calyculus* spp. is commonly abundant during high sea-level phases;
- *Mitrolithus* spp. dominates during maximum-flooding to high-stand conditions, when the trophic level is low.

The whole set of data reveals a succession of palaeoenvironmental and palaeoecological modifications in the sedimentary basin during the global Lower Toarcian transgression linked to two orders of eustatic and/or climatic cyclicity

3rd order cyclicity

Transgressive trend: The sea level rise created new available niches, promoting a phytoplanktonic speciation. The phytoplankton bloom contributed to the organic matter accumulation. The successive anaerobic conditions at the sea bottom were favored by the interplay of the sea level rise and sedimentary starvation. The stratified water column prevented nutrient recycling and phytoplankton reached climax conditions in the relatively oligotrophic surface waters. The decrease of basinward-transported carbonate mud is related to the flooding of the adjacent carbonate platforms and the scarce $CaCO_3$ is mainly produced by *Schizosphaerella* spp. At the end of the transgressive trend the maximum palaeoenvironmental distality, sedimentary starvation and TOC values are related to the maximum flooding event. The deeper and/or distal nannoplankton taxa prevailed concomitant with this event. The dinoflagellate cysts temporarily disappeared and the Tasmanites became the dominant organic-walled phytoplankton.

Regressive trend: The sea level fall at end of the Early Toarcian gave rise to a more efficient water circulation, producing a reoxygenation at the sea bottom, a better nutrient recycling and a new phytoplanktonic bloom. Export of carbonate mud produced on the platform increased again.

4th/5th order cyclicity

Time series evidenced that the fluctuations in the phytoplankton and geochemical indexes are controlled by orbital parameters (eccentricity, obliquity and precession cycles). These cyclic signals are interpreted as a result of climatic and oceanographic changes inducing variations in the surface fertility, carbonate productivity and sea bottom oxygenation. A climatic cycle may be inferred to explain the differences in the geochemical signature and phytoplankton distribution with respect to carbonate production. When carbonate-poorer layers were deposited, a warmer and more humid climate could have produced water stratification and organic matter accumulation and preservation. A more efficient water circulation and vertical mixing, suggesting higher seasonality, could have determined the deposition of carbonate-richer sediments.

Cretaceous Nannofossil Biostraigraphy of Lithuania

Romualda Mertiniene

Institute of Geology, Sevcenkos 13, Vilnius, LT 2600, LITHUANIA

The analysis of nannofossils from the Cretaceous of Lithuania have allowed us to distinguish the nannoplankton zones. The Lower Cretaceous consists of non-carbonaceous sands and siltstones. Nannoplankton are not found there. The Upper Cretaceous is represented by various carbonaceous rocks. Nannoplankton found in these deposits were investigated. Several nannoplankton zones, distinguished by the author in 1993 are determined more exactly.

The lower boundary of each zone is marked by the first appearance of the index-species. Sizes of individual zones are various. The determination of the nannoplankton zones is based upon the existing foraminferal zones.

Nannoplankton in the Lower-Middle Cenomanian are rare and badly preserved. A Nannoplankton zone is not distinguished there.

Ten nannoplankton zones were distinguished in the remaining Upper Cretaceous deposits:

- Upper Cenomanian-the bottom of Lower Turonian - zone *Gartnerago obliquum-Microhabdulus decoratus.*
- Most of the Lower Turonian - zone *Quadrum pyramidum.*
- Upper Toronian - most of Upper Coniacian - zone *Lucianorhabdus maleformis.*
- Top of the Upper Coniacian - the lower half of Lower Santonian - zone *Micula staurophora.*
- The upper part of Lower Santonian - Uppper santonian - zone *Lucianorhabdus cayeuxi.*
- The most of Lower Campanian - zone *Briosonia parca.*
- Top of the Lower Campanian - the lower part of Upper Campanian - zone *Ceratoltoides aculeus.*
- Top of the Upper Campanian-the Lower Maastrichtian - zone *Quadrum trifidum.*
- Top of Lower Maastcichtian- the lower part of Upper Maastrichtian =zone *Lithraphidites quadratus*
- Upper part of Upper Maastrcichtian- zone *Nephroltihus frequens*

Statistical Analysis of Sequential Abundances Data: Paleo-Ecological Evidences from the Upper Eocene Massignano Section (Central Italy)

Simonetta Monechi[1], Antonella Buccianti[1] and Silvia Gardin[2]

[1] Dipartimento di Scienze della Terra, Via La Pira 4, I-50121 FIRENZE, ITALY.
E-mail: monechi@cesit1.unifi.it
[2] CNRS URA 1761 Département de Géologie Sédimentaire Laboratoire de Stratigraphie, Université Pierre et Marie Curie 4, Place Jussieu F75252 PARIS Cedex 05, FRANCE

The analysis of sequential data has come to play a prominent role in a wide spectrum of sciences. The investigation of time series of fossil records has pointed out the possible signature of periodicity in mass extinctions probably related to external influences such has meteorite impacts (Sole' et al. 1997). Quantitative evaluation of data that can be considered as time (or spatial) series can be performed by using a large number of methods (e.g. Box and Jenkins, 1970; Kendall and Ord, 1990). In this work we attempt to analyze and interpret the changes of abundances of different species whose behavior can be related to climatic changes by using classical and geostatistical methodologies (Oliver et al., 1997). The aim is to identify meaningful patterns in the vertical distributions of each sequence of abundances data (autocorrelation), to perform cross-correlations among different sequences and finally to detect the presence of relationships with external factors as meteorite impacts. Since strong evidence for a major early late Eocene impact was found in a level of the Massignano section (stratotype of the Eocene/Oligocene boundary) the statistical analysis has been applied to data collected from it.

A problem in the analysis of the abundances data arises if the values are expressed in percentage (or relative data). As demonstrated by Aitchchison (1986), the analysis of compositional (closed) data requires the transformation of the original quantitatives in order to avoid the problem of the induced correlations. Thus, in this study the statistical analysis is applied by considering the problem of compositional data. Our efforts have been useful to point out and interpret: 1) the organization of the data inside each vertical sequences; 2) relationships between the different vertical sequences; 3) detection of grouping of variables (discoasters, olococcoliths, cold water taxa) that show a similar behavior related to the same climatic and/or paleoecological and paleoenvironmental features; 4) the link between changes in the abundances data and the occurrence of biotite.

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Calcareous Nannoplankton In The Cariaco Basin, Venezuela

Di Gianni C[1]. and Nieves M[2]

[1]Laboratorio Geológico El Chaure, Corpoven S.A., Apart.4623, Puerto La Cruz,
Edo. Anzoategui, Venezuela,
E-mail: gesp38@ccinet.corpoven.pdv.com

[2]LAMBERT, Bernard., Total Indonesie, Jalan Myniak, Balikpapan, Kalimantan Timur Indonesia.

In order to determine a referential environmental model, the horizontal and vertical distribution of calcareous nannoplankton in the water column of the Unare-La Tortuga traverse and its effect on the ocean floor sediments was investigated. For the study, water samples were taken in 9 hidrographic stations at depths ranging from 0 to 200 m, as well as, 5 ocean floor surface sediment samples corresponding to the continental shelf, the slope and the anoxic Cariaco basin. In addition, a bathymetric registry of the traverse was recorded and the hydrographic conditions of the water column were determined using parameters such as temperature, density, salinity, dissolved oxygen and chlorophyll content.

Around twenty species of nannoplankton were identified in the analyzed samples, which could be grouped into the genera Gephyrocapsa, Emiliania and "Others" (with species from the genera Florisphaera, Helicosphaera, Umbilicosphaera, etc.).

The largest concentration of cells in the water column (up to 4050 cell/liter) were obtained at 50 m of depth and in the center of the basin, decreasing noticeably in the north direction towards La Tortuga island. The predominance of Gephyrocapsa over Emiliania was observed along the entire traverse, especially in the coasts. Towards the center of the basin, this relation is reversed. At depths greater than 50 m, specimens from the "Others" group were more abundant, with the greatest amount accounted by the Florisphaera genus.

The results from the analyzed sediment samples indicate the predominance of the genus Gephyrocapsa. The sediments from the continental shelf sample show low diversity and abundance of nannoplankton, which increases considerably towards the center of the basin. In addition to the diversity of phytoplankton, complete and well preserved coccosphaeras can be observed at 1340 m, as well as, a great amount of pyrite and amorphous organic matter. The presence of the Discoaster genus and the Calcidiscus macintyrei species in the sediments, extinct in the Pliocene and early Pleistocene respectively, may indicate a low sedimentation rate or reworked specimens at this northeastern region of Venezuela.

