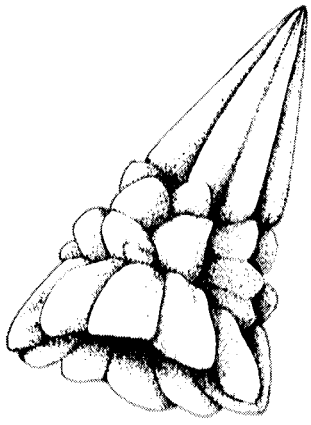
DIPARTIMENTO DI SCIENZE DELLA TERRA
UNIVERSITÀ DEGLI STUDI DI FIRENZE

INTERNATIONAL NANNOPLANKTON ASSOCIATION *MEETING*



FIRENZE
18-20 SEPTEMBER 1989

SPECIAL ISSUE

ABSTRACTS

INA NEWSLETTER VOLUME 11 - NUMBER 2 - 1989

INTERNATIONAL NANNOPLANKTON ASSOCIATION

MEETING

FIRENZE, 18-20 SEPTEMBER 1989

Organizing Committee:

Simonetta Monechi (Bari, Italy) Chairman
Franca Proto Decima (Padova, Italy)
Domenico Rio (Padova, Italy)
Jan Backman (Stockholm, Sweden)
Hans Thierstein (Zurich, Switzerland)

Secretariat:

Silvia Gardin (Bologna, Italy)
Viviana Reale (Firenze, Italy)

Excursion:

Angela Baldanza (Perugia, Italy)
Simonetta Monechi (Bari, Italy)
Viviana Reale (Firenze, Italy)

Under the Support of:

Università degli Studi di Firenze
Dipartimento di Scienze della Terra, Università di Firenze
Consiglio Nazionale delle Ricerche, Roma
Centro di Studio per la Geologia dell'Appennnino in rapporto alle Geosinclinali Mediterranee, Firenze
AGIP S.p.A.
Carl Zeiss Italiana S.p.A.

INA NEWSLETTER

proceedings of the

INTERNATIONAL NANNOPLANKTON ASSOCIATION

volume 11 number 2 September 1989

CONTENTS

PRELIMINARY DATA ON THE AGES OF THE NORTHERN APENNINES FOREDEEP CLASTIC FILLINGS DURING OLIGOCENE AND MIOCENE
M. Andreozzi, R. Catanzariti , S. Fornaciari , A. Negri, G. Plesi and D. Rio P.43

APTIAN TO CAMPANIAN CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF PELAGIC FACIES FROM MONTE PESO (LOMBARDIAN PREALPS, NORTHERN ITALY).
C. Attanasio P.44

GENUS SCHIZOSPHAERELLA: DISTRIBUTION, FREQUENCE AND PALAEOENVIRONMENTAL INDICATIONS
A. Baldanza, E. Mattioli, and V. Reale P.44

AALENIAN - BAJOCIAN NANNOFOSSIL EVENTS IN THE MONTE NERONE AREA AND NORTH-EASTERN AREA OF THE UMBRO-MARCHEAN APENNINE
A. Baldanza and E. Mattioli P.45

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHIC EVENTS FROM THE EARLY-MIDDLE JURASSIC SEQUENCES OF THE UMBRIA-MARCHE AREA (CENTRAL ITALY)
A. Baldanza, S. Monechi, V. Reale, and E. Mattioli P.45

TAXONOMIC CONCEPT IN THE GENUS RETICULOFENESTRA
L. Beaufort P.48

NEOGENE TECTONIC EVOLUTION OF THE SOUTHERN APENNINES. NEW BIOSTRATIGRAPHIC CONSTRAINTS
M. Bellatalla, E. Patacca, N. Perilli, U. Santini, and P. Scandone P.48

COMPARISON OF SILICEOUS ASSEMBLAGES WITH CALCAREOUS NANNOPLANKTON IN THE UPPER MIOCENE OF CAPPELLA MONTEI (SERRAVALLE SCRIVIA)
M. C. Bonci and C. Pirini Radrizzani P.49

CALCAREOUS NANNOFOSSIL EVOLUTION: A COMPARISON OF EVOLUTIONARY RADIATIONS IN THE LATE TRIASSIC/EARLY JURASSIC AND PALEOCENE
P. R. Bown, L.T. Gallagher, and J.A. Burnett P.50

COMPARISON OF UPPER PLIOCENE DISCOASTER ABUNDANCE VARIATIONS FROM THE ATLANTIC, PACIFIC AND INDIAN OCEANS: SITES 662, 677 AND 709
A. Chepstow-Lusty and N. J. Shackleton P.50

GENERA LOTHARINGIUS AND WATZNAUERIA: EVOLUTIONARY TREND DURING THE LOWER AND MIDDLE JURASSIC.
M. Cobianchi, E. Erba, and C. Pirini Radrizzani P.51

THE LATE CENOMANIAN OCEANIC ANOXIC EVENT FROM EASTBOURNE (SOUTHERN ENGLAND)
M. Cooper, G. Carson, D. Horne, I.Jarvis, P. Leary, and B. Tocher P.52

NANNOBIOSTRATIGRAPHY OF THE APTIAN-ALBIAN "SCISTI A FUCOIDI" (UMBRIAN-MARCHEAN APENNINES, CENTRAL ITALY).
A. De Poli and F. Lottaroli P.52

CALCAREOUS NANNOFOSSILS DISTRIBUTION PATTERNS IN THE LOWER PLIOCENE-LOWER PLEISTOCENE LAND SECTION AT MONTE SAN NICOLA (GELA, SICILY)
E. Di Stefano P.53

DISTRIBUTION OF COCCOLITHS IN SURFACE SEDIMENTS OF THE "GIN" SEA
L. K. Eide P.54

LOWER AND MIDDLE JURASSIC CALCAREOUS NANNOFOSSIL EVENTS FROM THE COLLE DL SOGNO SECTION (LOMBARDY BASIN, NORTHERN ITALY)
E. Erba P.55

A COMPILATION OF JURASSIC CALCAREOUS NANNOFOSSIL RANGES
E. Erba, and M. Cobianchi P.56

JURASSIC NANNOBIOSTRATIGRAPHY: A SYNTHESIS OF THE LOMBARDY BASIN (SOUTHERN CALCAREOUS ALPS).
E. Erba, M. Cobianchi, and C. Pirini Radrizzani P.56

CALCAREOUS NANNOFOSSILS RECORD FERTILITY AND TEMPERATURE CYCLES: EVIDENCE FROM THE ALBIAN GAULT CLAY FORMATION.
E. Erba, G. Guasti, and D. Castradori P.57

UPPER JURASSIC-LOWER CRETACEOUS NANNOFOSSILS FROM WESTERN PONTIDS
A. Fiorentino P.58

BIOMETRIC ANALYSIS OF EOCENE AND OLIGOCENE CALCAREOUS NANNOFOSSILS
J.V. Firth P.59

ANALYSIS OF THE CALCAREOUS NANNOFLORA AND PLANKTONIC FORAMINIFERA OF THE PRE-EVAPORITIC SEDIMENTS OF THE TYRRHENIAN SEA (O.D.P. SITE 654).
J.A. Flores, F.J. Sierro, and G. Glaçon P.60

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE LATE OLIGOCENE THROUGH MIDDLE MIOCENE MEDITERRANEAN MARINE RECORD AND RELATED CHRONOSTRATIGRAPHYC PROBLEMS
E. Fornaciari, A Negri, D. Rio, G. Villa, and R. Sprovieri P.61

TERTIARY CALCAREOUS NANNOFOSSILS FROM SOUTH-EAST ASIA
L.T. Gallagher P.61

CRETACEOUS AND PALEOGENE NANNOPLANKTON OF GEORGIA
T. Gavadze and E. Kilasonia P.62

COCCOLITHS AS STRATIGRAPHICAL AND PALEOENVIRONMENTAL TOOLS IN THE CARIBBEAN SEA, FOR THE LATE PLEISTOCENE (DSDP LEG 68 - BOLE 502B)
J. Giradeau P.62

TIME-PROGRESSIVE MORPHOLOGICAL CHANGES OF GEPHYROCAPSA DURING QUATERNARY
H. Matsuoka P.78

BIOSTRATIGRAPHY AND CORRELATION OF MIOCENE DEPOSITS OF GEORGIA BASED ON CALCAREOUS NANNOPLANKTON
T. Minashvili P.80

INTER-RELATIVE ASPECTS OF NANNOFOSSIL AND PALYNOMORPH BIOSTRATIGRAPHY AND PALEOECOLOGY AT THE K/T BOUNDARY, HOR HA'AR SECTION, SOUTHERN ISRAEL
S. Moshkovitz and Y. Eshet P.80

UPPER CRETACEOUS HIGH RESOLUTION STRATIGRAPHY IN THE PELAGIC SEQUENCE OF THE JUDEAN MOUNTAINS AND THE SHEPHELA REGION, CENTRAL ISRAEL
S. Moshkovitz, G. Gvirtzman, A. Almogi-Labin, Z. Lewy, A. Honigstein, and Z. Reiss P.82

NANNOFOSSIL MIGRATION AND DISTRIBUTION PATTERNS IN THE BOREAL LOWER CRETACEOUS OF NW-EUROPE
J. Mutterlose P.83

CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF LATE CRETACEOUS SEDIMENTS IN JORDAN
F. Naji P.84

RELIABILITY OF SPHENOLITHS AS ZONAL MARKERS IN OLIGOCENE SEDIMENTS FROM THE ATLANTIC AND INDIAN OCEANS
G. Olafsson P.84

OLIGOCENE/MIOCENE MORPHOMETRIC VARIABILITY OF THE CYCLICARGOLITHUS LINEAGE FROM THE EQUATORIAL ATLANTIC AND INDIAN OCEANS
G. Olafsson P.85

EXAMPLES OF DIACHRONEITY OBSERVED IN THE UPPER PALEOGENE OF THE TROPICAL INDIAN OCEAN AND POSSIBLE NEW DATUM EVENTS
H. Okada P.86

MORPHOMETRIC AND FLORAL VARIATIONS OF CALCAREOUS NANNOPLANKTONS IN RELATION TO THEIR LIVING ENVIRONMENT
H. Okada P.87

PROBLEMS AND PERSPECTIVES IN CALCAREOUS NANNOFOSSIL CORRELATIONS AT JURASSIC-CRETACEOUS BOUNDARY.
S. Ozkan and P. R. Bown P.88

HORSESHOE-SHAPED CALCAREOUS NANNOFOSSILS AND SALINITY CRISES
K. Perch-Nielsen P.89

TETHYAN AND BOREAL LOWER CRETACEOUS NANNOCONUS
K. Perch-Nielsen P.90

SOUTHERN HIGH LATITUDE K/T BOUNDARY CALCAREOUS NANNOFOSSILS FROM ODP SITES 690 AND 752
J. J. Pospichal P.90

INTEGRATED CRETACEOUS BIOSTRATIGRAPHY AND MAGNETO-, STRATIGRAPHY FROM ITALIAN PELAGIC SEQUENCES.
I. Premoli Silva, J.ET. Channell, R. Coccioni, E. E Erba, S. Monechi, and G. Parisi P.92

MORE THAN 200 MILLION YEARS OF COCCOLITH EVOLUTION
B. Prins P.93

THE CALCAREOUS NANNOFOSSILS AND THE MINERALOGICAL FRACTION <25μ IN QUATERNARY AND LATE NEOGENE SEDIMENTS OF THE NORTHEASTERN SUBTROPICAL ATLANTIC OCEAN
A. Pujos P.93

BIOSTRATIGRAPHIC RESOLUTION AND PRECISION ATTAINABLE IN THE EARLY PLEISTOCENE MARINE RECORD BY MEANS OF CALCAREOUS NANNOFOSSILS
I. Raffi, D. Rio, and J. Backman P.94

RESPONSE OF CALCAREOUS NANNOFOSSILS TO ORBITAL FORCING IN THE MEDITERRANEAN EARLY PLIOCENE TRUBI FORMATION
I. Raffi, D. Rio, and R.C. Thunell P.95

A BIOSTRATIGRAPHIC SYNTHESIS OF THE JURASSIC NANNOFOSSIL EVENTS FROM CENTRAL ITALY, FRANCE, PORTUGAL AND HUNGARY
V. Reale , S. Monechi, A. Baldanza and E. Mattioli P.96

CALCAREOUS NANNOFOSSIL BIOCHRONOLOGY IN THE MEDITERRANEAN PLIO - PLEISTOCENE MARINE RECORD
D. Rio, I. Raffi, A. Belli, E. Di Stefano, A. Negri, and G. Villa P.97

LATE CENOZOIC COCCOLITH ZONATION AND ITS APPLICATION TO THE PHILIPPINE SEA, JAPAN AND THE PLIOCENE/PLEISTOCENE BOUNDARY STRATOTYPE IN ITALY
T. Sato, K. Kameo and T. Takayama P.98

ASSOCIATION OF LATE PLEISTOCENE CALCAREOUS NANNOFOSSIL ASSEMBLAGES AND $^{18}0$ AND ^{13}C ISOTOPIC CHANGES, ODP LEG 117, OMAN MARGIN, ARABIAN SEA
S. A. Spaulding and T. Oba P.98

CHANGES IN THE LATITUDINAL STRUCTURING OF NANNOFOSSIL ASSEMBLAGES: CRETACEOUS-HOLOCENE CONTRASTS.
H. R. Thierstein P.99

NON-SYNCHRONOUS $\partial^{18}O$ STRATIGRAPHIES AND ^{14}C OFFSETS BETWEEN NANNOFOSSIL AND FORAMINIFERAL PELAGIC CARBONATES.
H. R. Thierstein, S. Hills, G. Bonani, W. Wolfli, and C. K. Paull P.100

VARIABILITY OF SPHENOLITHUS HETEROMORPHUS IN SOME TURBIDITIC SEQUENCES OF NORTHERN APENNINES
L. Tofacchi P.101

RELATIONSHIP BETWEEN CALCIUM CARBONATE CONCENTRATION AND NANNOFOSSILS ABUNDANCE IN THE MAASTRICHTIAN GOKDERE FORMATION, CENTRAL ANATOLIA, TURKEY
V. Toker and E.K. Sagular P.101

LATE QUATERNARY CALCAREOUS NANNOPLANKTON ZONATION FOR THE NORTHERN ATLANTIC OCEAN
J.W. Verbeek P.102

COCCOLITHOPHORES IN CULTURE: A STUDY OF INTRASPECIFIC VARIATION IN EMILIANIA HUXLEYI
J. R. Young P.103

COCCOLITHUS PELAGICUS IN THE LATE MIOCENE TO RECENT, TAXONOMY, SIZE VARIATION AND DEVELOPMENT OF THE BRIDGED FORM
J. R. Young, and J. Steinmetz **P.104**

THE LIVING COCCOLITHOPHORES EMILIANIA HUXLEYI AND PLEUROCHRYSIS CARTERAE IN CULTURE
J. R. Young, K. Linschooten, P. West broek, and K. Hausmann **P.105**

TURONIAN - MAASTRICHTIAN NANNOFOSSIL BIOSTRATIGRAPHY AND PALEOCEANOGRAPHY OF THE SOUTHERN OCEAN
D. K., Watkins, S. W., Wise, Jr., and J. J., Pospichal **P.106**

MORPHOMETRY OF DISCOASTER MULTIRADIATUS AND ITS BIOCHRONOLOGICAL UTILITY
W. Wei **P.107**

BIOGEOGRAPHIC GRADIENT OF LATE PALEOGENE CALCAREOUS NANNOPLANKTON IN THE SOUTH ATLANTIC OCEAN
W. Wei and S. W. Wise **P.109**

COCCOLITHOPHORES AND GLOBAL CO_2
A. Winter and J. Briano **P.109**

SILICOFLAGELLATE VARIABILITY: A HISTORICAL PERSPECTIVE
S. W. Wise, Jr., D. M. Harwood, K. McCartney, and R. Gersonde **P.110**

PROBING THE LIMITS OF NANNOFOSSIL STRATIGRAPHIC RESOLUTION IN THE SOUTHERN HIGH LATITUDES
S. W. Wise, Jr., J. J. Pospichal, and W. Wei **P.111**

CALCAREOUS NANNOFOSSILS AND THE CONDENSED SECTION IN SEQUENCE STRATIGRAPHY
W. W. Wornardt Jr. **P.112**

PRELIMINARY DATA ON THE AGES OF THE NORTHERN APENNINES FOREDEEP CLASTIC FILLINGS DURING OLIGOCENE AND MIOCENE

by M. ANDREOZZI (Istituto di Geologia, Università di Parma, Italy), R. CATANZARITI (Dipartimento di Scienze della Terra, Università di Pisa, Italy), S. FORNACIARI (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy), A. NEGRI (Dipartimento di Geologia e Paleontologia, Università di Bologna, Italy), G. PLESI (Dipartimento di Scienze della Terra, Università di Pisa, Italy), and D. RIO (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy)

During Oligocene, foredeep basins developed between the Northern Apennine (NA) thrust belt and the African foreland, which have been essentially filled by silicoclastic turbiditic sediments.

As a response to the compressional activity of the thrust belt, progressing toward NE, the foredeep migrated during the Neogene in the same direction (Ricci Lucchi and Ori, 1985). Later (middle Miocene through Pleistocene) stages of evolution of the Northern Apennines (NA) foredeep are well documented and dated, while earlier (Oligocene-early Miocene) evolutionary stages are poorly known.

An acute problem in recostructing the early migration timing and the paleogeography of the NA foredeep is represented by the poor biostratigraphy obtainable in the Oligocene-early Miocene turbiditic sediments. We have started a research project aimed to date this clastic bodies by means of calcareous nannofossils which, although scarce and poorly preserved, seem suitable to this purpose.

We have determined the age of the Macigno Formation, of the M.te Modino Formation, of the M.te Cervarola Formation outcropping between Reggio Emilia and Bologna provinces, and of the Marnoso-Arenacea Formation outcropping in Bologna and Forlì provinces.

The Macigno Formation is Late Oligocene - Early Miocene (NP 25 - NN1/NN2 Zones) in age. The M.te Modino Formation is essentially Early Miocene (NN1-NN2 Zone) in age.

Within clastic bodies ascribed to the M.te Cervarola Formation we have recognized ages progressively younger proceeding from the inner to the outer part of the outcropping area. Specifically, the inner tectonic units of this Formation (A and B structural units of Guenther and Reutter, 1985) belong to NN1/NN2 Zone (early Miocene); the next external C structural unit outcropping at Gova (Dolo Valley) belongs to NN4 Zone; the D and E structural units belong to NN5 Zone (Langhian-early Serravallian). These results suggest that most probably the fillings of progressively external and younger basins have been lumped under the Cervarola Formation label.

The lower part of the Marnoso-Arenacea Formation, outcropping in Romagna, is middle Miocene (Zone NN5) in age, and therefore is coeval with the external clastic bodies attributed to the M.te Cervarola Formation in the literature.

APTIAN TO CAMPANIAN CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF PELAGIC FACIES FROM MONTE PESO (LOMBARDIAN PREALPS, NORTHERN ITALY).

by C. ATTANASIO (Dipartimento di Scienze della Terra, Via Mangiagalli 34,.20133 Milano, Italy).

Calcareous nannofossil biostratigraphy was applied to the Scaglia formation outcropping in the Monte Peso area (Lombardian Prealps, Northern Italy), spanning the Aptian to Campanian interval.
The M.Peso is located north of Brescia and belongs, from a paleogeographic point of view, to the Lombardy Basin. In particular, the studied area represents the deepest part of the basin (Sebino Trough) at its eastern boundary with the Trento Plateau.
Here the Scaglia Variegata consists of varicolored marlstones and clayey marlstones with subordinate claystones and limestones and rare black shales. Pelagic turbidites deposited in the Upper Albian-Cenomanian interval.
This unit overlies the Maiolica (Upper Tithonian-Lower Aptian p.p.) and is followed by the Scaglia Rossa (Campanian). Six sections were measured and analysed for their nannofossil content. The nannofloral total abundance fluctuates from rare to abundant and preservation is poor to moderate.
The nannobiostratigraphy integrated with the planktonic foraminiferal biozonation, allowed a detailed stratigraphy of the Scaglia Variegata. The facies succession was dated and an important hiatus spanning the Late Cenomanian-Santonian was pointed out.

GENUS SCHIZOSPHAERELLA: DISTRIBUTION, FREQUENCE AND PALAEOENVIRONMENTAL INDICATIONS

by A. BALDANZA, E. MATTIOLI (Dipartimento Scienze della Terra, Perugia), and V. REALE (Dipartimento Scienze della Terra, Firenze)

From the reduced and normal Jurassic sequence quantitative data on genus *Schizosphaerella* have been assembled.
By the polarized light microscope analysis it can't be ascertained the differences between two species of the genus *Schizosphaerella* so that for this paper both have been considered as *Schizosphaerella* sp.
The variableness on the *Schizosphaerella* frequence observed for the many Early-Middle Jurassic Formations (Corniola, Marne del Monte Serrone, Rosso Ammonitico, Calcari a Posidonia and Bugarone) are probable linked to a particular environmental condition e/o to a variation in carbonate ratio.
Detailed distribution charts and frequence graphics have been drawn for each sequence.

AALENIAN - BAJOCIAN NANNOFOSSIL EVENTS IN THE MONTE NERONE AREA AND NORTH-EASTERN AREA OF THE UMBRO-MARCHEAN APENNINE

by A. BALDANZA and E. MATTIOLI (Dipartimento Scienze della Terra, Perugia)

In some Jurassic sequences of the Monte Nerone Area (Ranchi, Infernaccio, Fosso del Presale) and in the Fonte Avellana and Pale sequence was performed a biostratigraphical study based on calcareous nannofossil assemblages from the Upper Aalenian (*Murchisonae* Zone) to the Early Bajocian (*Sauzei* Zone).
The Upper Aalenian calcareous nannofossil assemblage was characterized by: *Biscutum novum, B. dubium, Crepidolithus crassus, Carinolithus superbus, Discorhabdus ignotus, Lotharingius crucicentralis, Watznaueria barnesae, W. manivitae* and *Cyclagelosphaera margereli.*
On the top of the *Concavum* Zone it has been found the FO of *Hexalithus magharensis* . This genus has been pointed out by Moshkovitz & Ehrlich (1976) from middle Bajocian sediments of Israel.
In the Umbro-Marchean Apennine sequences the decrease and the disappearance of the majority of the Domerian and Toarcian species, and the prevailing of the *Watzanueria* species were observed at the beginning of the Bajocian.
In the early Bajocian (*Discites* Zone) has been identified the first occurrence of *Watznaueria britannica* . The FO of *H. magharensis* in the *Concavum* Zone and the FO of *W.britannica* in the *Discites* Zone are very important for the identification of the Aalenian-Bajocian boundary when Ammonite are not available.

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHIC EVENTS FROM THE EARLY-MIDDLE JURASSIC SEQUENCES OF THE UMBRIA-MARCHE AREA (CENTRAL ITALY)

by A. BALDANZA (Dipartimento Scienze della Terra, Perugia), S. MONECHI (Dipartimento di Geologia e Geofisica, Bari), V. REALE (Dipartimento Scienze della Terra, Firenze), and E. MATTIOLI (Dipartimento Scienze della Terra, Perugia)

The pre-rifting phase, related to the opening of the western Tethys, caused in the Early Liassic the breaking up of a broad carbonate platform, originating the Umbria-Marche basinal area. The Jurassic paleogeography is dominated by an

extensional tectonics, with a possible transcurrent component (trans-extensional tectonism), and by subsidence. The result of this block faulting tectonism created structural highs, where the sedimentation rate is very low (*condensed* sequences); and relatively deeper areas, where the sedimentation rate is higher (*extended* sequences).

A detailed biostratigraphy based on calcareous nannofossils has been carried out on eight sequences. Four from the *extended* sequences: Valdorbia, Serrone, Pozzale and Fonte Avellana; and four from the *condensed* ones : Ranchi, Presale, Infernaccio and Pale (see Fig. 1). The studied sequences range from Late Pliensbachian to Early Bajocian, and are well known for a complete ammonite zonation.

The lithologies examined are calcareous limestones, calcareous nodular-marls and shaly-marls. Preservation of calcareous nannofossils varies from moderate to poor due to the lithology.

Many biostratigraphic events, calibrated with Ammonite Zones , have been found from the *Lavinianum* Zone (Early Domerian) to the *Discites* Zone (Early Bajocian).

The Domerian is characterized by the FO of *Mitrolithus jansae* in the *Lavinianum* Zone and by the FO of *Lotharingius hauffii* and *Biscutum finchii* in the *Emaciatum* Zone.

The Early Toarcian (*Tenuicostatum* Zone) is characterized by the FO of *Lotharingius crucicentralis, Carinolithus superbus* and by the LO *of Mitrolithus jansae.*

The FO of *Discorhabdus ignotus* is in the *Serpentinus* Zone; in the same zone we remark a decrease of *Calyculus* species. In the Upper Toarcian (*Erbaense* Zone-*Meneghini* Zone) has been found the FO of *Watznaueria barnesae* and an increase in size of *Biscutum novum* in the *Meneghini* Zone.

The Aalenian is characterized by the FO of *Watznaueria manivitae* and *Cyclagelosphaera margereli* in the *Murchisonae* Zone and by the FO of *Hexalithus magharensis* in the *Concavum* Zone.

The FO of *Watznaueria britannica* has been identified in the *Discites* Zone (Early Bajocian).

We have paid particular attention to the Marne del Monte Serrone Fm, that is considered a Toarcian Anoxic Event. The calcareous nannofossil assemblage is dominated by the presence of many species of *Crepidolithus, M.jansae, Schizosphaerella* and abundant *Lotharingius hauffii* and *L. barozii.*

Particular attention has been paid to the genera *Lotharingius* and *Watznaueria* and an evolutionary trend of the genus *Lotharingius* to the genus *Watznaueria* has been documented from the Upper Toarcian to the Early Bajocian.

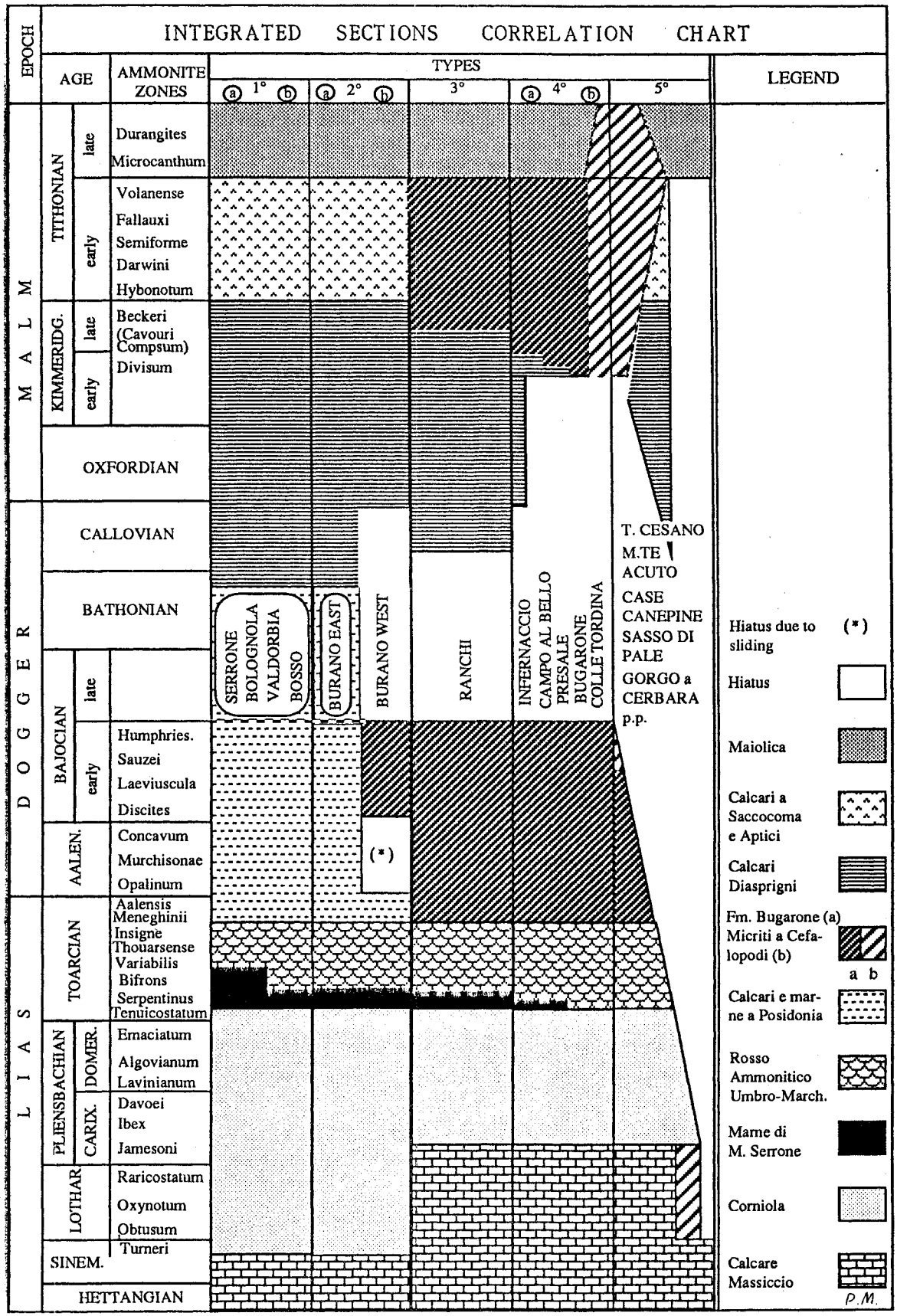


Fig.2. - Schematic diagram showing the chronostratigraphic range of the Jurassic Formations of the Umbria-Marche according to Ammonite stratigraphy; they are grouped into five chracteristic types. The thicknesses are not displayed; individual Formations tend to thin out progressively from type 1 to type 5.

TAXONOMIC CONCEPT IN THE GENUS RETICULOFENESTRA

by L. BEAUFORT (Departement de Sciences, de la Terre, Universite C. Bernard 27-43 Bvd du 11 Novembre 69622 Villeurbanne, France and Wood Hole Oceanographic Institution, Wood hole, MAS 02543, USA).

Distinction between species assigned to the genus *Reticulofenestra* is largely based on size differences. This is particularly true for the Neogene taxa which are commonly placed in the *Reticulofenestra pseudoumbilica* group but which have been separated in as many as 6 species. Analysis of calcareous nannofossil assemblages from upper Miocene sediments recovered at Site 552A (ODP, leg 81, North Atlantic Ocean, 56° N) reveals a great abundance of placoliths of *Reticulofenestra* in all assemblages. Their size ranges between 2µm and 13µm. In an attempt to distinguish between groups, the coccolith length was measured. In a large number of samples, two size classes were observed: 1) A small placolith group in which the size varies between 2 and ~7 µm. 2) A large placolith group ranging from ~7 to 13 µm. The median values and the size at which the classes separate varied between samples. In the other samples the coccolith length presented a more uniform distribution and no subdivision of the assemblage based upon size was possible. The measurement of the short axis diameter did not add further information to the results of the long diameter analysis.
These results do not support the use of the size as a main specific character to separate the Miocene *Reticulofenestra* group into species.

NEOGENE TECTONIC EVOLUTION OF THE SOUTHERN APENNINES. NEW BIOSTRATIGRAPHIC CONSTRAINTS

by M. BELLATALLA, E. PATACCA, N. PERILLI, U. SANTINI, P. SCANDONE (Dipartimento di Scienze della Terra dell'Universita di Pisa. Via S. Maria, 53. 56100 PISA).

The investigated area corresponds to the northern segment of the Southern Apenninic Arc, a complex bended structure which estends from the Maiella-Gaeta lineament to Sicily, through the Calabrian Arc. The mountain chain is constituted primarily of largely-displaced thrust sheets piled up with Adriatic vergence; as a consequence of the progressive migration of the thrust belt-foredeep-foreland system, some hundred kilometres of the Paleogene Apulian margin were affected by shortening during Neogene times. The complexity of the present-day structure, together with too many stratigraphic uncertainties in the surface geology, makes the construction of reliable balanced sections very difficult. Large disagreements, therefore, still exist among geologists concerning the possible palinspastic restorations of the tectonic units, the timing of the

deformation and the amount of the shortening. Nevertheless, some important biostratigraphic constraints, such as:
-age definition, for every tectonic unit, of the uppermost part of the sequence underlying the siliciclastic flysch-deposits (age of the elastic flexure of a rigid foreland area);
- age determination of the flysch deposits conformably overlying the different sequences representative of the recognized tectonic units (age of the foredeep-basin subsidence);
- time definition of the sedimentological events recording in far field, during the flysch deposition, major peaks of tectonic activity (time-space migration of the foredeep-foreland system);
- age determination of the sedimentary sequences deposited between consecutive compressional phases can eliminate a lot of persisting ambiguities and may drastically reduce the number of possible solutions.
Aim of this paper is to present new micropaleontological data based on forams and calcareous nannoplankton which will oblige regional geologists to revise some established "certainties" on the timing of the deformation and on the style of the forewards migration of the compressional fronts.
The most interesting results concern:
- the time definition and the extent of the so-called Burdigalian tectonic phase. The tectonic phase took place, in reality, close to the Langhian-Serravallian boundary, involving in the orogenic transport "internal" thrust sheets, as well as the carbonate units of the Campania-Lucania domains, and producing regional metamorphism in the Verbicaro and S. Donato nappes;
- the time definition and the extent of the Tortonian tectonic phase, which took place in late Tortonian and not in early Tortonian times as usually accepted in the geological literature;
- the meaning of the so-called Irpinian Flysch units, whose age is upper Tortonian-Messinian and not Langhian-lower Tortonian;
- the time difinition and the extent of the Messinian and Pliocene tectonic phases.
The discrepancies between many published data and the new biostratigraphic results mostly derive from widespread reworking processes which caused an extreme dilution of the autochthonous biocoenosis.

COMPARISON OF SILICEOUS ASSEMBLAGES WITH CALCAREOUS NANNOPLANKTON IN THE UPPER MIOCENE OF CAPPELLA MONTEI (SERRAVALLE SCRIVIA)

by M. C. BONCI & C. PIRINI RADRIZZANI (Universita di Genova - Dip. Sc. Terra - Sez. Geologia Palazzo delle Scienze - Corso Europa, 26 - 16132 Genova).

The upper part of the S. Agata Fossili Marls Formation outcropping at Cappella Montei, near Serravalle Scrivia, is characterized by the presence of levels of spongolites with Diatoms. The microfaunal and microfloral assemblages are

dominated by siliceous elements (Sponges spicules, Diatoms, Radiolaria, Silicoflagellates, Ebridians, Dinophyceae, Archeomonadaceae), but they are also rich in calcareous organisms (benthic and planktonic Forams, Nannoplankton).
The contemporary presence of siliceous organisms and calcareous Nannoplankton allowed to draw a parallel between the two kinds of assemblage, wich are ascribed to the Late Miocene.