Nannoplankton, Cariaco, Quaternary, water-samples, sediments

Name : Nieves Maria DI GIANNI CANUDAS
Address: Laboratorio Geologico El Chaure, (Corpoven, S.A.) P.D.V. S.A.
PUERTO LA CRUZ, EDO. ANZOATEGUI, VENEZUELA

E-mail: gesp38@ccinet.corpoven.pdv.com

FAX: 58-81-606445

TEL: 58-81-606399

Seasonal Variation of Modern Coccolithophores in the Subarctic Pacific Ocean and Bering Sea

H. Okada, and K. Hagino

Department of Earth and Planetary Sciences, Graduate School of Science,
Hokkaido University, SAPPORO, 060-0810 JAPAN
E-mail: oka@cosmos.sci.hokudai.ac.jp; hagino@strati.sci.hokudai.ac.jp

Observation of more than 500 surface and subsurface filter samples collected from the subarctic Pacific and Bering Sea revealed seasonal trends in coccolithophore flora. The samples were collected by various scientific cruises in spring to autumn seasons (June - September) for multiple years between 1964 and 1997. Seasonal variation of the flora within this subarctic realm was much more intense than was reported in the North Atlantic (Okada and McIntyre, 1975). The coccolithophore distribution was patchy, and many samples were barren or extremely scarce of coccolithophores.

Approximately 70% of the studied samples were barren, and only 9 out of 96 samples, collected in four years, yielded more than 1000/L cells in the Bering Sea. Major components of the flora were *Emiliania huxleyi* and *Coccolithus pelagicus* with the former being far more abundant in the densely populated samples. A moderate bloom of *E. huxleyi* (ca. 5 million/L cells) was recorded for the first time from the Pacific sector. *Calciopappus caudatus* dominated the flora (70%) in some samples. Due to insufficient number of samples studied, a clear seasonal trend was not observed, but the higher population density seems to occur during the middle to late June in the Bering Sea. The data also indicates a higher population in shallow (10-50 m) subsurface waters than in surface waters.

Seasonal variation in the standing crop was greater in the Subarctic Zone (north of ca. 45° N) compared to the northern Transitional Zone (ca. 40-45°N) in the Pacific. The generally low standing crop (< 10,000/L cells) in June has jumped to levels two orders of magnitude higher between late July and late September in the Subarctic Zone, whereas the seasonal difference in the Transitional Zone stayed within one order of magnitude, with the summer population of ca. 100,000/L cells.

Similar to the Bering Sea flora, the Pacific Subarctic flora was dominated by *E. huxleyi* and *C. pelagicus*. A sporadic occurrence of abundant *C. caudatus* was also common to both floras. Nannoflora of the northern Transitional Zone showed high diversity with common to abundant occurrences of *Syracosphaera* spp., *Calyptrolithophora* spp. and *Rhabdosphaera clavigera*. Standing crop was generally the highest in 25-50 m water depth, and the population density was often two orders of magnitude higher than the surface level. Moreover, the floral composition differed significantly between these water depths at some stations.

Multiple year studies of sediment trap samples have revealed significant annual variations in carbonate flux in subarctic regions (ex. Takahashi et al., 1996). As a result of this study, it is now obvious that the cause of the annual variation is a combined effect of regional (basin wide) and local variances. For an accurate estimation of total carbonate flux in the world subarctic realm, multiple intrabasinal geographic coverage of sediment traps is needed. Also the significant subsurface concentration of coccospheres in areas where the surface waters are devoid of the cells may require some adjustment for the interpretation of remote sensing data.

Miocene Calcareous Nannofossil Magnetobiostratigraphy and Biochronology

Alyssa M. Peleo-Alampay

Scripps Institution of Oceanography, University of California, San Diego
La Jolla, CA 92093-0208 USA.
now at National Institute of Geological Sciences, University of the Philippines
Diliman, Quezon City, Philippines 1101. E-mail: ampa@nigs01.cs.upd.edu.ph.

Fifty three calcareous nannofossil events of the middle to upper Miocene are investigated in eleven DSDP/ODP sites from the low to mid-latitude Atlantic, Pacific and Indian Oceans. Nannofossil datums are calibrated with magnetostratigraphy at each site and numerical ages are assigned based on the geomagnetic polarity time scale. This allows a comprehensive evaluation of the nannofossil datums in terms of their numerical ages and their consistency and reliability for stratigraphic correlation on a global scale.

The following middle to late Miocene datums are shown to be the most reliable: the last occurrence (LO) of *Discoaster quinqueramus*, the LO of *Amaurolithus amplificus*, the first occurrence (FO) of *Amaurolithus amplificus*, the LO of *Reticulofenestra rotaria*, the FO of *Reticulofenestra rotaria*, the LO of *Discoaster hamatus*, the FO of *Amaurolithus primus*, the FO of *Discoaster hamatus*, the FO of *Catinaster calyculus*, the FO of *Discoaster bellus* group, the FO of *Catinaster coalitus*, the LO of *Coccolithus miopelagicus* >13=B5m, the LO of *Cyclicargolithus floridanus*, the LO of *Triquetrorhabdulus serratus*, and the LO of *Calcidiscus premacintyrei*. Significantly different ages from those commonly used in the literature are shown for the following datums: the LO of *Discoaster loeblichii*, the FO of *Discoaster quinqueramus/D. berggrenii*, the LO of *Discoaster bollii*, the LO of *Discoaster hamatus*, the FO of *Minylitha convallis*, the FO of *Discoaster hamatus*, the LO of *Discoaster kugleri*, the FO of *Catinaster coalitus*, the LO of *Coccolithus miopelagicus* and the FO of *Discoaster kugleri*. Several datums (the FO of *Minylitha convallis*, the FO of *Discoaster neohamatus*, the LO of *Catinaster coalitus* and the FO of *Discoaster bollii*) show diachroneity across different regions or oceans. Two new datums are proposed: the LO of *Discoaster formosus* in subchrons C5r.2r/C5An.1n (11.3 Ma) and the LO of *Helicosphaera rhomba* in chron C5r (11.3 Ma).

Unusual Oligocene *Braarudosphaera*-rich Layers of the South Atlantic and Their Paleoceanographic Implications

Alyssa M. Peleo-Alampay

Scripps Institution of Oceanography, University of California, San Diego
La Jolla, CA 92093-0208 USA
now at National Institute of Geological Sciences, University of the Philippines
Diliman, Quezon City, Philippines 110. E-mail: ampa@nigs01.cs.upd.edu.ph

The origin of the Oligocene *Braarudosphaera* layers over large ocean basins has remained a mystery since the question was raised almost three decades ago by the Deep Sea Drilling Project. Results from a detailed micropaleontologic study coupled with oxygen and isotope data from Sites 363 and 522 in the South Atlantic have shed some new light on this question. The first quantitative *Braarudosphaera* abundance data collected in this study correlate with oxygen isotope curves and suggest that *Braarudosphaera* preferred cold waters. Variations in the relative abundance of sphenoliths (warm water taxa) and longer *C. pelagicus placoliths* indicate colder water conditions during times of elevated *Braarudosphaera* deposition. Upwelling and mid-ocean overturn of cold, nutrient-rich, low salinity water are inferred as possible paleoceanographic mechanisms for the deposition of *Braarudosphaera* layers.

Early-Middle Toarcian Calcareous Nannofossils of San Andrés and Camino Sections (Cuenca Vasco-cantábrica, Spain)

Nicola Perilli

Dipartimento di Scienze della Terra, PISA, ITALY. E-mail: perilli@dst.unipi.it

This study is focused on calcareous nannofossil biostratigaphy of lower and middle Toarcian platform deposits cropping out in the western sector of the Cuenca Vasco-Cantábrica (northern Spain). The continuous and nicely exposed San Andrés and Camino sections are located in the Reinosa area (Santander province of Cantabria Community).

The investigated successions span from Tenuicostatum to Variabilis Zones, and consist of thin to mediumly bedded alternating marstones and limestones. These sediments contain nicely preserved and continuous ammonite assemblages, which provide a refined biostratigraphic framework.

This study is based on more than 150 closely-spaced samples, mainly collected from marlstones and marly limestones. Semiquantitative analysis carried out with a light polarizing microscope revealed rare to common and medium to poorly preserved nannofossil assemblages. The samples from the lower portion of both sections yielded the most abundant, diversified and best preserved assemblages.

Among the others, the following calcareous nannofossil events are easily detectable: LCO of *Mitrolithus jansae*, FO of *Carinolithus superbus*, FO of *Discorhabdus striatus* and LCO of *Lotharingius hauffii*. The identified events are calibrated with the ammonite Zones, and correlated to the early-middle Toarcian biohorizons recognized in the Cordillera Iberica.

Calcareous Nannofossil Biostratigraphy of Early and Middle Toarcian from the Cordillera Iberica and Cuenca Vasco-Cantábrica (Spain)

Nicola Perilli[1] and Antonio Goy[2]

[1] Dipartimento di Scienze della Terra, Università degli Studi di PISA, ITALY. E-mail: perillia@dst.unipi.it
[2] Departamento de Paleontología, Universidad Complutense, de MADRID, SPAIN

A calcareous nannofossil biostratigraphy was performed on lower and middle Toarcian deposits from Spain. The investigated sections crop out in the central sector of the Cordillera Iberica (Rambla del Salto and La Almunia De Doña Godina-Ricla sections) and in the western sector of the Cuenca Vasco-Cantábrica (San Andrés and Camino sections). The studied platform deposits consist of thin to mediumly bedded alternance of marlstones and limestones. In both areas, the sediments contain quite common and nicely preserved ammonite assemblages, which allow to recognize and give a detailed definition of the Tenuicostatum, Serpentinus, Bifrons and Variabilis Zones and their Subzones.

In these sections, more than 400 closely-spaced samples, mainly from marlstones and marly limestones, were collected. Semiquantitative analysis performed with a light polarizing microscope points out an excellent and continuous succession of nannofossil assemblages from early to middle Toarcian. The identified calcareous nannofossil events are calibrated to the ammonite biostratigraphy, and compared to the early and middle Toarcian biohorizons recognized in other Tethyan and Boreal areas.

Ceramic Nannopalaeontology

Patrick Sean Quinn

University of Sheffield, ENGLAND. E-mail: prp95psq@sheffield.ac.uk.

Nannofossils are a relatively common component of Bronze Age archaeological ceramics from the Southern Aegean, but have been more or less ignored by ceramicists, perhaps due to their extremely small size, which is beyond the resolution of most petrographic microscopes. Nevertheless these minute calcareous inclusions have several advantages over the more conspicuous microfossils such as foraminifera and ostracodes as a means of characterizing, grouping and provenancing ceramics. The following paper outlines the methodology by which calcareous nannoplankton can be studied in ceramics and discusses the many difficulties involved in looking at microfossils from archaeological material, as well as presenting several case studies from an ongoing research project at the University of Sheffield.

Sequence Biostratigraphy of a Shallow Marine Environment: Campanian and Maastrichtian Sediments of South Carolina, U.S.A.

Jean M. Self-Trail and Gregory S. Gohn
U.S. Geological Survey, Reston, Virginia 20192, U.S.A. E-mail: jstrail@usgs.gov

Calcareous nannofossil biozones are used with core and geophysical-log data to identify and map subsurface Cretaceous depositional sequences in the South Carolina Coastal Plain. The processes controlling taxon ranges and depositional-sequence boundaries in marine sediments are not independent; calcareous nannofossil zonal boundaries occur at sequence boundaries where shelf sands are the basal deposits and above sequence boundaries where nearshore basal deposits are preserved. The Coachman Formation (oldest), Bladen Formation, and overlying Donoho Creek Formation (youngest) consist of six Campanian depositional sequences. Sediments near the base of the oldest depositional sequence contain the first appearance of Ceratolithoides aculeus, and therefore the two older sequences are assigned to calcareous nannofossil Zones CC 19 and CC 20. The base of the third-oldest sequence is approximated by the first appearance of *Quadrum sissinghii*, and sediments at the top of the Donoho Creek record the last appearances of *Reinhardtites anthophorus* and *Reinhardtites levis*. Accordingly, the younger four sequences are assigned to calcareous nannofossil Zones CC 21 and CC 22. Of these four sequences, the older two are separated from the younger two by an unconformity marked by the first appearance of *Quadrum trifidum*. In sequences where basal, nearshore, bedded-sand deposits are preserved above the basal unconformity, calcareous nannofossil zonal boundaries tend to occur above, not at, the sequence boundary in overlying deeper water muds (maximum flooding deposits).

Nannofossil assemblages are more diverse in the deep water muds, whereas holococcoliths tend to dominate the nannofloras in the nearshore sands. In contrast, calcareous nannofossil zonal boundaries tend to occur at sequence boundaries where basal homogeneous quartz-glauconite shelf sands overlie the unconformity. The top of the Donoho Creek Formation is truncated by a major unconformity that encompasses the Campanian-Maastrichtian boundary (Zones CC 23 and CC 24 are absent) and is traceable throughout the South Carolina Coastal Plain, using both calcareous nannofossil biostratigraphy and lithologic data from cores and geophysical logs. Division of the Maastrichtian Peedee Formation into two mappable sequences is facilitated by the coincidence of the first appearance of *Lithraphidites quadratus* with an extensive subsurface cemented zone (unconformity) that is present in the northeastern part of the South Carolina Coastal Plain. The Campanian and Maastrichtian depositional sequences and their corresponding calcareous nannofossil biozones have been traced across South Carolina and into neighboring states. Observed patterns of Late Cretaceous deposition and erosion tend to vary on a broadly regional basis, thereby facilitating regional analysis.

Biostratigraphy of the Genus *Scyphosphaera*

William G. Siesser

USA. E-mail: siesser@ctrvax.vanderbilt.edu

Scyphosphaerids are frequently found in low-latitude Miocene-Pliocene sediments. The genus first evolved in the early Eocene (Zone NP12), but abundance and diversity remained low until middle Miocene Zones NN5-NN6, when global radiation began. More new species (24) evolved during the Miocene NN5-NN6 and NN9 zonal intervals than at any other time. The abundance acme for the genus is the late Miocene (NN9)-late Pliocene (NN15) interval. Diversity peaked in early Pliocene Zones NN12 and NN13, with 31 extant species. Abundance and diversity began to decline markedly in the late Pliocene, with a first wave of extinctions occurring in late Pliocene Zone NN16B. A second wave of extinctions began in late Pleistocne Zone NN20. Only two scyphosphaerid species live in the oceans today.

Palaeobiogeography of Early Cretaceous Calcareous Nannoplankton

Christianne Street and Paul R. Bown

Department of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, UK
E-mail: c.street@ucl.ac.uk; p.bown@ucl.ac.uk

Distinct palaeobiogeographic distributions have been postulated for numerous Early Cretaceous calcareous nannofossil taxa, although these are based largely on qualitative observations. Species are commonly labeled 'boreal' or 'tethyan', and more recently bipolar distributions have been observed, as well as taxa with restricted southern high-latitude, i.e. austral, distributions. In this study we have attempted to quantify biogeographic differentiation through the Early Cretaceous. A transect of sites, mainly from the Atlantic Ocean, provides a North-South sample set. Additional samples sites from the Southern Hemisphere have been studied for comparison. Quantitative assemblage data have been gathered from each site for seven time-slices (Berriasian to Aptian), determined by well-established nannofossil datums. The data have been analyzed in a number of different ways, including 1) latitudinal relative abundance plots, which allow comparison with extant data sets, e.g. McIntyre and Bé, 1967, and Okada and Honjo, 1973; and 2) principal components analysis and other statistical techniques, providing a more objective measure of biogeographic differentiation.

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Summary of the Nannofossil Gulf Coast Equivalency Project

Michael J. Styzen and Terri Dunn

Shell Offshore Inc., Room: OSS-3202, P.O. Box 61933, New Orleans LA 70161
E-mail: mstyzen@shellus.com. Phone: (504) 728-4308

The Gulf Coast Equivalency Project is an ongoing project authorized by GCSSEPM. The goal of the project is to produce a publication reconciling all Gulf Coast biostratigraphic zonations. Most industry and academic biostratigraphers working this region have attended our first four meetings and/or participated through our list server. We generally focus on a specific lineage or family/genus grouping and discuss our various interpretations. We have discussed the *Discoaster quinqueramus/Discoaster berggrenii* lineage in detail. Mike Styzen, the nannofossil coordinator, has sketched all of the lineage members used as biostratigraphic markers by all participants and noted the terminology each uses for these morphotypes.