CALCAREOUS NANNOFOSSIL EVOLUTION: A COMPARISON OF EVOLUTIONARY RADIATIONS IN THE LATE TRIASSIC/EARLY JURASSIC AND PALEOCENE

by P. R. BOWN (University College London, Gower Street, London, WCIE 6BT), L.T. GALLAGHER (University College London, Gower Street, London, WCIE 6BT), and J.A. BURNETT (University College London, Gower Street, London, WCIE 6BT).

In palaeontology, the assumption is made that morphology is the phenotypic expression of the genotype, hence evolution is seen as the modification, through time, of morphology. Major evolutionary events within the calcareous nannoflora are described, from their inception in the Late Triassic, through their rapid diversification in the Jurassic and Cretaceous, the extinctions at the Cretaceous/Tertiary boundary, and their rapid regeneration in the Palaeogene. Particular emphasis is placed on the comparison of the two most significant evolutionary diversification events: at the Triassic/Jurassic and the Cretaceous/Tertiary boundaries.
Rates of evolution are plotted, and comparisons made of the number of root-stocks, occurrence of homeomorphy/parallel evolution, increases in coccolith size, and types of coccolith. The driving forces behind calcareous nannofloras - sea-floor spreading, climate, the carbon cycle, ocean chemistry - are considered, and a comparison made with the development of other plankton groups, e.g. dinoflagellates and foraminifera.

COMPARISON OF UPPER PLIOCENE DISCOASTER ABUNDANCE VARIATIONS FROM THE ATLANTIC, PACIFIC AND INDIAN OCEANS: SITES 662, 677 AND 709

by A. CHEPSTOW-LUSTY and N. J. SHACKLETON (Godwin Laboratory, Subdepartment of Quaternary Research, University of Cambridge, Cambridge CB2 3RS).

Variations in the abundance of seven species of Pliocene Discoasters are compared at three sites close to the Equator in different oceans using a sampling interval of about 3 Ka. The time interval analyzed is approximately the million years immediately prior to the extinction of Discoasters (i.e. 1.89-

3.00 Ma).
Age-models were first developed using biostratigraphic controls, mostly *Discoaster* datums whose ages were originally estimated from Pacific sites with magnetostratigraphy (Backman and Shackleton, 1983). *Discoaster* datums were selected for internal consistency between the three sites. These age-models are contrasted with refined models using stable oxygen isotope stratigraphy, originating from the orbitally tuned time-scale from DSDP Site 607 (Raymo et al., in press). ODP Site 709 (Indian) displays extremely high abundance; ODP Site 662 (Atlantic) has fairly high abundances but may be slightly reduced due to the influence of the South Equatorial Current; ODP Site 677 (Pacific) had similar abundances to ODP Site 662 though it is strongly influenced by upwelling.
At all sites cyclic variation in *Discoaster* abundance is observed that is probably in response to orbital forcing. This high variability at low latitudes suggests that varying productivity pressure may be a major influence since temperature variability was presumably small.

GENERA LOTHARINGIUS AND WATZNAUERIA: EVOLUTIONARY TREND DURING THE LOWER AND MIDDLE JURASSIC.

by M. COBIANCHI (Dipartimento di Scienze della Terra, Strada Nuova 65, 27100 Pavia, Italy), E. ERBA (Dipartimento di Scienze della Terra, via Mangiagalli 34, 20133 Milano, Italy), and C. PIRINI RADRIZZANI (Dipartimento di Scienze della Terra, Corso Europa 26, 16132 Genova, Italy).

Semiquantitative studies of nannofloras from several sections outcropping in the Lombardy Basin and Southeastern France pointed out that significant changes occurred in the assemblages during Early-Middle Jurassic. Particularly, an evolutionary trend of the genus *Lotharingius* to the genus *Watznaueria* was documented in the Domerian-Bathonian interval.
The moderate to poor preservation prevented the S.E.M. analysis being ultrastructure partially modified by dissolution and/or overgrowth. Therefore, the study was performed with L.M. and consequently taxonomy is simplified, mainly based on optical properties. For the same reason, statistical studies on populations were not applied. The extreme morphological variability of both genera, particularly at early stages of their occurrence, arised difficulties in defining species limits. Moreover, some morphotypes may reflect ontogeny more than phylogeny.
The evolutionary trend observed within the genus *Lotharingius* are:
1) an increase of size from 3 ,um to > 5 μm;
2) the shield develops from unicyclic to bicyclic;
3) the inner cycle decreases in size being much smaller than the outer cycle in younger forms;
4) the central area develops from subcircular to subelliptical and elliptical, and simultaneously increases in size;

5) the central structure becomes more and more complex but no neat trends were observed possibly due to diagenetic modifications.
The genus *Watznaueria* appeared to develop from bicyclic *Lotharingius* forms characterized by a small and simple central area. Its evolution is marked by two different trends: (a) the increase in size ending in *W.manivitae*; and (b) the reduction of the central process ending in *W.barnesae*.

THE LATE CENOMANIAN OCEANIC ANOXIC EVENT FROM EASTBOURNE (SOUTHERN ENGLAND)

by M. COOPER, G. CARSON, D. HORNE, I. JARVIS, P. LEARY and B. TOCHER (Stratigraphic Services International, Guilford Great Britain).

An ongoing interdisciplinary (palaeontological and geochemical) study from several sections across the Cenomanian-Turonian Oceanic Anoxic Event has permitted the sequencing of the biotic response to an expanding rising oxygen minimum zone. The details of one section (Dover) has been produced elsewhere (Jarvis et al. 1988). Here we present the results from the Eastbourne section, a more expanded basinal sequence with a rich background microfauna/microflora. This section has provided more information on the subtleties of the Oceanic Anoxic Event. Also, more detailed nannofossil studies have been attempted on this section, in particular statistical studies on the family percentages and their response to the rising oxygen minimum and their relationship to the other microfosil groups.

NANNOBIOSTRATIGRAPHY OF THE APTIAN-ALBIAN "SCISTI A FUCOIDI" (UMBRIAN-MARCHEAN APENNINES, CENTRAL ITALY).

by A. DE POLI and F. LOTTAROLI (Dipartimento di Scienze della Terra, via Mangiagalli 34, 20133 Milano, Italy).

Within the Cretaceous pelagic sequence of the Umbrian-Marchean Apennines, the "Scisti a Fucoidi" represent a more shaly interlude of Aptian-Albian age. They consist of varicolored clayey marlstones and marlstones with limestones and claystones as minor lithologies. Black shale layers, usually cyclically modulated, are scattered throughout the formation. In the past few years, an Italian-American group have focused on this peculiar unit in order to improve the biostratigraphic resolution of the Aptian-Albian interval and to understand the rhythmic sedimentation pattern.
We studied the calcareous nannofossil content of several sections measured in the Umbrian-Marchean Basin. Nannofloras are rare to abundant, generally well diversified and moderately preserved. The nannobiostratigraphy was integrated with the planktonic foraminiferal events resulting in a high

resolution zonation. The precise correlations throughout the basin pointed out facies changes and hiatuses due to morphostructural control and local tectonic activity.

CALCAREOUS NANNOFOSSILS DISTRIBUTION PATTERNS IN THE LOWER PLIOCENE-LOWER PLEISTOCENE LAND SECTION AT MONTE SAN NICOLA (GELA, SICILY)

by E. DI STEFANO (Dipartimento di Geologia e Geodesia, Universita degli Studi, 90134 Palermo).

Quantitative and semiquantitative methods have been used to determine the distribution patterns of stratigraphically significant calcareous nannofossils in a Lower Pliocene-Lower Pleistocene (Santernian) land section cropping out near Gela (Southern Sicily).
This continous and well exposed section (170 m thick) comprises pelagic nanno-foram mudstone (Trubi Formation) in the basal 32 m, followed by terrigenous grey silty-marls (Monte Narbone Formation). The topmost 10 meters are represented by turbiditic yellow sands.
From 160 samples along a profile ranging from the topmost part of the *Reticulofenestra pseudoumbilica* zone to the uppermost *Calcidiscus macintyrei* zone the rich nannofloral assemblages have been studied by light microscope. In order to quantitatively identify the distribution and the appearance/extinction events of the most important coccoliths and discoasters species, abundance data have been obtained by three different counting methods (see Rio et al., in press).
The results prove that this methodology, till now essentially used in deep-sea sequences (Backman & Shackleton, 1983; Rio et al.,in press) may be used with good results also in land-sections, where reworking and terrigenous imput may affect the dilution of the nannofloras. The same pattern in the quantitative distribution of species recognized in the pelagic record of Site 107-653 (Rio et al.,in press) has been identified in the studied sequence.
It is therefore assumed that appearance or disappearance events can be recognized by the same features both in deep-sea sequences and in this terrigenous land section. Integration of these data with planktonic foraminifera (Sprovieri, in progress) and paleomagnetic events (Channell, in progress) proves that in the Gela section the ranking and scaling of the three different stratigraphic data are well maintained, and comparable with the sequence of the same events identified in the Tyrrhenian Sites (Channell et al.,in press; Glaçon et al., in press).
Reticulofenestra pseudoumbilica extinction occurs 5 meters above the base in the topmost Gilbert chron shortly followed by the extinction of *Sphenolithus* spp. quite coincident with the Gilbert-Gauss boundary.
The high abundance of total discoasters with peaks of very high values (80 specimens per mm^2), between the base of the section (approximately the end of

R. pseudoumbilica biozone) and the top of the *Discoaster pentaradiatus* biozone may be correlated with the high productivity interval recognized in the same segment at Site 653. Also in Gela the covariant *D. tamalis* and *D. asymmetricus* essentially prevail in the lower part and gradually decrease till their definitive extinction level (at 54 m above the base). Coincident with the sharp decrease in abundance of these species, the anticovariant *D. pentaradiatus* sharply increases and maintains high values up to its drastic drop, coincident with the more generalized sharp decline in abundance of the Discoaster population in the lower part of the Matuyama chron, at about 2.4 Ma.

Above this event our plot indicates that Discoaster species (*D. brouweri* and *D. triradiatus*) are not continuously present in their final range and display short peaks in abundance. A similar pattern observed in the pelagic record of Site 107-653, may be correlated with the *D. brouweri* increase during favorable climatic conditions (Rio et al.,in press). High fluctuating values of *D. triradiatus*, in coincidence with the uppermost part of the range of *D. brouweri*, is again in good agreement with results from deep-sea sediments (Backman & Shackleton, 1983; Rio et al., in press). Both morphotypes become extinct together 110 meters above the base of the section, very close to the base of recognized Olduvai subchron. The *Gephyrocapsa oceanica* s.l. FAD has been recognized 37 m above this event.

The sediment accumulation curve plotted along the section clearly indicates an interval (characterized by several manganese rich levels), referable to the upper part of the *D. tamalis* and the base of *D. pentaradiatus* biozones, in which the accumulation rate sharply decreases with respect to the underlying interval. Above the Gauss - Matuyama boundary the manganese rich levels disappear and the sedimentation rate increases again till a maximum value of 26.66 cm/1000 yr at the top of the sequence, where silty-sandy marls are present.

References

Backman J. and Shackleton N.J. (1983), Mar. Micropal., 8, 141-170.

Channell J.E.T., Rio D., Sprovieri R. and Glaçon G., in Proc. Init. Rep. (Pt.B) 107 (ODP College Station, Tx, in press).

Glaçon G., Rio D. and Sprovieri R., in Proc. Init. Rep. (PtB) 107 (ODP College Station, Tx, in press).

Rio D., Raffi I. and Villa G., in Proc. Init. Rep. (Pt. B) 107 (ODP College Station, Tx. in press).

DISTRIBUTION OF COCCOLITHS IN SURFACE SEDIMENTS OF THE "GIN" SEA.

by L. K. EIDE (Institute for Marine Biology University of Bergen, Norway)

The distribution of the coccolith assemblage, was examined in surface sediments along a transect from east to west in the " GIN (Greenland-Island-Norwegian) Sea. Based on the abundance of ccccoliths and the composition of the coccolith assemblage, three coccolith zones have been established along this

transect. Due to the current system, there is a great variety in chemical and physical factors in the water masses in this region. Temperature, nutrient and ice cover seems to be among the most important environmental factors which influence this distribution. The coccolith assemblage seems therefore to be a good indicator of the different water masses in this region. Analysing the fossil coccolith assemblage in sediment cores in the "GIN" Sea provide useful information about paleoenvironment, paleoclimate and paleoceanography in this region.

LOWER AND MIDDLE JURASSIC CALCAREOUS NANNOFOSSIL EVENTS FROM THE COLLE DI SOGNO SECTION (LOMBARDY BASIN, NORTHERN ITALY).

by E. ERBA (Dipartimento di Scienze della Terra, Via Mangiagalli 34, 20133 Milano, Italy).

At Colle di Sogno (Lombardy Basin, Northern Italy) a basinal sequence spanning the entire Jurassic crops out. This work is focused on the crucial Toarcian-Bathonian interval there represented by the Sogno Formation. The latter consists of grey to brown well stratified marly limestones and marlstones including some "Posidonia beds" facies.
Scanty ammonites, occurring in the lower portion of the unit, date the base of Sogno Formation as Early Toarcian in age, whereas radiolarian biostratigraphy points to a Bathonian age for the Radiolarites overlying the Sogno Formation.
Calcareous nannofossils are rare to abundant and poorly to moderately preserved. Generally speaking, the total abundance and diversity increase upwards. Several nannofossil events were recognized and calibrated to the magnetostratigraphy and other fossil groups biozonations.
The succession of nannofossil events detected at Colle di Sogno is correlatable to previously proposed biostratigraphies. More precisely, the Toarcian-Lower Bajocian zonation is consistent with the nannobiostratigraphy established in several Lombardian sections dated on ammonites. The Bajocian-Bathonian events are consistent with nannozonations proposed for European ammonite dated sequences.

A COMPILATION OF JURASSIC CALCAREOUS NANNOFOSSIL RANGES.

by E. ERBA (Dipartimento di Scienze della Terra, Via Mangiagalli 34, 20133 Milano, Italy), and M. COBIANCHI (Dipartimento di Scienze della Terra, Via Strada Nuova 65, 27100 Pavia, Italy).

After the critical overview of the literature dealing with prae-Jurassic and Jurassic calcareous nannofossils, a compilation of ranges of most taxa was performed.
All data are filed in a Macintosh database. The nannofossil distribution was plotted against the chronostratigraphy provided by the original works.

JURASSIC NANNOBIOSTRATIGRAPHY: A SYNTHESIS OF THE LOMBARDY BASIN (SOUTHERN CALCAREOUS ALPS).

by E. ERBA (Dipartimento di Scienze della Terra, via Mangiagalli 34, 20133 Milano, Italy), M. COBIANCHI (Dipartimento di Scienze della Terra, Strada Nuova 65, 27100 Pavia, Italy), and C. PIRINI RADRIZZANI (Dipartimento di Scienze della Terra, Corso Europa 26, 16132 Genova, Italy).

A synthesis of the Jurassic calcareous nannofossil events from the central and western Lombardian Prealps is given. Jurassic sequences from the Lombardy Basin reflect the complex physiography created by the strong Liassic tensional tectonics. The rifting phase differentiated structural highs divided by relatively deep troughs persisting till the end of the Jurassic. This articulated physiography controlled the sedimentation characterized by complete sequences in the depressions and by condensed facies on structural highs.
Several measured sections spanning the Middle Carixian to Berriasian interval were investigated in their calcareous nannofossil content. These sections represent both basinal (Clivio, Breggia, Alpe Turati, Colle di Sogno), slope (Arzo, Val Cepelline, Val Varea), and high (Corni di Canzo) facies.
Semiquantative analyses of the nannofloras were performed at light microscope. Calcareous nannofossils are always present and their total abundance fluctuates from rare to common. Nannofloral assemblages are characterized successively, from older to younger, by frequent *Schizosphaerella, Crepidolithus, Mitrolithus, Biscutum , Lotharingius, Calyculus, Carinolithus, Discorhabdus, Cyclagelosphaera ,Watznaueria, Conusphaera, and Nannoconus* . Although preservation is moderate to poor, a complete succession of nannobiohorizons was recognized. Nannobiostratigraphy (mainly first occurrences and subordinate last occurrences) was calibrated to ammonite, radiolarian, and calpionellid biozonations, and in one case also to magnetostratigraphy. The resolution is excellent in the Carixian to Lower Bajocian interval, where 3 to 4 nannofossil events were recognized in every ammonite biozone. The Middle Bajocian to Lower Kimmeridgian interval is less detaily dated being usually characterized by hiatuses (Middle Bajocian-Bathonian p.p.) and radiolarites (Bathonian p.p.-Kimmeridgian p.p.). The

Kimmeridgian to Berriasian is well dated on the basis of calcareous nannofossils whose events were calibrated to radiolarian and calpionellid biozonations.
This regional nannobiostratigraphy is partially correlatable with previously proposed zonal schemes. We think that discrepancies can be related to paleobioprovincialism, but also to different taxonomic concepts .

CALCAREOUS NANNOFOSSILS RECORD FERTILITY AND TEMPERATURE CYCLES: EVIDENCE FROM THE ALBIAN GAULT CLAY FORMATION.

by E. ERBA, G. GUASTI, and D. CASTRADORI (Dipartimento di Scienze della Terra, Via Mangiagalli 34, 20133 Milano, Italy).

A quantitative study of calcareous nannofloras was applied to the Albian Gault Clay Formation. This unit, widespread in England, consists of grey marly claystones and claystones with phosphatic nodules and glauconitic layers as minor lithologies.
Two cores were analysed in detail to focus changes in calcareous nannofloral composition and their significance. Samples were routinely collected every 5 cm, but sampling was also more closely spaced in proximity of lithologic variations.
Preservation of calcareous nannofossils is excellent and therefore diagenesis cannot be invoked to explain, not even partially, changes in nannofloral assemblages.
Principal Component and Factor (R-Mode) Analyses extracted two factors with eigenvalue > 1. They are interpreted as fertility and temperature factors respectively. It must be pointed out that the percentage of total variance explained by these factors is quite low. Nevertheless, the two factors load on species already regarded as of paleoceanographic significance in previous works.
Biscutum constans is considered a fertility Index, whereas *Watznaueria barnesae* is regarded as a non-fertility indicator. *Repagulum parvidentatum*, a high latitude restricted species, appears to be a cold water form. On the contrary, *Parhabdolithus* asper is confirmed to be a warm water taxon. The meaning of *Lithraphidites carniolensis* is still not completely clear, but an affinity to fertile waters is observed.
The fluctuations in abundance of both *B.constans* and *W.barnesae* resulted to be orbitally driven. In fact, Spectral Analysis showed periodicities of 25kyr (precession cycle), 40 kyr (obliquity cycle), and 100 kyr (short eccentricity cycle). The axial obliquity cycle is the strongest signal as expected at high latitude (Boreal realm). At lower latitude (Tethyan realm) fertility was documented to be directly correlated with carbonate production. On the contrary, in the Gault Clay cores carbonate content was not directly correlated to fertility being *B.constans* and *W.barnesae* abundance out of phase in respect with $CaCO_3$ content.

Both *R.parvidentatum* and *P.asper* show a weak evidence of orbitally driven fluctuations. However, once again the obliquity periodicity (40 kyr) is preserved. In our case, changes of surface water temperature were probably controlled more by transgression/regression cycles than by orbital parameters. This interpretation is corroborated by the shift in the profile of *R. parvidentatum* in the Middle Albian, correlatable with a transgression event of the Haq et al.'s curve. Thus, espansions and contractions of higher (Arctic) or lower (Tethys) latitude water masses most probably controlled the migrations of temperature depending nannofossils and the abundance of endemic forms.

UPPER JURASSIC-LOWER CRETACEOUS NANNOFOSSILS FROM WESTERN PONTIDS

by A. FIORENTINO (Dipartimento di Scienze della Terra, Università di Roma "La Sapienza", 00185 Roma)

Nannofossil association from Western Pontids have been studied in order to complete the stratigraphy of calcareous sequences not very rich in fossils and to find out relationships with the contemporary associations already known.
The analysis show that Nannofossils are not very common in these sediments and that the majority of them is formed by very diffused species whose stratigraphical use is limited (*Ellipsagelosphaera britannica, Cyclagelosphaera margereli, Nannoconus* of *steinmanni* group).
The more useful species or markers are represented by few individuals, often 1 or 2, so that it is difficult to determine exact zonations. Anyway it was possible to determine the limits between Valanginian and Hauterivian, Hauterivian and Barremian, and the differences between Jurassic (Tithonian) and Cretaceous associations.
The Jurassic associations are formed by five species (all belonging to the family *Ellipsagelosphaeraceae*) and lack the *Nannoconus* group, hile in the Cretaceous ones this group is very abundant and there is a greater variety of species of different families.
Differences were found also between associations of calcareous and marly samples. In these last Nannofossils are more common, especially the group *Nannoconus*.

BIOMETRIC ANALYSIS OF EOCENE AND OLIGOCENE CALCAREOUS NANNOFOSSILS

by J.V. FIRTH (Florida State University, Dept. of Geology, Tallahassee, FL 32306).

Four Eocene to Oligocene calcareous nannofossil species groups were analyzed biometrically from DSDP and ODP Sites 366, 549, 558, 563, 628, 647, and 748. Integrated biostratigraphic and magnetostratigraphic data established the age of each sample in order to compare biometrically established events between sites. Principal Components Analysis (PCA) and Discriminant Eunction Analysis (DFA) of Cyclicargolithus shows that no significant differences in shape occur with changes in size, age, or latitude. Size increases are asynchronous between sites, and are not biostratigraphically useful within the Oligocene. All species of *Cyclicargolithus* are synonymized with *C. pseudogammation* .

Development of a large sized (mean >11 μm) population of the *Reticulofenestra_umbilica/R. hillae* group occurred between 45.0 and 42.8 Ma in three sites. The first occurrence of specimens >14 μm in size is highly diachronous and not biostratigraphically useful. A continuum between large and small holed forms indicates that *R. hillae* should be considered as a forma of *R. umbilica*. This forma is more abundant in the uppermost Eocene to lower Oligocene.

PCA analysis of the *Reticulofenestra bisecta* complex revealed an overall gradual size increase from middle Eocene to Oligocene, and a rapid increase in hole size beginning in early Oligocene in high latitudes. *R. bisecta* subsp. *filewiczii* is synonymized with *R. bisecta* subsp. *lockeri*, and *R. scrippsae* is synonymized with *R. bisecta*.

PCA analysis of the *Chiasmolithus expansus/C. oamaruensis/C. altus* group revealed large fluctuations in the width of the central 'X' structure from upper middle Eocene to Oligocene, possibly related to changes in water masses. The narrowing of the 'X' is due mainly to narrowing of the central bar connecting the cross bars of the 'X'. A trend towards smaller relative hole sizes occurred from the Eocene to Oligocene. Both *C. oamaruensis* and *C. altus* may have evolved directly from *C. expansus* in the upper middle to lower upper Eocene. End-member forms were geographically separated, with transitional forms occurring between them through the lower Oligocene. C. altus may be a colder water form than *C. oamaruensis*.

ANALYSIS OF THE CALCAREOUS NANNOFLORA AND PLANKTONIC FORAMINIFERA OF THE PRE-EVAPORITIC SEDIMENTS OF THE TYRRHENIAN SEA (O.D.P. SITE 654).

by J.A. FLORES, F.J. SIERRO (Departamento de Geologia-Paleontologia-. Universidad de Salamanca. 37008 Salamanca. Spain), and G. GLAÇON (Laboratoire de Stratigraphie et de Paléoécologie. Université de Provence. Marseille. France).

D.S.D.P. site 654 is located off the Continental margin of Sardinia in the Tyrrhenian sea and was recovered during Leg 107. This site is the only one that records a continous sequence of the Tortonian-Messinian transition of this Leg, before the characteristic evaporitic deposits of the Mediterranean.

It was chosen to perform a comparative study with sections and D.S.D.P. sites equivalent to the NE Atlantic, in which a detailed biostratigraphic scheme has been obtained.

From the lithological point of view, from base to top, the following can be recognized: a unit of continental red beds (unit 6), overlain by glauconitic sands from shallow waters (unit 5) that rapidly pass to oozes and muds of nannofossils (unit 4) and , above these, laminated dolomitic mudstone (unit 3) (Borsetti et al., in press) .

In the present work we study the evolution of the assemblages of calcareous nannoplankton and planktonic foraminifera through unit 4.

In the calcareous plankton of this Site most of the signals observed by Flores and Sierro (1987, 1989) in the NE Atlantic have been recognized. The distribution of these signals however exhibits certain variations, among which a " relative delay" in the first record of the pentaradiate asteroliths *Eu-discoaster quinqueramus* and *Eu-discoaster berggrenii* is striking. Similarly, the increase in "small placoliths" is recorded before the reduction in sinistral forms of *Globorotalia* (Vergnaud Grazzini et al., in press.) and other signals of nannoflora with which it was relatively synchronous (increase in *Dictyococcites antarcticus* and a reduction in the *Geminilithella jafarii/Geminilithella rotula* ratio).

The Tortonian/Messinian boundary, as in the Atlantic, is correlated with the first record of *Amaurolithus delicatus* and coincides with de appearance of planoconvex sinistral forms of *Globorotalia*.

The defined signals have also been calibrated with the magnetostratigraphic scale according to the data offered by Channel et al. (in press).

Overall, the data obtained in the analysis of the assemblages of nannoplankton and plankt suggest the occurrence of relatively warmer water masses in the Tyrrhenian than in the adjacent Atlantic over the same interval of time.

References

Borsetti et al., in press. Initial reports D.S.D.P., 107.

Channel et al. in press. Initial Repports D.S.D.P., 107.

Flores, J.A. and Sierro, F.J., 1987. Calcareous plankton in the Tortonian/Messinian transition series of the Northwestern edge of the Guadalquivir basin. Abh. Geol. B.A., 39: 67-84

Flores, J.A. and Sierro, F.J., 1989. Calcareous nannoflora and planktonic foraminifera in the Tortonian-Messinian boundary interval of East Atlantic DSDP sites and their relation to Spanish and Moroccan sections. In J.A. Crux & S.E. van Heck. Nannofossils and their applications. Ellis Horwood: 249-266 Vergnaud Grazzini, G. et al., in press. Initial reports D.S.D.P.. 107.

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE LATE OLIGOCENE THROUGH MIDDLE MIOCENE MEDITERRANEAN MARINE RECORD AND RELATED CHRONOSTRATIGRAPHYC PROBLEMS

by E. FORNACIARI (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy), A NEGRI (Dipartimento di Geologia e Paleontologia, Università di Bologna, Italy), D. RIO (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy), G. VILLA (Istituto di Geologia, Università di Parma, Italy), and R. SPROVIERI (Istituto di Geologia, Università di Palermo, Italy)

Calcareous nannofossils have been studied by quantitative methods from 7 late Oligocene through middle Miocene sequences from mainland Italy, Sicily and from western deep sea Mediterranean. Objective of the study is to establish the distribution patterns of selected calcareous nannofossil species and to test their utility for biostratigraphyc correlation in the western Mediterranean region. Some forms utilized in the standard zonations of Martini (1971) and Bukry (1973) (i.e. *D. druggi, T. carinatus, D. kugleri*) are sporadic or absent. The distribution pattern and the potential biostratigraphic value of the following species and events is discussed:
C. abisectus FO and LO; *H. recta* FO and LO; *S. distentus* LO; *S. predistentus* LO; *S. ciperoensis* FO and LO; *D. bisectus* LO; *S. belemnos* FO and LO; *S. heteromorphus* FO and LO; *C. floridanus* LO; *H. ampliaperta* FO and LO; *S. delphix* total range; *D. deflandrei* acme end; *D. exilis* FO; *R. pseudoumbilica* FO; *C. macintyrei* FO.
Special attention has been paid to small helicoliths, which are abundant in the emipelagic sediments of mainland Italy. Within this group *H. waldersdorfensis* FO which occurs within Zone NN5 (CN4) seems to represent a correlatable event in the region.
Stratotype sections of Langhian and Serravallian stages have been studied. The boundary between the two units is within the range of *Sphenolithus heteromorphus* (Zone NN5), and not close to the NN6-NN7 zonal boundary as stated in the literature. The base of the Tortonian is within NN9 Zone of Martini (1971), and the reported occurrence of *G. acostaensis* at the base of the Tortonian stratotype section may represent not the real first occurrence datum of the nominate species, which occurs in complete Mediterranean sequences below the FO of *Discoaster hamatus*.

TERTIARY CALCAREOUS NANNOFOSSILS FROM SOUTH-EAST ASIA

by L.T. GALLAGHER (University College London, Gower Street, London, WC1E 6BT).

A great number of samples from Nias, Simeulue, Sumatra, and Halmahera in Indonesia were examined for calcareous nannofossils as part of a much larger study involving the elucidation of the structural history of this region. The

assemblages recovered were used to greatly improve the existing biostratigraphy by providing accurate age dates of Late Oligocene through to Late Miocene based on the presence of established marker species, and could be used to correlate between areas within and between adjacent sub-basins.

CRETACEOUS AND PALEOGENE NANNOPLANKTON OF GEORGIA

T. GAVADZE and E. KILASONIA (Geological Institute of Acad. of Georgian, Tbilisi, USSR)

no abstract

COCCOLITHS AS STRATIGRAPHICAL AND PALEOENVIRONMENTAL TOOLS IN THE CARIBBEAN SEA, FOR THE LATE PLEISTOCENE (DSDP LEG 68 - HOLE 502B)

by J. GIRAUDEAU (Departement de Geologie et Océanographie - U.A. 197, Université de Bordeaux I Avenue des Facultés - 33405 Talence Cedex - France)

The Hole 502B, located West of the Caribbean Sea in the Colombia Basin, is selected because it has the most complete recovery and least disturbance for the whole Pleistocene among the other piston cores drilled in Caribbean.
The detailed analysis of calcareous nannofossils allow to individualize 20 taxa: 7 of them are used in a stratigraphical purpose and are not taken into account for the paleoenvironmental study: I usehere both well known datums according to THERSTEIN & al. (1977) (lowest Occurrence of *Emiliania huxleyi*, Highest Occurrence of *Pseudoemiliania lacunosa*, End of Acme of *Gephyrocapsa caribbeanica*), and the less common ones based on the "spatio-temporal distribution" theory of PUJOS (1988) (H.O. of *Gephyrocapsa aperta* and *Gephyrocapsa ericsonii* , L.O. of *G . ericsonii*) .
Paleoenvironmental study using IMBRIE & KIPP's method (1971), is applied on the remaining 13 taxa ; 8 of them are selected because of their relatively good abundance and their well documented response to surface waters Temperatures and Salinities.
The major problem in using nannofossils for Transfert Function is the fact that one or two taxa (in our study *Florisphaera* sp. and to a lesser degree *Rhabdosphaera* sp.) are often too much abundant and hide representativeness of other species;to avoid that problem I use a two steps transformation of exact counts : (l)' answering to a biological reality, qunatity of nannofossils is not expressed in coccoliths but in coccopheres ; (2) data are transformed into "Classes of abundance for each taxa". By this way, it is possible to obtain satisfying winter/ summer temperatures and salinities. These parameters are

compared with those calculated previously with foraminifera and nannofossils in the same area.
Temperatures estimated with nannofossils are 1°C warmer than those obtained with foraminifers; moreover gradients of temperatures between two successives climatic stages are differents : "forams" temperatures show variancesstronger than "nannos" temperatures.
Salinities estimations are closely reliable with isotopic measurements, salinity minima occurring during interglacial climatic stages. On a general rule, "nannos" salinities are underestimated of 0.5. to 1% in comparison with those obtained with forams.
Differences between our results and previous paleoecological estimations and isotopic studies using forams, may have been caused by both ecological reasons (depth distribution of living organisms,...) and oceanographical and environmental characteristics proper to the area of study (fluviatil inflow, tropical precipitations,...).

References

IMBRIE J., KIPP N.G. (1971) : Turekian K.K., ed., "The late Cenozoic ages", New Haven, Conn., Yale Univ. Press, 71-181.
THIERSTEIN H.R. & al. (1977) : Geology, 5, 400-404.
PUJOS A. (1988) : Oceanologica Acta, vol. 11, n° 1, 65-67.

NANNOFLORA ASSEMBLAGES IN THE CRETACEOUS-TERTIARY BOUNDARY AT ZUMAYA (NORTHERN SPAIN).

by A. GOROSTIDI, M.A. LAMOLDA (Paleontologia, Fac. Ciencias; Universidad del Pais Vasco; 48940 Leioa; Spain)

The Cretaceous-Tertiary (K/T) boundary of the Zumaya Section (Northern Spain) is well known by ist continuous stratigraphic record, (Herm,1965; von Hillebrandt,1965; Percival & Fischer,1977) . The fossil record shows somehow previous changes in abundance and number of species, macrofossils (Wiedmann,1988; Ward,1988), and microfossils (Herm, 1965; Percival & Fischer,1977; Lamolda,1985, and Lamolda et al. ,1988). In this work the nannoflora assemblages of the uppermost Maastrichtian and lowermost Danian have been studied quantitatively. Five hundred nannoflora specimens have been counted in each sample, and the percentage of each species has been computed. The uppermost Maastrichtian is characterised by an assemblage of the Murus Zone, where the main species are *Watznaueria barnesae, Micula desussata, Prediscosphaera cretacea, Cribrosphaerella ehrenbergi , Arkhangesckiella cymbiformis,* and *Stradneria crenulata.* The Prinsii Zone is not well characterised, and only some rare specimens are identified as *Micula prinsii* , just below and above the K/T boundary. The lowermost Danian shows an increase of *Cyclasgelosphaera reinhardtii, Thoracosphaera* spp. and *Markalius inversus* , and a decrease of *W.barnesae, C. ehrenbergi, S. crenulata, Micula murus, M. decussata,* and *Chiastozygus amphipons.* Below the K T

boundary the species *Ch. amphipons, S. crenulata and Microrhabdulus attenuatus* show a decrease, whereas *C. reinhardtii and Thoracosphaera* spp. show a increase, being both species consídered persisting species. There are not similar changes in the nannoflora assemblages at about 2-3 meters below the K/T boundary where *Abathomphallus mayaroensis* and other planktonic foraminifera dissapear, confirming a different pattern in the occurrence of both planktonic organisms.

References

Herm, D.1965. Mikropalaontologisch-stratigraphische Untersuchunge im Kreideflysch zwischen Deva und Zumaya (Prov. Guipuzcoa, Nord Spanien).Z.dtsch.geol.Ges.,115,277-348.