The official focus of the project is the Oligocene to Recent section. The nanno group agreed to use Mike Styzen's published chart, Late Cenozoic Chronostratigraphy of the Gulf of Mexico, as a starting template for stratigraphic discussion. We have discussed definitions and stratigraphic placement of the Oligocene-Recent marker species of many genera. These include *Helicosphaera, Gephyrocapsa, Pseudoemiliania, Reticulofenestra, Dictyococcites,* and *Sphenolithus*. In addition to the *D. quinqueramus* lineage, most other biostratigraphically useful Neogene Discoasters have been discussed. We have covered *Cyclicargolithus* to a lesser extent.

Most recently we have begun compiling original definitions of marker species and adding the modifications of these definitions that we use in the Gulf Coast. Mitch Covington has established a list server and he is also responsible for the database compilation. Ralph Solomon has agreed to make photographs from his web site available for use in the project. Our publication will include data compilation and photographs of marker and other significant species. The format of this publication has not yet been decided.

In addition to our Oligocene-Recent project, we have recognized that the industry will encounter Cretaceous section in future Eastern Gulf and in the " Ultra Deep Play " in Gulf of Mexico exploration. In November 1997, Professor David Watkins from the University of Nebraska presented a week long workshop at Shell in New Orleans for industry biostratigraphers and coordinators. As the scope of exploration in the Gulf of Mexico expands to include the Cretaceous, it is likely that we will expand the scope of our equivalency project to include discussion of Cretaceous taxa.

Evidence of the *Braarudosphaera*-rich Sediments in the Turonian of the Bohemian Cretaceous Basin, Czech Republic

Lilian Švábenická

Czech Geological Survey, 118 21 PRAGUE, CZECH REPUBLIC. E-mail: svab@cgu.cz

Nannofossil assemblages enriched in *Braarudosphaera bigelowii* were observed in the Turonian epicontinental marine sediments of the Bohemian Cretaceous Basin in the Upohlavy quarry, NW part of the Czech Republic. Calcareous mudstones exposed at the bottom of the section yield rich and well preserved nannofossils with *Lithastrinus moratus* and *Marthasterites furcatus* giving evidence for the Late Turonian, CC13 Zone sensu Burnett (1996). Specimens of *B. bigelowii* were not observed there.

Above, *B. bigelowii* appears abruptly at the base of a rhythmically bedded succession of carbonates (7.5 m in thickness - see Èech et al., 1996). Its relative abundance fluctuates between 1% and 5%. At the same horizon, character of nannofossils is distinctly changed. Assemblages with reduced species diversity contained also *Kamptnerius magnificus* and *Lucianorhabdus maleformis* in higher quantities. In contrast, *Marthasterites furcatus, Lithastrinus moratus* and "fragile" nannofossils, such as representatives of the family *Stephanolithiaceae* and related genera disappear.

According to Uliènỳ (in Èech et al., 1996), the underlying mudstones represent transgressive systems tract. The basal surface of the carbonate succession is interpreted as the maximum flooding surface. The limestone succession can be regarded as a condensed section at the base of a highstand systems tract. The upward decrease in $CaCO_3$ content across the carbonate succession is explained to result from progressive dilution of pelagic component by fine-grained terrigenous material, during deceleration of sea-level rise or stillstand in sea level. The *Braarudosphaera* enrichment and the reduced diversity in nannofossil assemblages well reflect this change in the paleoenvironmental conditions. The input of terrigenous material probably triggered the abrupt *Braarudosphaera* bloom.

Both species *M. furcatus* and *L. moratus* manifest their inconvenience to be useful markers for precise biostratigraphic conclusion. It appears that their presence is strongly influenced by lithological character of sediments.

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Modern Nannoflora from Off the Coast of Western Australia

Kyoma Takahashi

Earth and planetary material sciences,
Graduate School of Science, Hokkaido University
tel:+81-11-716-2111ex.3519 fax:+81-11-746-0394
kyoma@cosmos.sci.hokudai.ac.jp
URL:http://strati.sci.hokudai.ac.jp/members/kyoma/index.htm

Distribution of modern calcareous nannoplankton was studied off the coast of western Australia by analyzing 191 filter samples. These samples were collected from 0-200 meter water depth at 33 stations during a scientific cruise of R/V Franklin (CSIRO Australia) on 21 Feb. - 6 Mar. 1996.

A total of 95 taxa was observed by SEM observation of 118 samples in which nannoplankton are common, and the presence of the upper and lower photic flora was evident as have been documented in previous studies.

Association characteristics of the fourteen major taxa were analyzed and five groups were identified. These are, Group A: *U. irregularis* abundant and no lower photic taxa existed; being common in shallower samples of low latitude area. Group B: abundant *G. oceanica* coexisting with lower photic taxa and having characteristic distribution pattern. Group C1: common association of *D. tubifera*, *R. clavigena stylifera* and *U. tenuis* without any lower photic taxa; occurring in shallower depth of the higher latitude. Group C2: cooccurrence of *E. huxleyi*, *G. ericsonii*, *Syracosphaera spp.*, Holococcolithophores and *U. hulburtiana* with some lower photic taxa being common in shallower depth of the higher latitude. Group D: association of *F. profunda*, *O. fragilis cavum*, *G. flabellatus* and *A. oryza*; its common occurrence limited in deeper water.

In the upper photic community, the relative abundance of A/(A+C1+C2) had clear positive and negative correlations with temperature and salinity, respectively. In the lower photic community, the value D/(D+C2) stays in lower level as long as the three nutrients, phosphate, nitrate and silicate, are in lower concentration. The value, however, becomes variable with some high points in samples with higher nutrient levels. Meanwhile the occurrence of Group B had no correlation with oceanographic environmental parameters including these three nutrients.

Late Quarternary Nannofossil Assemblages in the Transitional Northwestern Pacific Ocean

Yuichiro Tanaka

Geological Survey of Japan
e-mail: yuichiro@gsj.go.jp

Coccolith assemblages from two core collected in the Shatsky Rise (32°19.8'N, 157°51.0'E, depth of 2612 m) and the Hess Rise (34°11.7'N, 179°15.4'E, depth of 2664 m) have provided information on characteristics of the water masses. Two core sites are located on the Kuroshio front region from the boundary between the subtropical and the transitional water masses.

In two cores coccolith shows the glacial and interglacial cyclicity with major changes in assemblages and abundances. The coccolith assemblages during the last 200 kyr are dominated by small placoliths (*Emiliana huxleyi* and *Gephyrocapsa spp.*) and *G. muellerae*. The reversal in dominance between small *Gephyrocapsa* and *E. huxleyi* was identified in the isotope stage 5. *E. huxleyi* shows a regular increase, whereas small *Gephyrocapsa* radical decreases in abundance. *G. muellerae* and *Calsidiscus leptoporus* show higher fluxes in the north of the Kuroshio front based on time series sediment traps around Hess Rise (Tanaka, 1995). *Florisphaera profunda* is generally abundant in low latitude region within the lower photic zone from 10° C to 28° C (Okada and McIntyre, 1979) . In the sediment traps around Hess Rise, this species occurs only at latitudes lower than 35° N. Reversely, Coccolithus pelagicus occurs at latitudes higher than 37.5° *N. G. muellerae* is dominant at the glacial stages 2, 4, 6, and *C. leptoporus* are abundant during interglacial stages 1, 5, 7 at two cores. In the interglacial stage abundances of *C. leptoporus* are comparable to modern values. *F. profunda* is also abundant in interglacial stages and occurs 2 to 8 % in abundance during glacial stages. In two core sites, therefore, suggest north-south displacement of the transition zone water mass throughout the past 200 kyr, but the integrity of the Kuroshio branch region has been maintained.

Paleobiology of the Pelagic Realm

Hans R. Thierstein[1], Jörg Bollmann[1], Mara Cortés[1], Ali Haidar[1], Heinz Hilbrecht[1], Michael Knappertsbusch[2], David Lazarus[3], K. von Salis Perch-Nielsen[1], Cinzia Spencer-Cervato[4]

[1]Geological Institute, ETH-Zentrum, CH-8092 ZURICH, SWITZERLAND.
E-mail: thierstein@erdw.ethz.ch, mara@erdw.ethz.ch
[2]Natural History Museum, Augustinergasse 2, CH-4001 Basel, Switzerland
[3]Institut für Paläontologie, Humbolt-Universität, Invalidenstrasse 43, D-10115 Berlin, Germany
[4]Department of Geological Sciences, University of Maine, Orono, ME 04469-5764, USA

Global change issues are successfully being tackled by analyses and models of the physical and chemical processes occurring on various timescales in the Earth system. What have systematic biology, functional ecology, and paleobiology to contribute to Earth System Science? What are the issues, theories and approaches?