Hillebrandt,A.von.1965. Foraminiferen-Stratigraphie im Altertiar von Zumaya (Provinz Guipuzcoa, NW Spanien) und ein Vergleich mit anderen Thetys-Gebieten. Bayer. Akad. Wiss. mat.-naturwissensch. Kl. Abh. N.F., 123, 62 pp.

Lamolda,M.A.1985. Fossil record and the Cretaceous-Tertiary crisis at Zumaya (Northern Spain). Gwatt Conference-Rare events in Geology. Gwatt, Switzerland) May,1985.

Lamolda,M.A.; Mathey,B. and Wiedmann, J.1988. Field-Guide Excursion to the Cretaceous-Tertiary boundary section at Zumaya (Northern Spain). In Palaeontology and Evolution: Extinction Events (M.A.Lamolda, E.G.Kauffman and O.H.Walliser, Eds.) Revista Espanola de Paleontolog;a, n° Extraordinario, 141-155.

Percival, S.F. and Fischer, A.G. 1977. Changes in calcareous nannoplankton in the Cretaceous-Tertiary biotic crisis at Zumaya, Spain. Evolutionary Theory, 2, 1-35.

Ward, P.D.1988. Maastrichtian ammonite and inoceramid ranges from Bay of Biscay Cretaceous-Tertiary boundary sections. In Palaeontology and Evolution: Extinction Events (M.A.Lamolda, E.G. Kauffman and O.H.Walliser Eds.). Revista Espanola de Paleontologla, n° Extraordinario,119126.

Wiedmann, J.1988. The Basque Coastal sections of the K/T boundary - A key to understanding "Mass Extinction" in the fossil record.In Palaeontology and Evolution: Extinction Events (M.A.Lamolda, E.G.Kauffman and O.H. Walliser Eds.).Revista Espanola de Paleontologla, n° Extraordinario, 127-140.

CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE "AUTOCHTHONOUS PALEOGENE" SEDIMENTS OF THE SLOPES OF THE BOHEMIAN MASSIF (SOUTH MORAVIA, CZECHOSLOVAKIA)

by B. HAMRSMID (Dep. of Micropaleontology, MND Hodonìn, 69530 Hodonìn Czechoslovakia), J. KRHOVSKY (Dep. of Paleontology, Charles University, Albertov 6, 12843 Praha 2, Czechoslovakia), and L. SVABENICKA (Geological Survey, Malostranské nàm. 19, 11821 Praha 1, Czechoslovakia)

Thick complexes of the Paleogene autochthonous sediments, covered by nappes of the West Carpathian Flysch units, were found on the SE slope of the Bohemian massif. They represent the sediments of the northern Tethyan margins, preserved in the deep erosion-tectonic depressions (Nesvacilka and Vranovice grabens) and their vicinity.
This predominantely pelitic complex, found in many boreholes, was supposed to be of the Lower Oligocene - Upper Miocene age. The detail examination of calcareous nannoplankton revealed, however, that the geological history of this area was more complicated, then previously presumed.
The Upper Campanian, Upper Maastrichtian, Paleocene - Lower Eocene, Middle Eocene - Upper Eocene and Lower Oligocene nannoplankton taphocenoses wer found in evident stratigraphical superposition in some boreholes. Thus, it is probable, that the Nesvacilka and Vranovice grabens have originated before the Campanian already and that the "autochthonous Paleogene" rocks were deposited during several transgressions that reached the area under study.
These temporary transgressions (and regressions) can also be proved in the western part of the Washberg zone, Austria, and they could have been connected with the eustatic shifts of sea level.
Between the crossed nicols, the great part of coccoliths from the Paleocene - Lower Eocene strata show no extinction figure; their calcite was replaced or covered by minute grains of another mineral, probably by siderite, preventing the birefringence.

LATE CENOZOIC NANNOPLANKTON FROM THE NORTH EAST ATLANTIC

by N. HINE (University of East Anglia, Norwich, NR4 7TJ), and P.P.E. WEAVER (Institute of Oceanographic Sciences, Surrey, GU8 5UB).

Six sites from the North East Atlantic have been investigated for biostratigraphic and palaeoceanographic purposes. The nannoplankton assemblages over the last 1 Ma are dominated by the genus *Gephyrocapsa*. An

amended taxonomy for this genus is suggested which is applicable under both SEM and light microscopy. The species and varieties established are later used to generate a high resolution biozonation based on species dominance.
The six sites (DSDP 610, 609, 607, 658, 659, 663) provide a north-south transect (55.N to 1.S) across the region of greatest climatic response to Northern hemisphere glacial-interglacial oscillations. A number of elements in the flora are found to be temperature sensitive, in particular *Gephyrocapsa oceanica* and *Gephyrocapsa muellerae*. A comparison is made between the fluctuatlons in relative abundance of nannoplankton species, foraminiferal assemblages, and in stable isotope stages. Large scale features are found
to be similar, but small scale features are dissimilar.

LATE CRETACEOUS-PALAEOGENE COCCOLITH-COCKTAIL EXUDED FROM THE MUD VOLCANO OF BARATANG ISLAND, ANDAMAN-NICOBAR ISLANDS, INDIA

by S. A. JAFAR, U. C. MAINALI and O. P. SINGH (Birbal Sahni Institute of Palaeobotany, P.O. Box 106, Lucknow-226 001, India).

The Andaman basin occupying the southeastern region of the Bay of Bengal, represents a part of larger geotectonic unit of southeast Asia. Highly deformed and weathered Late CretaceousPalaeogene sediments are exposed in non-volcanic Outer Arc, whereas Neogene sediments are exposed in Archipelago group of Islands displaying gentle folds and contain richly fossiliferous layers. Although considerable field, geophysical and borewell data is available, almost total lack of mega-microfossils in dominantly deep sea Flysch sediments, herein designated as Andaman Flysch [Baratang and Port Blair Formations ca.3000m] posed problems for elucidating subduction and evolutionary history of these Islands. Radiolarian cherts and cherty limestones are the oldest sediments found associated with typical ophiolite suite and exposed on the eastern margin of the Andaman Islands. One such cherty limestone block overlying the ophiolite of Dimbu Nala in Baratang Island, yielded critical species of *Globotruncana* in thin section: *G. ventricosa, G. fornicata, G. bulloides, G. lapparenti* including *Pseudotexularia elegans, Heterohelix globulosa, Hedbergella* spp., *Rugoglobigerina* spp. and minor radiolarian remains suggesting broad Middle Campanian Early Maastrichtian, probably Campanian age. However, sedimentaries constituting the bulk of Andaman Islands, are highly folded and reverse-faulted alternations of Greywacke-Shale displaying typical features of Flysch turbidites with deformational structures and a suite of ichnofossils of *Palaeodictyon* facies (notably *P. minimum*). Intermittent flux of shelf/seamount derived clastics contained larger foraminifera, algal limestone, terrestrial palynofossils/plants represented by carbonised wood or thin coal pockets, which earlier served as tool for erecting basic stratigraphic framework. Rare sections are reported to yield a rich suite of Palaeogene autochthonous deep sea agglutinated foraminifera mixed with

shelf derived Late Cretaceous calcareous benthic and planktonic foraminifera. Autochthonous Late Cretaceous benthic or planktonic microfossils remain unknown from thick pile of Flysch sediments. A rich suite of coccoliths and discoasters comprising over 100 species and recovered after several months of searching of mud samples exuded from the Nayagarh Mud Volcano of Baratang island [dominantly euxinic Lipa Black Shale facies of Baratang Formation in subsurface] offers valuable data on subsurface stratigraphy.

Rucinolithus irregularis, Eprolithus floralis, Radlolithus planus and *Prediscosphaera* cf. *P. columnata* suggest the presence of Albian age sediments and other Cretaceous elements suggesting Early Campanian-Late Maastrichtian time slice are interpreted to have been reworked from marginal shelf area by turbidity currents and comprise: *Arkhangelskiella cymbiformis, Arkhangelskiella* cf. *A. specillata; Aspldolithus parcus; Chiastozygus* cf. *Ch. striatus; Eiffellllthus turriseiffeli, E. eximius, Elffellithus* spp.; *Ellipsagelosphaera fossacincta; Watznaueria barnesae; Manivitella pemmatoidea; Microrhabdulus decoratus; Retecapsa* sp.; *Stradneria crenulata; Cretarhabdus* spp.; *Polypodorhabdus schizobrachiatus; Cribrosphaerella ehrenbergi; Rucinolithus* cf. *R. hayi, Rucinolithus* spp.; *Hexalithus* sp.; *Micula mura, M. decussata, Micula* spp.; *Quadrum trifidum, Q. sissinghi, Ouadrum* spp.; *Prediscosphaera grandis, P. intercisus, P. cretacea, P.majungae, P. microrhabdulina,P. spinosa; Cylindralithus serratus, Zygodiscus spiralis, Reinhardtites anthophorus; Glaukolithus diplogrammus; Tranolithus* sp.;*Zeugrhabdotus embergeri; Ceratolithoides aculeus; Bukryaster* sp.; *Blscutum* spp.; *Thoracosphaera saxea* and *Th. deflandrei* .

Precise timing of onset and duration of flysch sedimentation must remain speculative but broadly corresponds to Early Palaeocene-Late Eocene time slice for which marker nannofossil species are recorded with notable absence of Oligocene.

The assemblage is interpreted to have been largely derived from plankton crop and partly from marginal shelf area but heavily diluted by terrigenous influx of turbidites and comprises: *Biantholithus sparsus; Cruciplacolithus tenuis, C. cribellum; Campylosphaera eodela, C. dela; Ericsonia eopelagica, E. ovalis, Ericsonia* spp.; *Cyclococcolithus protoannulus; Heliolithus kleinpelli; Helicosphaera intermedia, H. seminulum, H. bramlettei, Helicosphaera* cf. *H. reticulata, Helicosphaera* spp.; *Pontosphaera* sp.; *Transversopontis* sp.; *Cribrocentrum reticulatum, Cribrocentrum* sp.; *Dictyococcites scrippsae, D. callidus, Dictyococcites* cf. *D. bisectus, Dictyococcites* sp.; *Reticulofenestra umbilica, R. dictyoda, Reticulofenestra* spp., *Cyclicargolithus floridanus; Sphenolithus pseudoradians, Sphenolithus* cf. *S. radians, Sphenolithus* spp.; *Neochiastozygus perfectus, N. eosaepes, N. chiastus Neochiastozygus* spp.; *Tribrachiatus orthostylus, T. contortus.*

References

Jafar, S. A. 1985: Discovery of mixed coccoliths from Mud Volcano of Baratang Islands, Andamans, India. Curr. Sci . 54[4], 1 70-1 73 .

Jafar, S. A. and Jyotsana Rai 1989: Discovery of Albian nannoflora from type Dalmiapuram formation Cauvery basin, India - Paleoceanographic remarks. Curr. Sci. 58[7], 358-363.

Karig, D. E . et al . 1978: Structure and Cenozoic Evolution of the Sunda Arc in the Central

Sumatra Region. AAPG Mem. 29, 223-237.
Pandey, J. 1972: Depositional Environment and geological history of the Baratang Formation, Andaman Islands. Proceed. IInd Ind.Colloq. Micropal. Stratrig., Lucknow, 66-76.
Rodolfo, K. S. 1969: Bathymetry and Marine Geology of the Andaman basin, and Tectonic Implications for Southeast Asia. Geol . Soc . Am . Bull., 80, 1203-1230.

FIRST REPORT ON PALAEOGENE DISCOASTERS OF ANDAMAN ISLANDS, INDIA

by S. A. JAFAR, U. C. MAINALI and O. P. SINGH (Birbal Sahni Institute of Palaeobotany, P.O.Box 106 Lucknow- 226 001, India).

Scrapping off of the Bengal Fan sediments lying on subducting Indian-Australian Plate, resulted in remarkable Island-arc system stretching from Burma to Indonesia. Gently deformed rocks of Archipelago group with thin forest cover, have yielded megafossils and critical pelagic microfossils of both siliceous and calcareous types permitting erection of high resolution stratigraphic-paleoceanographic framework for Neogene sedimentaries. In contrast, nearly 3000m of Late Cretaceous-Oligocene turbidite Flysch sequence making bulk area of the Islands, posed problems for dating owing to: (i) Thick forest cover and rare deeply weathered outcrops (ii) highly tectonised beds with vertical to overturned disposition (iii) Inaccessibility of areas frequented by hostile tribes. Datable fossils, permitting rather broad stratigraphic resolution are known from: (i) Chert and cherty-limestones, yielding Late Cretaceous (Early Campanian) Radiolaria and *Globotruncana* in thin sections and associated with dismembered ophiolite complex -outcropping in several localities on eastern margin of the Outer High (ii) Palaeocene-Eocene algae and larger foraminifera with Grits-Conglomerates interbedded with the Flysch (iii) Late Cretaceous Radiolaria and Globotruncana found in olistostromal cherty-limestone in Lipa Black Shales of Baratang Formation (iiii) Extremely rare benthic-planktonic foraminifera found within thin marly layers, comprising Late Cretaceous and Palaeogene assemblage with reworking of Cretaceous elements. Thus, thick succession of greywacke-shale alternation comprising Andaman Flysch (Baratang and Port Blair Formations) is practically barren in pelagic microfossils except for rare occurrence of echinoid-spines, bryozoa, mollusks, coal pockets, carbonised wood, leaf-impressions and frequent ichno-fossils at sandstone-shale contact and terrestrial palynofossils.

Andaman Islands display N-S trending folds-faults and eastward dipping thrusts. Along one of these major faults, the diapiric cores of the folds with deep seated shale intrusives, appear as Mud volcanoes on surface, spewing silty-rnud admixed with crude oil, gas and saline water. Remarkably, the mud samples yielded, though after a prolonged search, a diverse and datable assemblage of palynofossils, planktonic foraminifera, coccoliths and discoasters. Our study of coccoliths (reported separately in this volume) and discoasters from Mud volcano samples of Nayagarh, Baratang Island, suggests minor occurrence of hemipelagic component in dominantly terrigenous Flysch

sediments, which otherwise proved barren of nannofossils in exposed sections, owing to deep tropical weathering. Despite rare and slightly overgrown nature of nannofossils and the non-availability of FAD/LAD levels, such as in normally exposed pelagic sections, extensive search of marker species and employing their total range, suggests Early Campanian - Late Eocene time slice with notable absence of Late Palaeocene and Oligocene in subsurface of Baratang Island.

Marker species of *Discoaster* including *Rhomboaster cuspis*, recorded under LM observations are: *D. megastypus* Bramlette ~ Sullivan 1961 (NP 7-10) 10µm; *D. elegans* Bramlette & Sullivan 1961 (NP 9-11) 9 rayed, 10 µm; *D. binodosus* Martini 1958 (NP 10-18) 7 rayed, 13µm; *D. salisburgensis* Stradner 1961 (NP 9-12) 12 rayed, 15 µm; Bramlette & Riedel 1954 (NP 12-14) 5-7 rayed, 14-24 µm; *D. kuepperi* Stradner 1959 (NP 12-14) 9-10 µm: *D. barbadiensis* Tan 1927 (NP 10-20) 8-11 rayed, 8-18µm; *D. tanii* Bramlette & Riedel 1954 (NP 17-23) 5 rayed, 9 µm; *D. saipanensis* Bramlette & Riedel 1954 (NP 16-20) 7 rayed, 9 - 11µm and *Rhomboaster cuspis* Bramlette ~ Sullivan 1961 (NP 9-10).

Besides this a few less significant species include, *D. nonradiatus, D. aster, D. hilli* and *Discoaster* spp. Evidence of *Discoaster* species, thus suggests presence of Early Eocene (Ypresian), Middle-late Eocene Flysch sediments in subsurface of Baratang Island. Our results have important bearing on understanding geotectonic and emergence history of Andaman Islands.

THE VARIABILITY OF THE DISCOASTER RAY NUMBER AND ITS STRATIGRAPHIC SIGNIFICANCE

by M. C. JANIN (Univ. P.-et-M. Curie, Lab. Stratigraphie, 4 Pl. Jussieu (T15 E4), 75 252, Paris Cedex 05, France).

A detailed analysis of the ray number variations in *Discoaster* populations was carried out on late Paleocene to late Pliocene calcareous oozes from different localities: classical Oligo-Miocene sections of Trinidad, manganese nodule areas of the Northeastern Pacific (Clarion Clipperton Zone), and DSDP-ODP sites in Atlantic and Indian Oceans (Legs 22, 23, 25, 44 and 101).

It reveals a precise correlatron between the main occurring *Discoaster* taxa and the distribution of asterolith ray number in the *Discoaster* populations on the whole. Successive distribution patterns can be distinguished, particularly for the late Paleocene-late Eocene and middle Miocene-late Pliocene intervals, where the maximal asterolith diversity is usually recorded: abrupt changes characterize the Paleocene/Eocene, early/middle Eocene, Eocene/Oligocene and middle/late Miocene boundaries. A slow modification is also pointed out in the Oligocene/ early Miocene interval.

Similar changes are noted at the same times in sediments from different areas. Consequently, the *Discoaster* ray number variations seem suitable alternative markers in case of the absence of identifiable index taxa, especially for samples with scarce *Discoaster* or poorly preserved nannofossil assemblages. Careful

interpretation of the data is however required in case of heavily diagenetised sediments, because of the differential solubility of the morphotypes according to their ray number: the general trend of the variations appears more significant than the absolute percentages of each morphotype.