With the development of data bases and computer-aided morphometric methods, new opportunities arise for paleobiological analyses on ecological as well as evolutionary time scales. In the micropaleontology group at the ETH attempts are being made to link the information gained from analyses of living phytoplankton dynamics at the JGOFS time-series stations at Bermuda and Hawaii to the geological record preserved in deep-sea sediments.

The example of biodiversity and its potential controls is used as a model to address some fundamental issues of ecology as well as evolution.

On ecological timescales, Ali Haidar and Mara Cortés have correlated the multi-annual coccolithophore cell density variability throughout the photic zone with the variability of various environmental parameters measured by JGOFS scientists. Their results suggest, that between 45-89% of the cell density changes can be explained by abiotic processes (bottom-up control) and the remainder possibly by biotic interactions (e.g. grazing, competition, infections, etc.)

On the longer evolutionary timescales, analyses of longevity of major skeletonized plankton groups using our Neptune microfossil data base, have revealed surprising results. The average geological age of recent species in the four major plankton groups (coccolithophores, diatoms, foraminifera, radiolaria) is between 13.4-23 Ma, i.e. much older than generally assumed. If three long-term coccolithophore survivors (*Braarudosphaera bigelowii, Scapholithus fossilis, Coccolithus pelagicus*) are excluded, the range narrows to 13.4-15.0 Ma, which is surprisingly small, considering the vastly different life strategies of the four groups.

Numerous coccolith species show distinct morphological variability in the living plankton, in Holocene sediment assemblages and in the older sediment records. To what extent the observed patterns are phenotypic (environmental adaptations) and/or genotypic (genetically distinct) is still an open question. A combination of culture experiments of monoclonal coccolithophores under various growth conditions and analyses of their molecular genetics may provide answers.

Calcareous Nannofossil Biostratigraphy of the Oligo-Miocene Mollassic Succession of Korca Depression, Southeastern Albania

Kico Vathi and Xhevdet Islami

Instituti Gjeologjik i Naftes
Fier, ALBANIA

The Depression of Korca represents the extension towards the north of the Mesohellenic basin in the Albanian territory. The oligo-miocene succession is transgressive on the basement composed of the ophiolites, cretaceous-eocene limestones and the flysch of the Krast-Cukali zone. In this series several formations of local value have been distinguished.

The Middle Oligocene is characterized by coarse deposits including conglomerates, sandstones, biodetritic limestones and silts. Their shallow origin (delta-shelf) is also proven by the presence of the macrofauna and the neritic fauna. The Late oligocene consists of turbidites showing a predominance of the massive sandstones and conglomerates. Successively, the same character of the sedimentation continues in Aquatinian and the lower part of the Burdigalian. The upper part of the Burdigalian and the Langhanian are marked by the bluish marls rich in plankton. The lacustrine plio-pleistocene deposits are transgressive and contain only rare Ostracoda and Charophyta.

The calcareous nannofossil assemblages observed in the Mesohellanic basin are very similar to those of the Ionian zone. The abundance depends on the marine environment and the sort of sediment. Thus, the Middle Oligocene assemblages are very poor and generally of small size. Gradually, the depth increases and the associations become more abundant, reaching the maximum in the upper part of the Burdigalian and Langhanian. At the top of the series, an unusual predominance of *Braarudosphaera* and *Micrantolithus* announces the filling up of the basin.

In terms of Martini (1971) biozonation, the mollasic deposits of the Korca Depression include the interval of NP 24-NN 5 zones. The absence of *Triquetrorhabdulus carinatus* and *Discoaster druggi* makes it difficult to distinguish the Early Miocene zones, so other events have been used.

Multivariate Analysis of Calcareous Nannoplankton and Stable Isotopic Study in the Upper Campanian - Lower Maastrichtian of the Campos Basin (SE Brazil)

Luiz Carlos Veiga de Oliveira[1], René Rodrigues[1], Valesca Brasil Lemos[2], Ricardo Ayup-Zouain[2], and Ivanise Maria Wolff[2]

[1] PETROBRAS/CENPES/DIVEX/SEBIPE, Pd. 20, Cid. Universitária, Quadra 7, 21949-900, RIO de JANEIRO, RJ, BRAZIL. E-mail: lcveiga@cenpes.petrobras.com.br.
[2] Instituto de Geociências/UFRGS, Campus Vale, Av. Bento Gonçalves 9500, 91509-900, P. ALEGRE, RS, BRAZIL

Multivariate analysis was applied to nannofossils from 18 meter core drilled within an upper Campanian - lower Maastrichtian section composed of hemipelagic shales and marls. Identified biozones included CC-23a, CC-22b and CC-21 after the zonal scheme of Sissingh (1977). A hiatus is suggested by the absence of zone CC-22a. According to biostratigraphic correlations, absolute age estimates (Harland et al., 1989) and relative sea-level curves (Haq et al., 1987), the bottom of the cored section was deposited approximately at 76.5 M.a, and the top at 73.8 M.a ago. The hiatus represents an erosional / non depositional time of about 1 M.a (75.7 - 74.7 M.a).

Multiple regression helped to determine the best counting method. Nineteen nannofossil groups have been quantified, up to a cutoff of 200 specimens per sample. Fifty-seven samples with 30 cm spacing have been analyzed. *Watznaueria barnesae* and *Micula decussata* dominate the fossil assemblage and show inverse abundance in relation to each other.

Q-mode factor analysis (57 samples, 19 variables) shows that two factors explain 99.2% of the total variance in the microfossil assemblage. The first factor represents 83.6% of the total variance, and the second factor only 15.6%. The first is associated with *Watznaueria barnesae*, *Cribrosphaerella ehrenbergii* and *Stradneria crenulata*, and probably represents the original nannoplankton population. The second factor is associated with *Micula decussata*, and is interpreted to reflect nannofossil dissolution. Both factors were used to develop a depth-related dissolution curve for nannofossils, which emulates a 4th to 5th order sea-level curve.

The interval corresponding to biozone CC-21 shows the highest dissolution rates and great amplitude oscillations in the oxygen isotope curve. The latter suggests that diagenesis affected the oxygen cycle, but not the carbon cycle. The top of the studied interval corresponds to a sea-level fall responsible for the hiatus, which is well marked in the oxygen isotope curve.

The phase of relative lowstand and reduced dissolution (CC-22b and CC-23a) corresponds to more homogeneous oxygen isotope values. These, however, present locally remarkable negative shifts, covariant with carbon isotope values, which suggest that diagenetic events affected both carbon cycle (sulphate-reduction) and oxygen cycle (subsurface diagenesis).

The general behavior of the oxygen isotope curve points out to a decrease in temperature of ocean waters from late Campanian to early Maastrichtian during the 2.7 Ma time span recorded in the cored section.

Quaternary and Miocene Thoracosphaera in the Ross Sea (77° S Latitutde)

Giuliana Villa[1] and Sherwood Wise[2]

[1] Cape Roberts Scientific Par, ITALY. E-mail: Geol01@ipruniv.cce.unipr.it
[2] Department of Geology, 4100 Florida State University, Tallahassee, FL 32306-4100 USA.
E-mail: Wise@gly.fsu.edu.

Ice-based drilling in the Victoria Land Basin of the southwestern Ross Sea during the first season of the Cape Roberts Project (October, 1997) has recovered *Thoracosphaera* (a calcareous dinoflagellate) in small but consistent numbers in Quaternary sediments (1.6-1.0 Ma according to diatom stratigraphy) as well as in equally small numbers in lower Miocene sediments (including their contained sedimentary clasts). No other calcareous nannofossils were found throughout the 147-m core; similarly, no other nannofossils been have reported previously from the Quaternary of the margins or shelves of East Antarctica. The Quaternary *Thoracosphaer*a occur as well-preserved fragments up to 40 microns in a peculiar 2-m-thick, carbonate-rich fossiliferous sequence that is essentially a hash of invertebrate macrofossil shells within an otherwise clastic-rich glacial or glaciomarine sequence. Part of the material has been winnowed and other parts not. The best preservation and more abundant occurrences of these microfossils were recorded in the finest sediments, which is an unwinnowed mud. Two samples from winnowed material were barren.

Thoracosphaerids have been described from the Eocene of the Ross Sea and are known to have bloomed shortly after the K/T boundary event in the peculiar environment of the Strangelove oceans in several parts of the world. Like calcareous nannofossils, dinoflagellates (and presumably calcareous dinoflagellates) as a group prefer warmer waters.

As the late Neogene/Quaternary were times of rapid climatic change, such conditions may have favored the presence of thoracosphaerids as opposed to other calcareous nannoplankton. The presence of thoracosphaerids in the Quaternary, therefore, could suggest either a peculiar adaptation to this environment, due to their ability to develop cysts, or to warmer conditions at the time of their deposition, or a combination of both.

Recent Distributions of Calcareous Dinoflagellates in the South Atlantic and Their Potential Use in Palaeoecology

Annemiek Vink, Karin Zonneveld and Helmut Willems

Fachbereich 5 - Geowissenschaften, University of Bremen Postfach 33 04 40,
D-28334 BREMEN, GERMANY. E-mail: vink@micropal.uni-bremen.de; willems@micropal.uni-bremen.de

Dinoflagellates are generally unicellular algae and live in most aquatic environments. Approximately 10% of all living dinoflagellate species produce geologically preservable cysts as an important part of their life cycle. These cysts are generally organic walled and are extremely resistant to degradation, although a few dinoflagellate taxa incorporate calcite into their cyst wall (i.e. the calcareous dinoflagellates). In addition, the calcareous walled vegetative coccoid *Thoracosphaera heimii* is preserved in the sediment. As many cysts are species-specific, cyst associations found in sediments are considered to represent the dinoflagellate community present in the upper water column at the time of deposition. The spatial distribution of motile dinoflagellates in the upper water column of the oceans is dependent on environmental factors such as temperature, salinity, nutrient content and the availability of light. As such, we can therefore use fossil dinoflagellate cysts as tools for reconstructing palaeoenvironment, palaeoclimatology, palaeoecology and palaeoceanography.

Even though the calcareous forms overwhelmingly dominate the total dinoflagellate cyst flux into the sediment (concentrations of several millions of cysts per gram of sediment are not uncommon), the ecological information concerning these dinoflagellates is extremely limited and their use as palaeoenvironmental indicators has only started to develop in the last couple of years. Recent studies suggest that enhanced abundances of calcareous dinoflagellates occur when the productivity is low, i.e. in oligotrophic water conditions. However, a more detailed knowledge of the ecological preferences of each dinoflagellate species must be obtained. For these purposes, a comparison between calcareous cyst and *Th. heimii* distributions in the surface sediments from different regions of the South Atlantic and the environmental characteristics of the overlying water column (i.e. temperature, salinity, nutrient content) is made in the scope of the current study. In doing so, the effects of transport and preservation of cysts and *Th. heimii* should not be overlooked (for example, calcite may partially or totally dissolve at depths below the lysocline or Calcium Compensation Depth respectively). Studies as these provide a basic skeleton of ecological information on which the analysis of Quaternary sequences should be based.

Microfossils Help in Deciphering a Complex Metamorphic and Paleogeographic Enigma

S. Volin,[1] Y. Eshet[2], H. Kisch[1]

[1] Dept. of Geology and Mineralogy, Ben- Gurion University, Beer-sheva 84105, ISRAEL.
E-mail: yoram@mail.gsi.gov.il
[2] Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem 9550, ISRAEL

Microfossils help of deciphering a complex metamorphic and paleogeographic enigma The Hatrurim Formation in Israel forms a meta-sedimentary sequence, of colorful, mainly reddish and black carbonates. Its mineralogy indicates a high-temperature thermal metamorphism. It is commonly suggested that the unit formed from the thermal metamorphism of Campanian-Maastrichtian organic-rich layers that were combusted and burned, probably during the Tertiary. The metamorphism probably occurred in foci of different sizes, in which temperature in the center was the highest, whereas toward the margins of the focus, temperature dropped. Until recently, most studies of the formation focused on the high- temperatures mineralogy, and very little is known about the low-temperatures part of this event, since there are very little mineralogical changes there, and the organic matter is almost completely missing. This is why most studies in the past failed to reconstruct the shape and size of combustion foci. The present research deals with the reconstruction of combustion foci and the metamorphic halo in their margins, with a special emphasis on the reconstruction of the low-grade metamorphic levels. Assuming that the composition and preservation of the microfossil assemblage in the metamorphic rock reflects the metamorphic process, optical and structural changes in organic and calcareous-walled microfossils were used to characterize the low- grade metamorphic changes, and to draw isograde lines that reconstruct combustion foci. The authors developed or used existing optical methods in this paleometamorphic reconstruction: 1. Structural changes in calcareous nannofossils: the method is based on the rate of elimination of calcareous nannofossil taxa during the metamorphic process. The following parameters are analyzed: Species diversity: a gradual decrease in species diversity with increasing metamorphism is observed, until only nannofossil "ghosts" are left. Number of specimens: parallel to the decrease in species diversity, a decrease in number of nannofossil specimens is observed. Change in optical properties: As a result of the metamorphic process, crystals undergo a reorganization. This results in the creation of new optical properties for calcareous nannofossil taxa. 2 . Thermal Alteration Index (TAI): a method based on the fact that organic matter in rocks (pollen, algae and spores) undergoes a process of darkening with the increasing thermal alteration. It is calibrated to the vitrinite reflectance method and can be used to detect low-temperature metamorphism in a high-resolution.

Jurassic Nannofossil Ecology and Environmental Cycles: Preliminary Results

E. Benedict Walsworth-Bell[1], Paul R. Bown[1] and Graham P. Weedon[2]

[1] Department of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, UK.
E-mail: b.walsworth-bell@ucl.ac.uk; p.bown@ucl.ac.uk
[2] Department of Geology, The University of Luton

A striking feature common to many Mesozoic pelagic sequences is the occurrence of rhythmic bedding. Many of these cycles display periodicity at Milankovitch frequencies. Such cycles in pelagic carbonates typically record variations in primary productivity. Fluctuations in marine phytoplankton productivity are driven by shifting temperature and fertility gradients, associated with the changes in global climate linked to metronomic perturbations in the Earth's orbital geometry. Nannoplankton constituted an important component of Mesozoic phytoplankton, and nannofossils are useful indicators of the physical and chemical conditions of the surface waters in which they lived; nannofossil assemblages thus provide a basic tool in the investigation of such cyclicity.

The primary aim of this project is to examine the quantitative distribution of calcareous nannofossils through Jurassic sedimentary sequences which exhibit clear environmentally-forced cycles, in order to establish patterns of stratigraphic distribution, and interpret these in terms of surface-water environments. The Belemnite Marls Formation (Lower Pliensbachian) has been chosen for initial study because of its well-documented sedimentary cyclicity (Weedon and Jenkyns, 1990) and well-preserved nannofossil assemblages. Preliminary results, presented here, suggest that the cyclic nature of the lithology is essentially mirrored by in-phase changes in nannofossil content (e.g. *Schizosphaerella punctulata*). Closely-sampled nannofossil assemblages will be characterised in terms of palaeocommunity composition (e.g. diversity/relative abundance of taxa). These datasets will be studied with reference to sedimentological/geochemical data, allowing ecological controls on specific taxa of Jurassic nannofossils to be identified. They will also be subjected to time series analysis, in order to test for the regular cyclicity that is diagnostic of orbital forcing. The identification of Milankovitch cycles and their frequencies may prove useful for high-resolution correlation of Jurassic sequences across wide geographical areas. As such the results may potentially be of great stratigraphical, as well as palaeoecological, value.

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High Resolution Sequence Biostratigraphy with Calcareous Dinoflagellate Cysts, Coccoliths and Foraminifera in the Cenomanian (Paris basin).

Jens Wendler, Kai-Uwe Grafe, Hartmut Mai, Helmut Willems

Fachbereich Geowissenschaften, Universität Bremen, Postfach 33 04 40, 28334 BREMEN, GERMANY
e-mail: wendler@uni-bremen.de

A high resolution study focusing on the distribution and absolute abundances of calcareous dinoflagellate cysts was carried out to improve our understanding of Late Cretaceous orbital forcing (21 ka precession period) of chalk-marl sedimentary cycles. The results of this study were compared to the distribution of coccoliths and planktic and benthic foraminifera.

The studied subcycle forms part of a Middle Cenomanian section of the London-Paris Basin and is composed of rhythmically alternating grey chalk with chalky marl and claystone. The section (Escalles, S of Calais, NW France) is situated in a central, outer shelf position of this epicontinental basin. The complete Cenomanian/Turonian profile was interpreted in terms of biostratigraphy and sequence stratigraphy by ROBASZYNSKI & AMEDRO 1993.