VARIATIONS IN THE ASSEMBLAGES OF CALCAREOUS NANNOPLANKTON AROUND 2.4 M.Y. (UPPER PLIOCENE) AT D.S.D.P. SITES 606, 608 AND 609B (NORTH ATLANTIC)

by A. JIMENEZ, J.A. FLORES (Departamento de Geologia -Paleontologia-. Universidad de Salamanca. 37008 Salamanca. Spain).

At a limit of about 2.4 million years B.P., Shackleton and Opdike (1977) have reported a pronounced glacial pulse; this was based on isotopic studies and has later been conffirmed with the use of other techniques (Ruddiman et al., 1987; Latouche et al 1987; Backman & Pestiaux, 1987...) at different series. In the present work we offer a high and low resolution quantitative analysis concerning the assemblages of calcareous nannoplankton from three ocean drillings obtained in the Leg 94 of the DSDP on the western side of the central Atlantic ridge, for the period referred to 2.4 m.y.(Upper Pliocene). The sites chosen were 606, 608 and 609B, situated between 37° and 57° N. According to the findings, it is possible to observe the effect of this glaciation on the masses of surface waters at different latitudinal points, for the North Atlantic zone, and also the changes that took place as a result of variations in the subtropical gyre during the Upper Pliocene. In turn, a definition is offered of a series of biostratigraphic signals; making significant use of the variations occurring in the smallest taxa (small placoliths...etc) common throughout the area; their equivalence with conventional scales and their relationship with adjacent areas is also offered.

References

Backman, J. & Pestiaux, P., 1987. Pliocene Discoaster abundance variations, D.S.D.P. site 606. Biochronology and paleoenvironmental implications. Initial Reports D.S.D.P., 94 (2): 903-910

Latouche, C. et al. , 1987. X-ray mineralogy of the clay fraction from Cenozoic strata, Leg 94: Comparison with previous North Atlantic data. Initial Reports D.S.D.P., 94 (2): 1089-1102

Ruddiman, W.F. et al.,. 1987. Leg 94 Paleoenvironmental synthesis. Initial Reports D.S.D.P., 94 (2): 1207-1215

Shackleton, N. J. & Opdyke, N. D., 1977. Oxigen isotope and paleomagnetic evidence for early Northern Hemisphere glaciation. Nature, 307: 620623.

DISTRIBUTION OF LIVING COCCOLITHOPHORIDS IN THE N.E. ATLANTIC

by R . W . JORDAN (Geophysics Division, British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 OET, England).

The biogeography of coccolithophorids from the N.E. Atlantic has recently been investigated using data from four summer sampling programmes. The community structures from both the Temperate and Subtropical Zones have been well defined from both latitudinal and longitudinal transects. The transitional region (the Azores Front) between these two zones has also been studied.

The Temperate Zone was characterised, throughout the photic zone, by members of the Coccolithaceae and in particular by *Emiliania huxleyi* (cold water form) and *Gephyrocapsa muellerae* . In addition, in the vicinity of the mid-Atlantic ridge holococcolithophorids (especially *Calyptrolithophora papillifera*) became more numerous in the surface waters.

In contrast the Subtropical Zone was characterised by a stratified photic zone, in which the upper portion was dominated by *Umbellosphaera tenuis*, holococcolithophorids and members of the Rhabdosphaeraceae, and the lower portion by *Florisphaera profunda* (both varieties). At some stations a middle portion was discernible, characterised by members of the Syracosphaeraceae and *U. tenuis*. In the vicinity of the mid-Atlantic ridge there was an increased contribution from the holococcolithophorids in the surface waters and *Ceratolithus cristatus* represented about 10% of the coccolithophorid flora. The contribution of the Coccolithaceae was severely reduced, although the warm water form of *E. huxleyi* was always present.

Attempts have been made to relate these findings to in-situ environmental conditions, with most of the emphasis being placed on temperature, light attenuation, wind mixing and water mass movement.

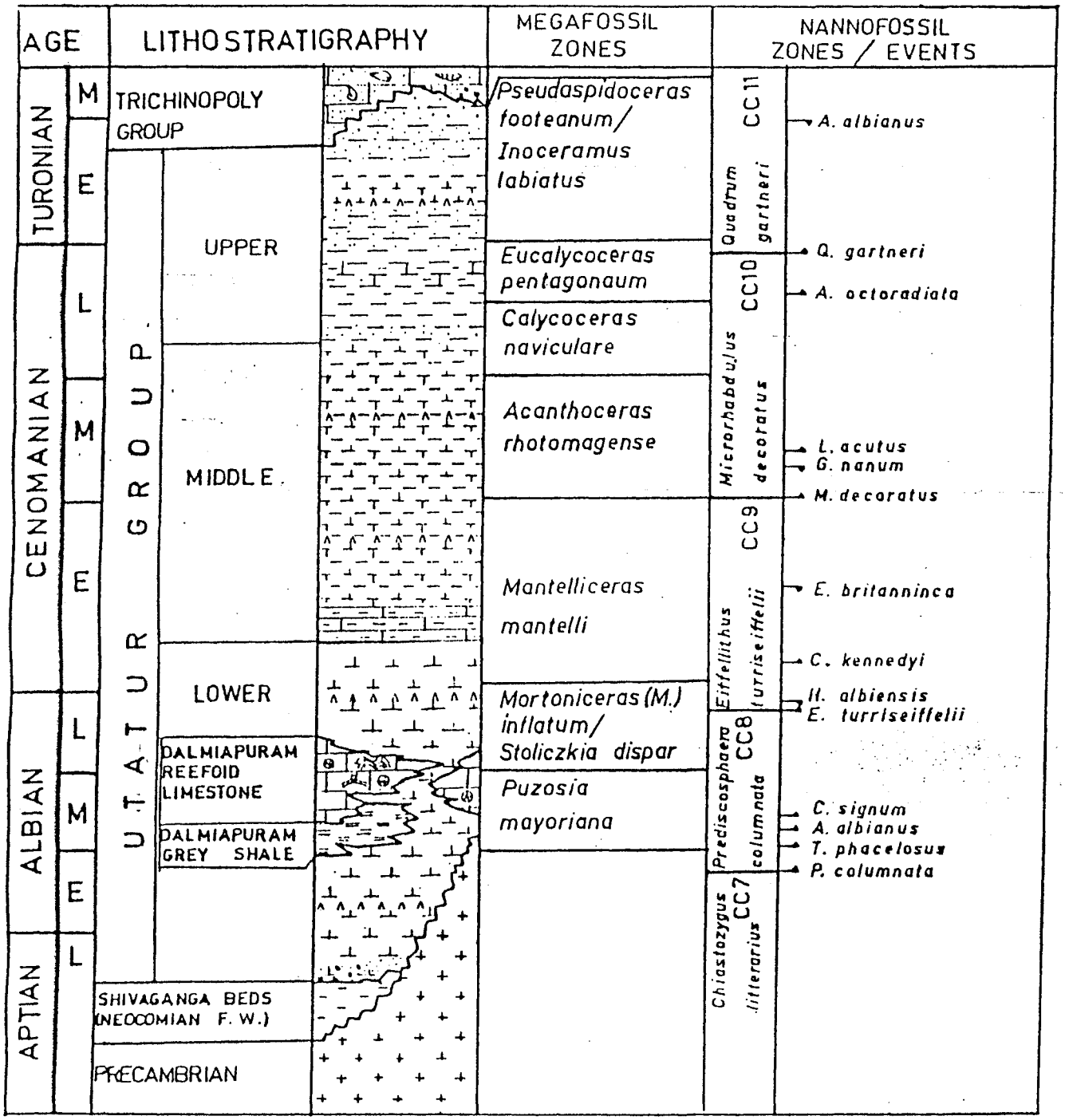
NANNOFOSSIL BIOSTRATIGRAPHY OF THE UTATUR GROUP, TRICHINOPOLY DISTRICT, SOUTH INDIA

by A. S. KALE, V. G. PHANSALKAR (Department of Geology, University of Poona, PUNE - 411 007, INDIA).

The Utatur Group represents the oldest marine sequence of sediments in the Cauvery Basin of the Trichinopoly district of South India. Nannofossils from the sediments of this Group, of Early and Middle Cretaceous age have been studied in details.

Five nannofossil biozones, viz. *C. litterarius* to *Q. gartneri* [CC 7 to CC 11] are used to divide the Late Aptian(?) to Middle Turonian strata. These are summarised in Figure I along with the significant nannofossil events recorded in the Basin. The established ammonite zones are also given.

The nannoflora of the Utatur Group shows distinctive paleogeographic


AGE
LITHOSTRATIGRAPHY
MEGAFOSSIL ZONES
NANNOFOSSIL ZONES / EVENTS
TURONIAN
CENOMANIAN
ALBIAN
APTIAN
M
E
L
M
E
L
M
E
L
TRICHINOPOLY GROUP
UTATUR GROUP
UPPER
MIDDLE
LOWER
DALMIAPURAM REEFOID LIMESTONE
DALMIAPURAM GREY SHALE
SHIVAGANGA BEDS (NEOCOMIAN F.W.)
PRECAMBRIAN
Pseudaspidoceras footeanum/ Inoceramus labiatus
Eucalycoceras pentagonaum
Calycoceras naviculare
Acanthoceras rhotomagense
Mantelliceras mantelli
Mortoniceras (M.) inflatum/ Stoliczkia dispar
Puzosia mayoriana
Quadrum gartneri
CC11
Microrhabdulus decoratus
CC10
Eiffellithus turriseiffelii
CC9
Prediscosphaera columnata
CC8
Chiastozygus litterarius
CC7
A. albianus
Q. gartneri
A. octoradiata
L. acutus
G. nanum
M. decoratus
E. britannica
C. kennedyi
H. albiensis
E. turriseiffelii
C. signum
A. albianus
T. phacelosus
P. columnata

signatures. In the Aptian(?) - Albian times it is a high latitude Southern flora. This gradualy gives way to a temperate / tropical - subtropical flora in the Cenomanian to Turonian times.

MODERN COCCOLITHOPHORIDS FROM THE MEDITERRANEAN SEA: A COMPARISON BETWEEN PLANKTON-ASSEMBLAGES DURING SUMMER 1986 & WINTER 1988 AND ITS RELATIONSHIPS TO THE COCCOLITH-COMPOSITIONS SEDIMENT-SURFACE

by M. KNAPPERTSBUSCH (Geologisches Institut,ETH, 8006-Zurich, Switzerland)

A quantitative study of the variation in the standing-crop of living Mediterranean coccolithophorids during the French oceanographic cruises VICOMED I (September/October 1986) and VICOMED II (February/March 1988) has been done. The purpose is to examine the diversity of living calcareous nannoplankton species at different hydrological regimes from watermasses of the Western and Eastern Mediterranean Sea, to investigate its relationships to the physico-chemical parameters such as temperature & salinity, and to recognize its relationships to the species composition as preserved in the surface sediments. Plankton-samples have been collected from 21 locations during the first cruise and 22 locations during the second expedition along the almost identical routes (from Toulon to Heraklion). From each station, eight to ten liters of seawater, coming from six different depths between 0 m and 200 m, have been filtered with a Millipore-filtering system. For taxonomic descriptions I used the SEM, whereas coccospheres were counted with a light microscope. From each station, samples of the sediment surface have been obtained for smearslide investigations. Coccosphere assemblages from the summer period seem to reflect the strong hydrological gradients between the Eastern and Western Mediterranean basins, that have been recognized from temperature- and salinity profiles at each station, whereas nannoplankton-assemblages during the winter period are dominated by blooms of *Emiliania huxleyi* and seem to be rather uniform throughout the Mediterranean Sea.

MORPHOLOGICAL EVOLUTION OF THE NEOGENE COCCOLITH GROUP CALCIDISCUS LEPTOPORUS - CALCIDISCUS MACINTYREI

by M. KNAPPERTSBUSCH (Geologisches Institut,ETH, 8006-Zurlch,Switzerland)

A study of morphological changes of coccoliths within a time interval of more than 20 My and with respect to geographic shape variability has been done within the Neogene coccolith group *Calcidiscus leptoporus* (Early Miocene to Recent) and *Calcidiscus macintyrei* (Early Miocene to Early Pleistocene). The morphological similarity of coccoliths of the two species have given rise to assume a close phylogenetical relationship between *C.leptoporus* and *C.macintyrei* . Measurements of intact coccospheres and its appertaining coccoliths of *C. leptoporus* from plankton samples from the Equatorial Pacific, the North-Atlantic and from the Mediterranean Sea by electron microscopy show that the living community of this taxon consits of two different populations: A small type, with coccosphere diameters between 4.5 and about 11.0 µm and which are covered by small sized coccoliths (2.5 to 7.0 µm); and a large type including coccospheres between 11.0 µm and 23.5 µm, bearing coccoliths with distal shield diameters between 4.6 µm to more than 10.5 µm.The frequency distribution of these coccosphere types is highly bimodal with its centers at 7.0 µm and 14 µm respectively. From the isolated coccoliths, size and numbers of its distal shields elements are positively correlated. Although there is an overlapping area of these two morphological parameters (e.g.between 4.6 to 7.0 µm for the distal shields diameter and between 16 to 24 elements), both coccosphere types can be distuinguished by the distribution of its isolated coccoliths alone.

In a second phase, the analysis of sediment-surface assemblages along a transsect from the Subpolar to the Tropical Atlantic Ocean, the Southern Pacific and from the Equatorial to Southern Indian Ocean revealed that the mean number of elements and the mean diameter of *C.leptoporus* coccoliths are correlated to the sea-surface water temperatures: Large coccoliths, that can be assigned to the large type coccosphere occur consistently in the sediments of tropical waters and seem to be the dominant portion among the *C. leptoporus* fraction above a temperature-threshold at 26°C, whereas the smaller coccolith morphotypes are cosmopolitans and coexist with the former. From the Holocene data set it also turned out, that the increase of mean numbers of elements with temperature is a step-like function and has no gradual change. As a conclusion, I infer that small- and large type coccospheres of *C.leptoporus* may represent two genetically different strains, which may have been separated in the past.

The morphological changes of *C.leptoporus* and *C.macintyrei* coccoliths with time have been investigated within a interval between Early Miocene to Early Pleistocene at three Deep Sea Drilling Sites: Site 251 (Southern Indian Ocean), Site 236 (Equatorial Indian Ocean) and at Site 608 (North Atlantic). At Site 608,

the oldest (22.4 Ma) *C.leptoporus* specimens measured during this study consist of small coccoliths with a unimodal frequency distribution, representing the small cell type of living *C.leptoporus* . At 20 My, first large coccoliths of the large cell type have been detected at the same Site,which eventually signify a first cladogenetic event within the *C. leptoporus* taxon. At 16.2 Ma first coccoliths of *C.macintyrei* have been discovered at Site 608. However, at the tropical Indian Ocean Site 236, coccoliths of *C. macintyrei* occurred already at 17.8 Ma, and, according to J. Boudreaux, 1972 (Init.Rep.DSDP, Vol. 23, page 1082), *C.macintyrei* even occurred within the *Triquetrorhabdulus carinatus* zone, about 24 Ma, in the Arabian Sea (DSDP Site 223).These findings prove a strong diachroneity of the first appearance dates of *C.macintyrei* at various locations in the ocean. The most reasonable explanation for the morphological variability of the *C.leptoporus* - *C.macintyrei* plexus may be a second cladogenetic event during the Lower Miocene which led to the evolution of *C.macintyrei* from early *C.leptoporus* forms. Subsequently, a third cladogenetic event between 10.3 Ma and 8.4 Ma appears to have given rise to very large morphotypes of *C.macintyrei* as documented at Site 251.

MONTE ACUTO SECTION : EOCENE-OLIGOCENE BOUNDARY EVENTS

by M. MADILE (Università degli Studi di Firenze, Italy)

The biostratigraphy based on calcareous nannofossils of the Late Eocene - Early Oligocene pelagic section of Monte Acuto has been investigated.
Variations in abundance of several calcareous nannofossils species have been observed close to the E/O boundary defined by planktonic foraminifera.
The most important variation is the increase in abundance of the cold water indicator, *I.recurvus* near the last occurence of the rosette shaped discoasters.
This event recognized in other sections is very usefull for correlating low and middle latitudes sequences.
The events recognized are correlated with other sequences from Umbria~Spain and some DSDP sites.

CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY IN THE TOARCIAN SEDIMENTS FROM FRANCE AND GREECE: CORRELATION WITH AMMONITES, MAGNETOSTRATIGRAPHY, ISOTOPES AND ORGANIC MATTER

by H. MANIVITT, F. BAUDIN, B. GALBRUN, R. MOUTERDE (University P. et M. Curie, Department of Sedimentary Geology URA 1315; B.R.G.M. BP 6009, 45060 Orleans Cedex 2; Catholic Faculty, Geological Laboratory, Lyon, France)

This study presents the early results of analyses of three sections in the Ionian zone (Greece). An integrated biostratigraphy with ammonites and nannofossils, magnetostratigraphy, isotopes and organic matter data was carried out according to the paleoenvironmental conditions. We attempted a comparison between Greece and Paris Basin (parastratotype Toarcian from Airvault section and a core drill at Sancerre Couy).

The calcareous nannofossils are present in most samples. Although they are poorly preserved and not very diversified the typical robust Tethyan assemblages and events are recorded in Greece as: *Mitrolithus elegans, M. jansae, Parabdolithus liasicus, Carinolithus superbus.* The nannofloras are characteristic of the *falciferum* and *spinatum* zone and can be correlated with the Toarcian anoxic event. They are very similar to the nannofossils recovered in Italy in the Longobucco material and in the Central and North Apennines at Valdorbia section and Sentino formation or in the northwestern African margin on DSDP site 547 B.

The ammonites presence in some sections is in good agreement with the nannofossil results which also provide valuable information in the absence of any biostratigraphic data.

The biostratigraphic study shows that low abundance reduce diversity and the preservation states reflect the fluctuations in the sedimentation and in the depositional environment.

VARIABILITY OF COCCOLITHUS PELAGICUS AND DICTYOCOCCITES SPP. IN THE UPPER MIOCENE-PLIOCENE SITE 116 (D.S.D.P.; N. ATLANTIC).

by A.J. MARTIN and J.A. FLORES (Departamento de Geologia-Paleontologia-. Universidad de Salamanca, 37008 Salamanca. Spain).

The assemblages of calcareous nannoplankton of the Tertiary sediments at Site 116 were studied in depth by Backman (1980), with important findings from biometric studies on different groups of taxa.

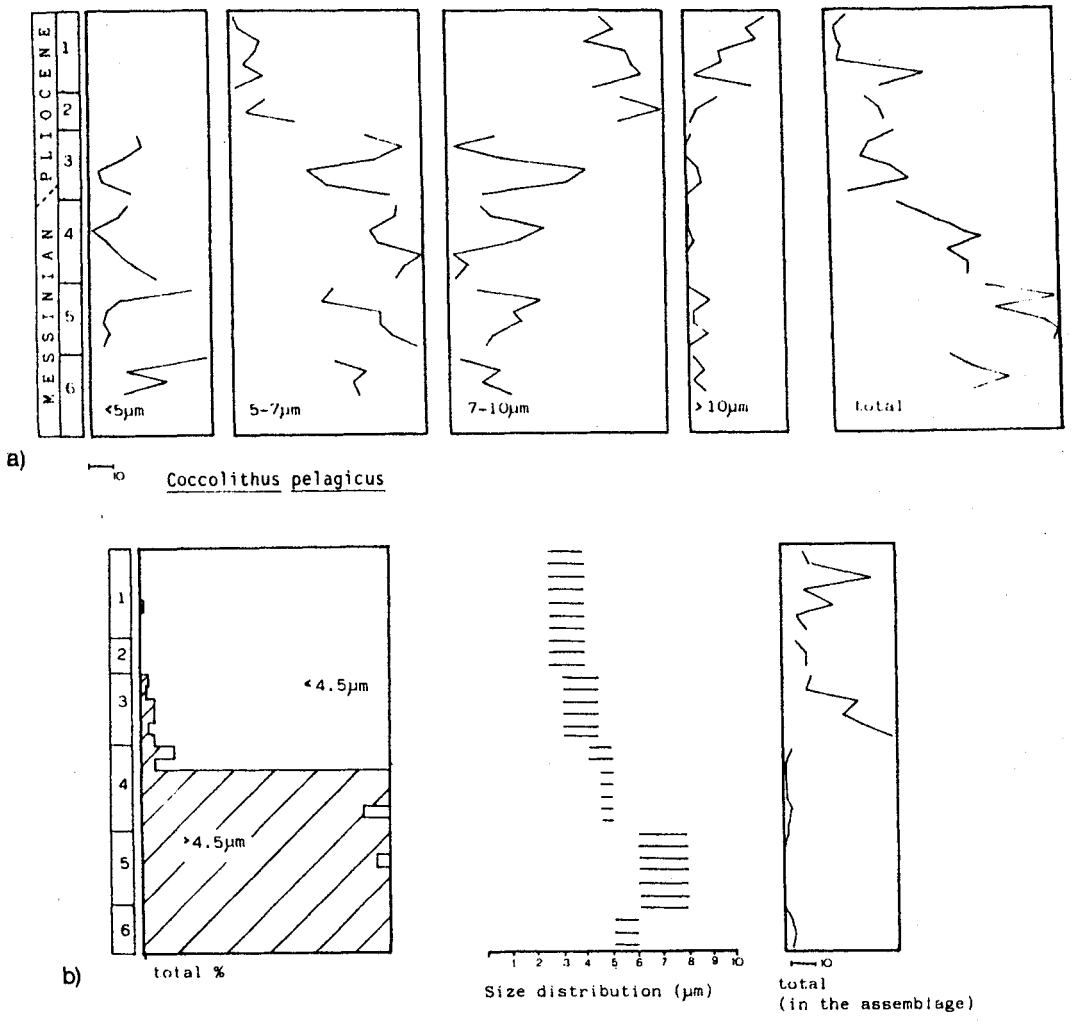
In the present work we offer the results of a new biometric analysis centered on *Coccolithus pelagicus* and *Dictyococcites* spp. with a view to studying their variability. In both cases easily-obtained parameters such as maximum length of the placolith were handled.

The results, including the groups defined on the basis of size, are show in figure 1: a) *Coccolithus pelagicus* and b) *Dictyococcites* spp.. Other data

corresponding to total abundance are also included.
In *Coccolithus pelagicus* it is clear that towards the top of the section (upper Pliocene) the large forms have been substituted by smaller ones and that total abundance decreases.
As well as showing a greater abundance towards the top *Dictyococcites* spp. shows a cleaar substitution of forms smaller than 4.5 mm and a clear ordering by size in the different periods.
These results are interpreted in relation to the paleoenviromental variations and are contrasted with different biostratigraphic proposals.

References.

Backman, J., 1980. Miocene-Pliocene nannofossils and sedimentation rates in the Hatton-Rockall basin, NE Atlantic Ocean. Stockholm Contr. Geol., 36 (1): 1-91



TIME-PROGRESSIVE MORPHOLOGICAL CHANGES OF GEPHYROCAPSA DURING QUATERNARY

by H. MATSUOKA (Graduate school of Natural Science and Technology, Kanazawa Univ. Kanazawa 920, Japan).

Investigation was carried for the morphological changes of *Gephyrocapsa* through Quaternary in an ODP core 709c which was recovered from the tropical Indian Ocean. Overall size and diameter of central opening were measured under electron microscope for the coccoliths of Gephyrocapsa, and the results are shown in Fig.1.

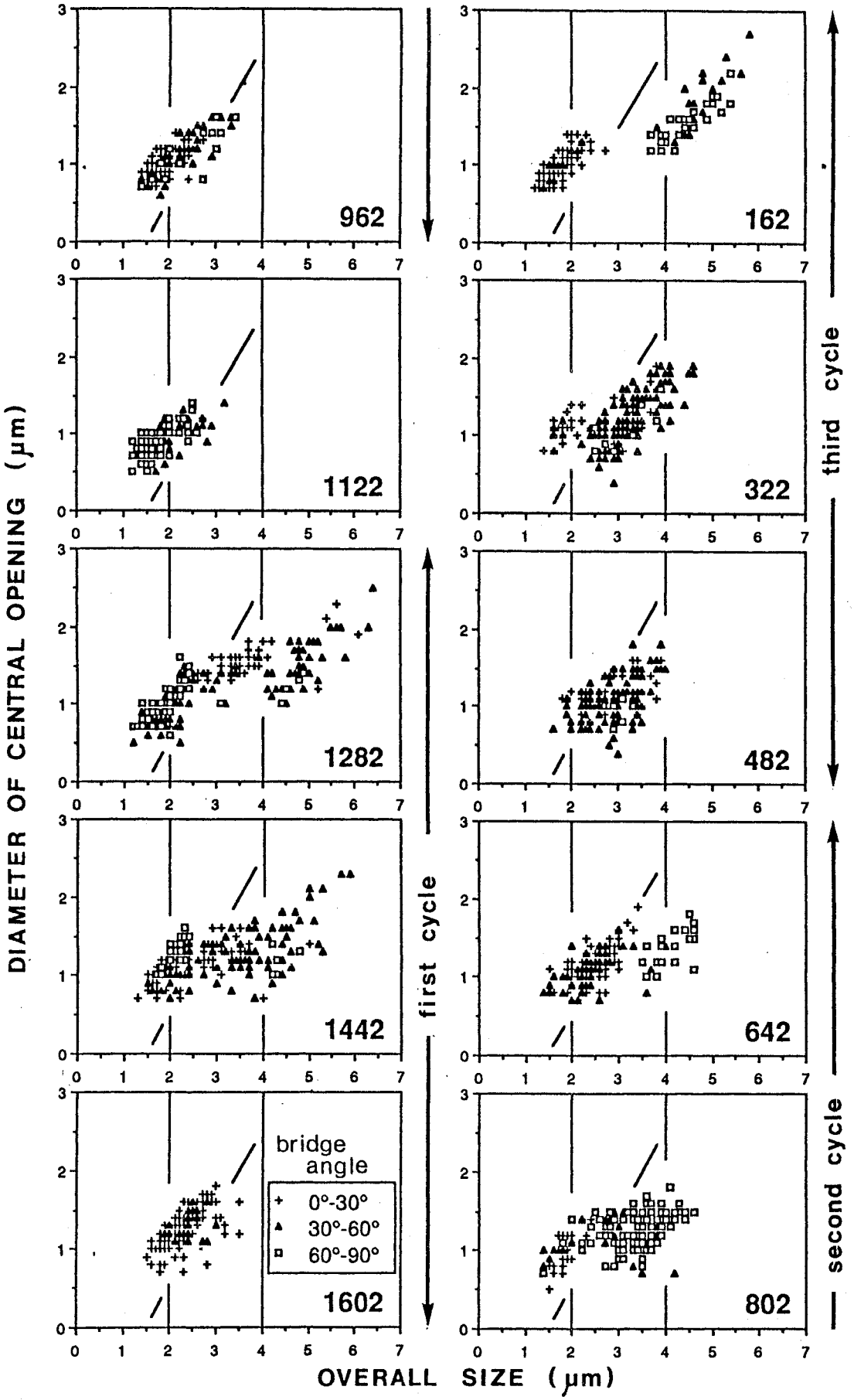
Gephyrocapsa can be divided roughly into small and large forms. Mainly with respect to the overall size of the coccoliths, morphology of the large forms show a timeprogressive change consisting of three cycles: the first cycle is located at the interval between 1602 and 1202cm of the core (about 1.6 - 1.1 Ma); the second cycle is at 962-602cm (about 0.9 - 0.5 Ma); and the third cycle at 562-2cm (about 0.5 Ma present) respectively. An interval lacking the large forms is found between the first and second cycles, and it corresponds to "small Gephyrocapsa zone". Overall size of the large forms is about 3~m on average at the early stage of each cycle, and tends to increase with time, but the forms suddenly disappear at the last stage of the earlier two cycles. The relative abundance of the large forms decreases with the increase of the overall size as if the two factors are inversely correlated. Because of the duration each cycle(ca. 0.4 - 0.5 Ma), the changes can hardly be attributed to a specific environmental cause.

The appearance and disappearance as well as the change of overall size and relative abundance of the large forms play the major role in the change of nannofloras through Quaternary. Matsuoka and Okada (in press) indicated time progressive changes of nannofloras through the past 1.3 Ma from the subtropical Pacific, and proposed six nannoflora assemblages essentially based on the change of Gephyrocapsa. Because the same assemblages are recognized in the Indian core, it is expected that these morphological changes and the assemblages can be traceable worldwidely to, at least, subtropical and tropical oceans.

Reference

Matsuoka,H. and Okada,H. (in press) Quantitative analysis of Quaternary nannoplankton in the subtropical northwestern Pacific Ocean. Mar. Micropaleontol., 14, 97-118 .

Fig. 1 - Overall size and diameter of central opening of 200 specimens of Gephyrocapsa at selected layers (intervals of 160cm during Quaternary). The numerical values of the Gothic form in each figure shows depth from the top of the core. The diagonal line in each figure approximately indicates boundary between small and large forms. The occurrence of the large forms at 1422cm and 1282cm is much less than that at the other layers, so that minimum 100 specimens of them are counted at the two layers. A bridge angle denotes an inclination of bridge against the long axis of coccolith.


962
162
1122
322
1282
482
1442
642
1602
802
bridge angle
0°-30°
30°-60°
60°-90°
first cycle
second cycle
third cycle
DIAMETER OF CENTRAL OPENING (μm)
OVERALL SIZE (μm)

BIOSTRATIGRAPHY AND CORRELATION OF MIOCENE DEPOSITS OF GEORGIA BASED ON CALCAREOUS NANNOPLANKTON

T. MINASHVILI (Geological Institut of Acad. of Science of Georgian, Tbilisi, USSR)

no abstract

INTER-RELATIVE ASPECTS OF NANNOFOSSIL AND PALYNOMORPH BIOSTRATIGRAPHY AND PALEOECOLOGY AT THE K/T BOUNDARY, HOR HA'AR SECTION, SOUTHERN ISRAEL

by S. MOSHKOVITZ and Y. ESHET (Geological Survey of Israel, 30 Malkhe Yisrael St., Jerusalem 95501)

Preliminary study of nannofossils and palynomorphs (mainly dinoflagellate cysts and varíous types of organic matter) revealed competitive relationships between the two groups, which are expressed by the type of assemblages and organic matter. Four stratigraphic phases are correlatable between the nannofossil and palynologic record and are presented here from the older to the younger (see Fig. 1):

A: MICULA DECUSSATA OOZE (latest Maastrichtian, samples 84-75) Dominated by overwhelming quantities of *M. decussata* accompanied by *Thoracosphaera operculata* (calcareous dinoflagellate). Organic matter is mainly very fine corroded inertinites (terrestrial particles), with *Palaeocistodinium* sp. A, as the only dinocyst. Biodegradation is strong, probably reflecting the harsh conditions that preceded the K/T transition.

B. INERTINITES AND ABUNDANT *THORACHOSPAERA* AT K/T BOUNDARY (samples 63-60)

The base of this interval is marked by the FO of the foraminifer *G. eugubina* and rare occurrences of *B. romeinii* and *B. parvulum* . A competition among the various phytoplankton groups might be indicated by the abundance of thorachosphaerids and absence of dinocysts. The abundant inertinites may indicate a regressive phase at the K/T boundary.

C. RE-ESTABLISHMENT OF MARINE CONDITIONS FOR DINOFLAGELLATES AFTER K/T CRISIS (samples 58-43)

Gradual increase in quantity and variety of dinocysts, associated with a decrease in terrestrial particles indicate a transgressional phase after the E/T boundary. Dinocysts become very abundant, forming a "dinoflagellate ooze". A later decrease in dinocysts and increase in inertinites (samples 40-28), associated with *Thoracosphaera* ooze (samples 42-37) suggest a regressive phase.

D. RE-ESTABLISHMENT OF MARINE CONDITIONS FOR CALCAREOUS NANNOPLANCTON AFTER K/T CRISIS (above sample 21)

Characterized by increase in Early Tertiary nannoplankton forms, indicating the return to normal marine conditlons for nannoplankton after the K/T

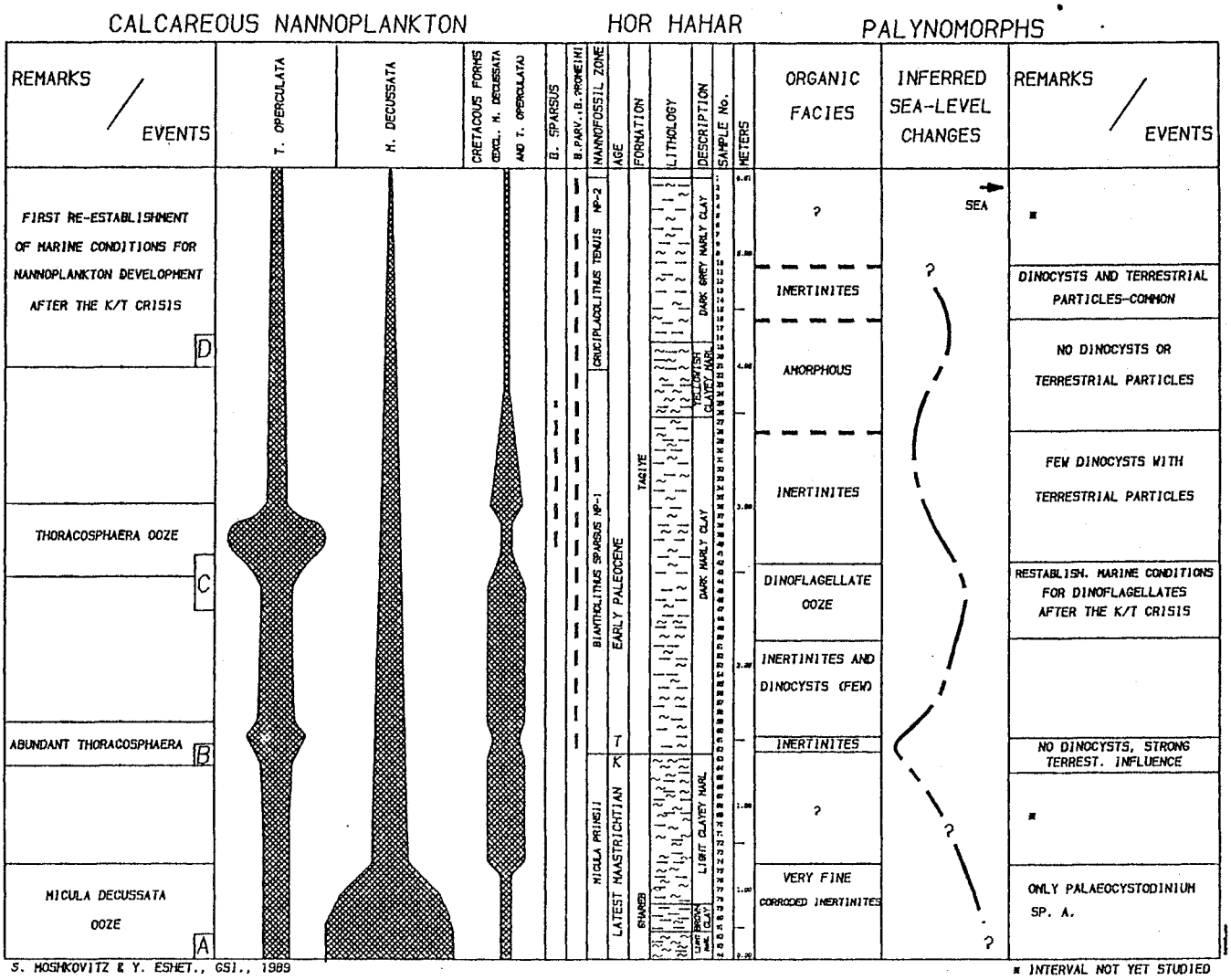


Figure 1. Biostratigraphy and inferred paleoecology based on calcareous nannoplankton and palynomorphs at the K/T boundary interval, HorHaHar outcrop, southern Israel.

crisis. Organic-walled phytoplankton (dinoflagellates) seems to have recovered faster than the calcareous nannoplankton. The lower part of this interval (samples 28-16) contain amorphous organic matter and very low terrestrial particles, indicating a transgressional trend, which agrees with the evidence from nannoplankton.