The aim of the present study is to investigate high frequency cycles with respect to the calcareous dinoflagellate cyst content. The species spectra and the absolute abundances of specimens were analysed in detail. Calcareous dinoflagellate cysts are subdivided into subfamilies according to their wall structure. Orthopithonelloid forms show a strict radial calcite crystal orientation, pithonelloid forms show a uniformly declined crystal orientation and obliquipithonelloid forms are marked by a randomly oblique crystal orientation.

The investigated sedimentary cycle is, excluding two exceptions, dominated by pithonelloids (>95 % of the assemblage).Therefore, the ratio *Pithonella sphaerica/Pithonella ovalis* was plotted, showing clear fluctuations during the cycle. Low ratios are recorded in the basal marl, in the culmination point of the chalk development (middle part of the cycle) and in the cycle top. Pithonelloids are very rare at the base of the cycle, then rapidly increase in number to dominate the assemblage, and their relative abundances decrease to about 70 % only in the middle part of the cycle. There is a relation to the changes occuring within the oblique forms which are mainly represented by *Obliquipithonella pachystrata* ZÜGEL 1994 and the paratabulated forms *Cubodinellum renei* KEUPP 1987 and *Pentadinellum vimineum* KEUPP 1987. The abundances of *O. pachystrata* ZÜGEL 1994 peak in the middle part of the cycle. The cycle shows a general increase in the absolute abundances of cysts in which certain peaks probably represent short term productivity variations.

The data were compared to the lithological data of the cycle derived from plotting the percentages of certain grain size fractions of the sediment. This plot clearly shows a gradual development of the cycle without abrupt changes in lithofacies. No signs of dissolution or dilution have been recorded suggesting that these Milankovitch cycles may be interpreted as productivity cycles. In addition, the data set was compared to the distribution of foraminifera and coccoliths. The distribution patterns of these three groups, their relationship to one another and the various environmental factors that are likely to have controlled these distribution patterns will be discussed.

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Modeling Biosphere-Geosphere Interactions

Paul Westbroek

Gorlaeus Laboratories, University of Leiden, P.O. Box 9502, 2300 RA Leiden,
THE NETHERLANDS. E-mail: westbroek_p@rulgca.leidenuniv.nl

Life is a major geological force, and it is therefore impossible to understand the dynamism of the earth without considering the role of the biota in global models. However, a flagrant contrast exists between the limitations of sound modelization and the dynamics of life in the real world. In the first place, models must be simple, while life is complex and diverse. And secondly, models can only operate over a limited range in time and space, while living systems characteristically operate over a wide range of temporal and spatial scales.

This deep problem may nevertheless be solved, for three reasons: (1) order and simplicity appears to emerge at distinct levels of biological organization; (2) uniformity of the biological organization appears to underly biodiversity; and (3) instead of single models of geosphere-biosphere interactions, nested suites of hierarchical modules may be constructed, each concentrating on one particular level of organization. The exemplary role of the coccolithophore *Emiliania huxleyi* as a model system for the study of global dynamics will be discussed in some detail. In order to be useful, the results of this study must be generalized to the calcifying plankton as a whole. Thus, a comparative investigation of important coccolithophore species is an important component of this research.

A new type of research organization, required for the efficient execution of interdisciplinary studies such as on *Emiliania* will be discussed.

Geobiology, Definition, Organization and Some Representative Research

Peter Westbroek[1], Bas Kooijman, Jan van Hinte, Patrizia Ziveri[2]

[1] Gorlaeus Laboratories, University of Leiden, P.O. Box 9502, 2300 RA Leiden, THE NETHERLANDS. E-mail: westbroek_p@rulgca.leidenuniv.nl
[2] Geomarine Center, Vrije Universiteit Amsterdam de Boelelaan, 1085 1081HV AMSTERDAM, THE NETHERLANDS. E-mail zivp@geo.vu.nl)

Geobiology is concerned with the role played by life in geodynamics over geological time. Geophysics and geochemistry having reached maturity, the full scale implementation of geobiology is now in order. This composite poster explains the fundamental problem of geobiology and how it may be approached by coordinated modeling of geosphere-biosphere interactions at the molecular, organismal, ecological and global levels of organization. This approach is illustrated by two geobiological projects -- the Global Emiliania Modeling Initiative (GEM), with its sister CODENET, and UTE, the modeling program of a universal theoretical ecosystem.

Chirality and the K/T Boundary

Jeremy R. Young[1], Paul R. Bown[2] and Andrew Howard[2]

[1] Palaeontology Department, The Natural History Museum, LONDON, ENGLAND. E-mail: jy@nhm.ac.uk
[2] Department. of Geological Sciences, University College LONDON, ENGLAND.
E-mail: p.bown@ucl.ac.uk; a.howard@ucl.ac.uk

Almost no heterococcoliths display pure radial ultrastructures. Instead most cycles of elements show obliquity, curvature or imbrication which imparts a handedness or chirality to the structure. For instance *Calcidiscus* coccoliths show clockwise curvature and imbrication of distal shield elements. There is no obvious reason why an alternative, mirror-image, form with anti-clockwise element curvature should not be developed but in practice it never appears to be. This consistency of chirality within any one species appears to be a universal character of heterococcoliths - it is well shown for instance by the consistency of bridge orientation in *Gephyrocapsa*, of flange spiralling in *Helicosphaera*, and of arkhangelskiellid central area structures. To test the consistency we have carried out a special survey of *Emiliania huxleyi*, which shows, relatively subtle, chirality, in distal shield element obliquity, proximal shield element terminations, inner tube element imbrication and central area element curvature. Survey of electron micrographs of several thousand specimens has failed to discover any examples of reversed chirality. This consistency, and analysis of growth, indicate that chirality is a product of the nucleation stage of coccolith growth and provides further evidence for precise regulation of calcite nucleation in coccoliths.

The consistency of chirality means that it provides extremely useful additional taxonomic characters. Perhaps the most interesting example of this is provided by the families Chiastozygaceae (Mesozoic) and Zygodiscaceae (Cenozoic), both of which are muroliths with an outer rim cycle of V-units and inner rim cycle of R-units. These two groups have frequently been linked and indeed are not distinguished in some classifications. However, in the Chiastozygaceae the outer cycle shows clockwise imbrication whereas in the Zygodisceae it shows anti-clockwise imbrication. On the basis of this we suggest that the Zygodiscaceae did not simply evolve from Chiastozygaceae survivors of the K/T boundary event but rather were a homeomorphic group which evolved after the K/T boundary.

Chirality is also a widespread feature among nannoliths; sphenoliths are the only apparent major exception. This supports other evidence for the close connection, and probable homology of heterococcoliths and nannoliths. Holococcoliths are much less commonly chiral, one more expression of the great differences between holococcolith and heterococcolith biomineralisation.

Cenomanian Nannofossils and Milankovitch Cyclicity

Jeremy R. Young[1], Andrew S. Gale[1], Matteo Tazzi[1], Paul R. Bown[2], and Dawn Windley[2]

[1] Palaeontology Department, The Natural History Museum, LONDON, ENGLAND. E-mail: jy@nhm.ac.uk
[2] Department of Geological Sciences, University College LONDON, ENGLAND. E-mail: p.bown@ucl.ac.uk

Chalk-marl alternations are characteristic of Cenomanian shelf sediments on an almost global basis. Recent research has shown that these facies are direct expressions of precession-band Milankovitch cyclicity (Gale 1995). Moreover these sequences can be correlated on a bed to bed basis by using a combination of bed thickness variations, geochemical signals and biostratigraphy. Correlation across Western Europe is now very well established (Gale 1995) and has recently been extended to more distant sequences including in the Crimea.

The nannofossil distribution in the Anglo-Paris basin sequences has been studied by Windley (1995). This showed that there was no great change in assemblages between marls and chalks but that the chalks consistently contained higher abundances of *Zeugrhabdotus* and *Biscutum* species than the marls. By contrast *Watznaueria* showed an inverse distribution, being more abundant in the marls. This pattern cannot easily be interpreted as a preservational effect since the preservation is not greatly variable and if anything is slightly better in the marls. Moreover Erba *et al* (1992) recorded a similar, but higher amplitude, pattern from the exceptionally preserved nannofloras of the Gault Clay. *Zeugrhabdotus* and *Biscutum* have been widely interpreted as eutrophic indicators on a range of evidence (e.g. Roth & Krumbach 1986, Watkins 1989, Erba 1992); whilst *Watznaueria* has been interpreted as an oligotrophic indicator, or perhaps more reasonably, as a background mesotrophic species. So, like Erba *et al.* (1992), we interpret the *Zeugrhabdotus* + *Biscutum* rich levels as indicative of periods of higher productivity. The pattern can be conveniently summarised using a productivity index: Log[(%*Zeugrhabdotus* + %*Biscutum*)/(%*Watznaueria*)]. An index of this type provides a cleaner signal than the abundance pattern of any single species or genus and circumvents the closed sum constraint.

Study of the Crimean sections however reveals an inverse relationship, the productivity index increases in the marls rather than the chalks. This not *a priori* difficult to explain since marls could easily be associated with riverine nutrient input and so higher productivity. Indeed Watkins (1989) documented patterns of this type from the Greenhorn Basin. However the bed-by bed correlation to UK sequences which show the inverse relationship raises interesting problems of interpretation and strongly suggests that even in the UK-type facies coccolith productivity is not the dominant mechanism responsible for lithological expression of Milankovitch cyclicity.

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Coccolith Fluxes in the Central Arabian Sea

Alexandra Zeltner

G.P.I. Tuebingen, Sigwart Strassel, D-72076 Tuebingen, GERMANY.
E-mail: alexandra.zeltner@uni-tuebingen.de.

In the central Arabian Sea (14°27,46'N, 64° 34,32'E) PARFLUX Mark VI time series sediment traps (WG Prof. Ittekkot, University of Hamburg) were moored in 508 m (CAST shallow), 999 m (CAST middle), and 2986 m (CAST deep) water depth. Six presplits of CAST middle and seventeen presplits of CAST deep were available for nannoplankton analysis. Sampling of CAST middle and deep started at November 1st, 1995 and ended at October 2nd and April 30th, 1997, respectively. Sampling intervals were 26 days. Sample processing was modified after Andruleit (1997).

Coccospheres contributed only 1 % to the total coccolithophore flux. The average daily fluxes at CAST-12 deep were 5.67 x 10^8 coccoliths m^{-2} d^{-1}. Average daily carbonate flux rates were 9.80 mg m^{-2} d^{-1} (= 4.33 g m-2 y^{-1}, November 1995 - April 1997). Elevated coccolith fluxes were detected at CAST-12 deep during the inter-monsoon period in spring, 1996 and the ending SW-monsoon, 1996. The maximum of coccolith fluxes coincided with the peak fluxes recorded in the Somali Basin during upwelling relaxation 1993 (BROERSE in prep.).

Coccolith fluxes at CAST-12 middle ranged between 2.03 - 4.27 x 10^8 ind. m^{-2} d^{-1}. The highest flux (4.27 x 10^8 ind. m^{-2} d^{-1}) coincided with the NE-monsoon 1996. The coccolith calcite flux ranged between 3.82 - 4.08 mg m^{-2} d^{-1}. A total of 31 heterococcolithophore taxa were recorded at CAST-12 middle. *Gephyrocapsa oceanica Kamptner* and *Emiliania huxleyi var. huxleyi* (Lohmann) Hay et Mohler were the most abundant species, contributing between 59 - 83 % to the total coccolith assemblage. Coccoliths of other species occurred in very low numbers.

Coccolith fluxes at CAST-12 deep ranged between 2.12 - 8.68 x 10^8 ind. m^{-2} d^{-1}. Highest fluxes were recorded during the end of SW-monsoon, 1996 (September, October 1996, 8.53 - 8.68 x 10^8 ind. m^{-2} d^{-1}) and the intermonsoon period in spring, 1996 (April 1996, 7.33 x 10^8 ind. m-2 d-1). Lowest coccolith fluxes occured during both NE-monsoon periods, 1996 and 1997, and during the beginning SW-monsoon, 1996. The coccolith calcite flux ranged between 3.99 - 14.85 mg m^{-2} d^{-1}. A maximum of 45 hetero- and 1 holococcolithophore taxa were identified at CAST-12 deep. The most abundant species at CAST-12 deep was G. oceanica (50 - 70 %). Together with *E. huxleyi var. huxleyi* they contributed 66 - 78 % to the total coccolith assemblage. *G. oceanica* showed the highest coccolith fluxes during SW-monsoon (2.83- 5.89 x 10^8 ind. m^{-2} d^{-1}). The familiy of the Coccolithaceae comprised between 10 - 24 % of the total coccolith assemblage. During SW-monsoon diversity became lowest while the highest coccolith fluxes were recorded. In contrast to observations of the living coccolithophore assemblage the seasonal alteration of the coccolithophore assemblage influenced by the monsoon could not be recorded in the coccolith fluxes. Only the opportunistic species *G. oceanica* showed increasing values of coccoliths at CAST-12 deep during the SW-monsoon 1996. In contrast, the coccoliths of the oligotrophic species *Umbellosphaera spp.* increased during SW-monsoon. The coccolith flora showed a strong alteration in species diversity compared to observations of the living coccolithophore flora in the Arabian Sea and represented the most resistant coccoliths (placoliths).

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Export Production and Preservation of Coccolithophores from Upwelling and Oligotrophic Areas.

Patrizia Ziveri
Geomarine Center, Free University Amsterdam, de Boelelaan 1085, 1081HV
Amsterdam, The Netherlands
E-mail: zivp@geo.vu.nl

A good way to monitor coccolithophore production is to study the fluxes recorded by sediment traps deployed at different depths below the euphotic zone production. In the present study, the export production of Coccolithophores was determined from sediment trap samples moored at 500m in Guaymas Basin, in the central Gulf of California, at 3700m in the Northeast Atlantic and at 3000m in Bannock Basin, in the eastern Mediterranean and compared with coccolith accumulation rates in the top sediment underneath the trap stations. The integration of production, sinking and fossilisation -processes is fundamental for the understanding of the coccolith record as paleoclimate proxy. In fact a serious limitation of this approach is that for large parts of the ocean floor no coccolith record is available, because the surface sediment is located below the calcite compensation depth (CCD), moreover even above the CCD the reconstruction of the record could be by no means straightforward.

I will illustrate the problems by concentrating on three locations where the vertical coccolith fluxes are quantified: the North Atlantic coccolithophore bloom-dominated, the oligotrophic eastern Mediterranean coccolithophore dominated and a coastal, upwelling area near Gulf of California diatom boom-dominated. In the latter setting only 20 % of the originally produced coccoliths are preserved in the sediment. I shall present an hypothesis that may explain the dramatic difference in preservation. Our results indicate that for different oceanic settings the models must be adapted in order to arrive at reliable dynamical interpretations of the coccolith record and to develop global models.

Coccolith $CaCO_3$ Actuo and Paleo-fluxes from the Eastern Mediterranean

Patrizia Ziveri[1], Arrian Rutten[2], and Cesare Corselli[3]

[1]Geomarine Center, Free University Amsterdam, de Boelelaan 1085, 1081HV, Amsterdam, The Netherlands
E-mail:zivp@geo.vu.nl

[2]Institute of Earth Sciences, Dept. of Geochemistry, University of Utrecht, 3508TA Utrecht, The Netherlands
[3]Dept. of Earth Sciences, University of Milan, via Mangiagalli, 34, 20133, Milan, Italy

Coccolith $CaCO_3$ actuo- fluxes are measured by sediment traps to quantify carbonate export production. The comparison of coccolith $CaCO_3$ rain to the sea floor and its preservation at sites above the calcite saturation horizon, in oxic and anoxic conditions allows us to quantify and model calcium carbonate dissolution above this level. We present here the results obtained from a sediment trap deployment and surface sediment investigations in the eastern Mediterranean. The eastern Mediterranean is a suitable recorder of global climatic variations. In this area the particle fluxes as well as the deep pelagic biogenic sediment can be compared between oxic and anoxic conditions. The study was carried out within MAST -Marflux and -Paleoflux European programs. Two time-series sediment traps have been deployed from November 1991 through August 1994 at 2900dbar and 3700dbar, respectively above and below the brine/normal sea water interface in the Bannock Basin, central eastern Mediterranean, to allow comparison under oxic and anoxic conditions.

The annual coccolith, coccolith $CaCO_3$ and total $CaCO_3$ fluxes have been compared with their accumulation rates in surface sediments in anoxic and oxygenated sediments near the trap site. Coccoliths are the major contributor to the carbonate flux in the basin and are also the dominant phytoplankton group. The comparison of the sediment trap results with the coccolith accumulation rates and coccolithophore species diversity show a very high preservation of coccolith CaCO3 in the surface sediments of both oxic and anoxic environments.