UPPER CRETACEOUS HIGH RESOLUTION STRATIGRAPHY IN THE PELAGIC SEQUENCE OF THE JUDEAN MOUNTAINS AND THE SHEPHELA REGION, CENTRAL ISRAEL

by S. MOSHKOVITZ, G. GVIRTZMAN, A. ALMOGI-LABIN, Z. LEWY (Geological Survey of Israel, 30 Malkei Israel Street, Jerusalem 95501, Israel), A. HONIGSTEIN (Department of Geophysics and Planetary Science, Tel Aviv University, Tel Aviv 69978, Israel), and Z. REISS (Geological Survey of Israel, 30 Malkei Israel Street, Jerusalem 95501, Israel)

Results of multidisciplinary studies (1,2,3) of the Upper Cretaceous sediments in Central Israel are presented. Biostratigraphic, lithologic, as well as electric log markers from outcrops (Judean Mountains) and boreholes (Hashephela Basin), were used to reconstruct the geological history in different paleo-environmental parts of the pelagic sequence (Coniacian-Maastrichtian) in the eastern Tethys province.

The soft material of the Mont Scopus Group, comprising chalks, marls, shales as well as some cherts, was extensively investigated, integrating calcareous nannofossils, benthic and planktic foraminiferids, ostracodes and ammonites.

As a result of these studies, a fine stratigraphical subdivision into thirty seven local datum levels could be distinguished; of these, twenty nine are based on fossils of global significance.

The stage boundaries (Santonian-Campanian and the Campanian-Maastrichtian) are now more firmly established. Subdivision at various stages, especially the Maastrichtian, based on nannofossils and foraminiferids are now easily reached.

The geological history and development of Hashephela basin and the Judean Mountains during the Coniacian-Maastrichtian times is discussed.

References

Moshkovitz, S. 1984. Late Cretaceous calcareous nannofossil biostratigraphy of the Mount Scopus Group, Israel, GSI., Curr. Res., 1983-1984, pp. 46-55.

Gvirtzman, G., Moshkovitz, S. & Reiss, Z., 1985. Senonian to early Eocene Mount Scopus Group in the Hashefela Region, Central Israel: Stratigraphy and Basin Evolution. Isr. J. Earth Sci., 34, pp. 172-192.

Gvirtzman, G., Almogi-Labin, A., Moshkovitz, S. Lewy, Z., Honigstein, A. & Reiss, Z., 1989. Upper Cretaceous high resolution multiple stratigraphy, northern margin of the Arabian Platform, central Israel. Cret. Res. 2/2 (in press).

NANNOFOSSIL MIGRATION AND DISTRIBUTION PATTERNS IN THE BOREAL LOWER CRETACEOUS OF NW-EUROPE

by J. MUTTERLOSE (Institut für Geologie und Paläontologie, Universität Hannover, Callinstr. 30, 3000 Hannover 1).

The nannofossil assemblages of the boreal Lower Cretaceous of NW-Europe show a two scaled cyclicity. Small scaled cycles, represented by marl-clay rhythms, are characterized by changes of nannofossil abundances and diversity from bed to bed. The marly layers yield abundant and diverse assemblages, relatively rich in *Nannoconus, Micrantolithus* and *Conusphaera*. On the other hand the flora of the clay horizons are impoverished both in diversity and abundance. Interpolations for the Hauterivian gave a duration of 33.000 - 67.000 years for each rhythm, which corresponds to Milankovitch cyclicity. Superimposed on these small scale variations, which are probably caused by orbital forcing, are first and second order eustatic shifts. These are represented by major influxes of tethyon nannoconids, which occurr during four intervalls: - earliest Late Valanginian - earliest Early Hauterivian - latest Late Hauterivian~Early Barremian - "mid" Aptian.
These periods reflect sea level high stands and probably warm water conditions. Cooler phases are on the other hand the Early Valanginian, the Late Valanginian, the "mid" Hauterivian and the Late Barremian/Early Aptian. These cycles have a duration of 3-5 million years.

CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF LATE CRETACEOUS SEDIMENTS IN JORDAN

by F. NAJI (Natural Resources Authority, P.O. Box 7, Amman, Jordan)

Due to the presence of phosphate deposits, oilshales and oilreservoires, the Late Cretaceous sediments in Jordan are of economic value. Accordingly their biostratigraphic investigations became of great importance.
Calcareous nannoplankton analysis were carried out on outcrop samples from North, Central an South Jordan. Core chips and ditch cuttings samples from oil exploration wells which have been drilled by the Natural Resources Authority in the Northern Highlands, Azraq, Risha and Sirhan areas have also been analyzed.
According to the recovered calcareous nannoplankton assemblages, the Late Cretaceous sediments in Jordan can be subdivided into the following zones: *Eiffellithus turriseiffeli, Eiffellithus eximius, Zygodiscus spiralis, Marthasterites furcatus, Tetralithus trifidus, Arkhangelskiella cumbiformis, Lithraphidites quadratus* and *Nephrolithus* frequens.

RELIABILITY OF SPHENOLITHS AS ZONAL MARKERS IN OLIGOCENE SEDIMENTS FROM THE ATLANTIC AND INDIAN OCEANS

by G. OLAFSSON (Department of Geology, University of Stockolm, S-106 91, Stockolm, Sweden).

The number of conventionally used biostratigraphic marker events is lower in the Oligocene time interval than it is in most other Cenozoic interval of corresponding duration. Because of this, it is of great importance that these events are defined in a reliable and reproducible way in order to maintain, or increase, the biostratigraphic resolution in the Oligocene. The reliability of Oligocene *Sphenolith* marker events is investigated by means of quantitative methods and correlated to the magnetic polarity timescale. The material used is from DSDP Hole 522 in the South Atlantic Ocean and from ODP Hole 711A in the equatorial Indian Ocean. *Sphenolith* are used to define four out of nine datum levels used for the subdivision of the Oligocene into biozones. These four events are; FAD of *S. distentus* , FAD of *S. ciperoensis* , LAD of *S. distentus* and LAD of *S. ciperoensis* . By using strict taxonomical definitions it is possible to use the LAD of S. predistentus too, wich falls shortly above the FAD of *S. ciperoensis* in the South Atlantic Ocean. *Sphenolithus pseudoradians* , a distinct and easily recognized species could be useful biostratigraphically, although it is only present in low numbers and occurs sporadically in its uppermost range.

OLIGOCENE/MIOCENE MORPHOMETRIC VARIABILITY OF THE CYCLICARGOLITHUS LINEAGE FROM THE EQUATORIAL ATLANTIC AND INDIAN OCEANS

by G. OLAFSSON (Dept. of Geology, University of Stockholm, S-106 91 Stockholm, Sweden).

The diameter of members of the genus *Cyclicargolithus* was measured in smear-slides of samples from around the Oligocene/Miocene boundary with an average sample interval of 82 kyrs in Hole 667A (eq. Atlantic) and 150 kyrs in Hole 709C (eq. Indian). The measurements were made using a light microscope connected to an image analysis system. Measurements on a calibration micrometer (10 micrometers between the bars) on the image screen gave a mean value of 10.03 ± 0.03 µm (N = 50; 95% confidence interval). Increased number of measurements indicate that a sample size of 150 specimens is sufficient to give a good representation of the whole *Cyclicargolithus* assemblage. No attempt was made to disiinguish between *C. floridanus* and *C. abisectus*. Judging by the original descriptions of *C. floridanus* (Roth and Hay) and *C. abisectus* (Müller) it is virtually impossible to distinguish between these two species since their size overlap considerably and they have very similar optical behavior in the light microscope. The diameter of *Cyclicargolithus* specimens vary from about 5 µm to over 14 µm, the biggest form measured had a diameter of 14.55 µm. The diameter range of each sample shows a normal distributicn where the forms larger than 10 µm are absent above Zone CP19, but a trend towards a bimodal distribution can be seen in the upper part of Zone CP19 where the large forms are present. Above the CP19/CN1 boundary the large forms (diameter larger than 10 µm) are very rare in the *Cyclicargolithus* assemblage and occur only sporadically. The large forms appear in both sites In the upper part of Zone CP18, at about the same stratigraphic level as *Triquetrorhabdulus carinatus*.

EXAMPLES OF DIACHRONEITY OBSERVED IN THE UPPER PALEOGENE OF THE TROPICAL INDIAN OCEAN AND POSSIBLE NEW DATUM EVENTS

by H. OKADA (Department of Earth Sciences, Yamagata University, Yamagata, 990 Japan)

ODP Leg-115 recovered diverse Oligocene and Eocene nannofossils from several sites in the tropical Indiana Ocean. Stratigraphic occurrences for some of datum events observed in these sites are significantly different from current "standard" time tables.

One of the major differences observed is for the first appearances (FA) of *Sphenolithus distentus*. Its FA is supposed to follow the last appearances (LAs) of *Ericsonia formosa* and *Reticulofenestra umbilica* in the lower Oligocene. At LEG-115 Sites, a *Sphenolith* which looks similar to *S. distentus* commonly occurs in the lower Lower to middle Lower Oligocene coexisting with *E. formosa* and *R. umbilica*. This taxon is generally larger and is more robustly constructed compare to true *S. distentus*, and it disappeared in the middle Lower Oligocene prior to the FA of true *S. distentus*. A casual investigator, however, can easily mistake the earlier taxon as *S. distentus*. Duration of Zone CP17 which is defined by the LA of *R. umbilica* and FA of *S. distentus* is short (0.5 My) in Berggren et al (1985) compare to that of Bukry (1975; 4.0 My). An identification of the new *Sphenolith* taxon as *S. distentus* is a possible cause of the discrepancy. Since the FA of new taxon precedes the LA of *E. formosa*, however, the possible misjudgment alone can not explain the time gap, and a diachroneity is suspected for the FA of either *S. distentus* (s. str.) or the new taxon.

True FA of *S. ciperoensis* is also hard to detect in the tropical Indian Ocean. A short form resembling early *S. ciperoensis* are common in the upper Lower Oligocene, and it later evolved into larger and wider forms. These forms could be member, of *S. ciperoensis* complex, but identification of separate taxa based upon biometrical studies may be beneficial for the refinement of Late Oligocene Biostratigraphy.

R. umbilica occurs sporadically within the Lower Oligocene sequence at Leg-115 sites, and its LA is an unreliable biostratigraphic marker Its FA defining the base of Subzone CP14a is suppose to be synchronous with that of *Discoaster bifax* , but the former event actually occurs much higher than the later event. Obviously either the evolution of *R. umbilica* or disappearance of *D. bifax* is diachronous. The FA of *D. bifax* actually occurs shortly above the LA of *Chiasmolithus gigas* , and Subzone CP13c is much shorter than Subzone CP13b in the tropical Indian Ocean. The FA of *D. bifax* may also be a diachronous event.

The distinct LO of *Ericsonia obruta* observed in the Lower Oligocene of South Atlantic (Backman, 1987) is another example of diachroneity; its stratigraphic range clearly extend into the Lower Miocene in the tropical Indian Ocean as well as in the Philippines Sea.

On the positive side for improved biostratigraphy, two new species have emerged as good biostratigraphic markers. One of them is a new sphenolith observed in the lower Middle Eocene interval at Site 115B711. This taxon

which has four radiated apical spines is similar to the Miocene species *Sphenolithus quadrispinatus* , and is a good example of iterative homeomorphy. The other one is a robustly constructed coccolith which seems to has no affiliation to any existing genus. Throughout the Leg-115 sites, it occurs exclusively within a very short interval of the latest Oligocene. Since an identical occurrence was observed in the Philippines Sea, this new taxon has a high potential to improve the biostratigraphic scheme of the upper oligocene. The LOs of *Hayella sitiliformis* and *Bramletteius serraculoides* are also good biostratigraphic markers for the lower Oligocene of the tropical Indian Ocean.

MORPHOMETRIC AND FLORAL VARIATIONS OF CALCAREOUS NANNOPLANKTONS IN RELATION TO THEIR LIVING ENVIRONMENT

by H. OKADA (Department of Earth Sciences, Yamagata University, Yamagata, 990 Japan)

Biogeographical changes of calcareous nannoplankton was further clarified in the surface sediments of the Sea of Kumano, locating offshore central Japan, and the adjacent Ise Bay. Although the ranges somewhat overlap, the floral compositions plotted in a ternary diagram drown by *Gephyrocapsa* spp., *Florisphaera profunda* and all other species as end members clearly shows a environment-controlled shift.

In the semi-enclosed environment of Ise Bay, *Gephyrocapsa oceanica* dominates the flora in the central and inner parts, but the mixing of bay water with open sea water at the mouth of the Bay results a drastic reduction of *G. oceanica* ; from the almost complete monopoly to approximately 60% level of the flora. A sharp increase of *Emiliania huxleyi* is mostly responsible for the drastic decline of *G. oceanica.*

In the open sea environment of the Sea of Kumano, an increase in water depth results a progressive increase in relative abundance of *F. profunda,* reaching to approximately 60% level in the deeper part of the basin. Contrarily, *G. oceanica* shows an opposite trend in the shallow coastal area and becomes rather consistent in the deeper part of the Sea. Beside of these two major species, few other species indicate environmentally controlled variations in their relative abundance; *Calcidiscus leptoporus* and *Umbilicosphaera sibogae* becomes progressively more common in deeper waters, whereas *Helicosphaera* spp. becomes less abundant.

A study of filtered sea water samples collected from the North Atlantic Ocean identified a temperature-controlled morphometric Variation in *Emiliania huxleyi.* The four ecophenotypes, warm, transitional, cold and subarctic types occur within individually regulated temperature ranges, and proportions of their relative abundances varies in accordance with water temperature. This observation opens up a simple new technique to estimate paleotemperature for the latest Quaternary.

A subsequent investigation of a piston core C-6 taken from offshore southern

coast of Central Japan produced a stratigraphic record of the last 16,000 years in the relative abundances of these ecophenotypes. The observed result is similar to the previous result of Chinzei et al (1987) which shows a time-progressive changes in relative water temperature in the same core. Their data is a result of compilation utilizing micropaleontological data covering major microfossil groups. The new approach experimented here uses much simpler procedure and requires far less time of investigation. The strong possibility for direct conversion to water temperature is another advantage of this new technique.
Seasonal variation of nannolith flux was investigated at a station locating off-shore southern coast of Japan by studying sediment-trap samples. The flux of coccoliths shows a prominent peak corresponding to a spring broom while no increase was observed to indicate the autumn broom. The largest (3.1×10^9 individuals/m^2/day) and the smallest (0.5×10^9/m^2/day) fluxs were observed in the early June and the late March samples respectively, and the calculated average flux was 1.2×10^9/m^2/day. The year-round existence of *Florisphaera profunda* was observed first time, and its average flux was 2.3×10^8/m^2/day. As was the case for coccoliths, a prominent peak (5.1×10^8/m^2/day) corresponding to the spring broom was noticed, and an additional second peak (3.2×10^8/m^2/day) which corresponds to an autumn broom was also recognized in this flux.

PROBLEMS AND PERSPECTIVES IN CALCAREOUS NANNOFOSSIL CORRELATIONS AT JURASSIC-CRETACEOUS BOUNDARY.

by S. OZKAN and P. R. BOWN (Dept. of Geological Sciences, University College Cower Street London WC1E 6BT London).

While receiving far less attention than many other stratigraphic boundaries the Upper Jurassíc-Lower Cretaceous interval is nevertheless of great interest in terms of both stratigraphy and palaeontology. The stratigraphy, biostratigraphy and correlation of the boundary interval will be reviewed.
The boundary interval represents a particularly important period for calcareous nannofossils. The potential for a refined nannofossil biostratigraphy has been well íllustrated in recent studies by Roth (1983), Cooper (1984) and Bralower et al. (in press). These biostratigraphical refinements reflect an important evolutionary episode which was initiated in the Tithonian and continued into the Berriasian. The evolutionary radiation also coincided with the first occurrence of pelagic carbonates whose origin ís attributed to nannofossils. Despite these favourable factors of increased diversity and abundance, biostratigraphy across this interval remains difficult due to problems of preservation and provincialism. The application of nannofossil bostratigraphy will be discussed and illustrated with reference to DSDP sites 534 and 261, and onshore sections from Turkey.

HORSESHOE-SHAPED CALCAREOUS NANNOFOSSIL AND SALINITY CRISES

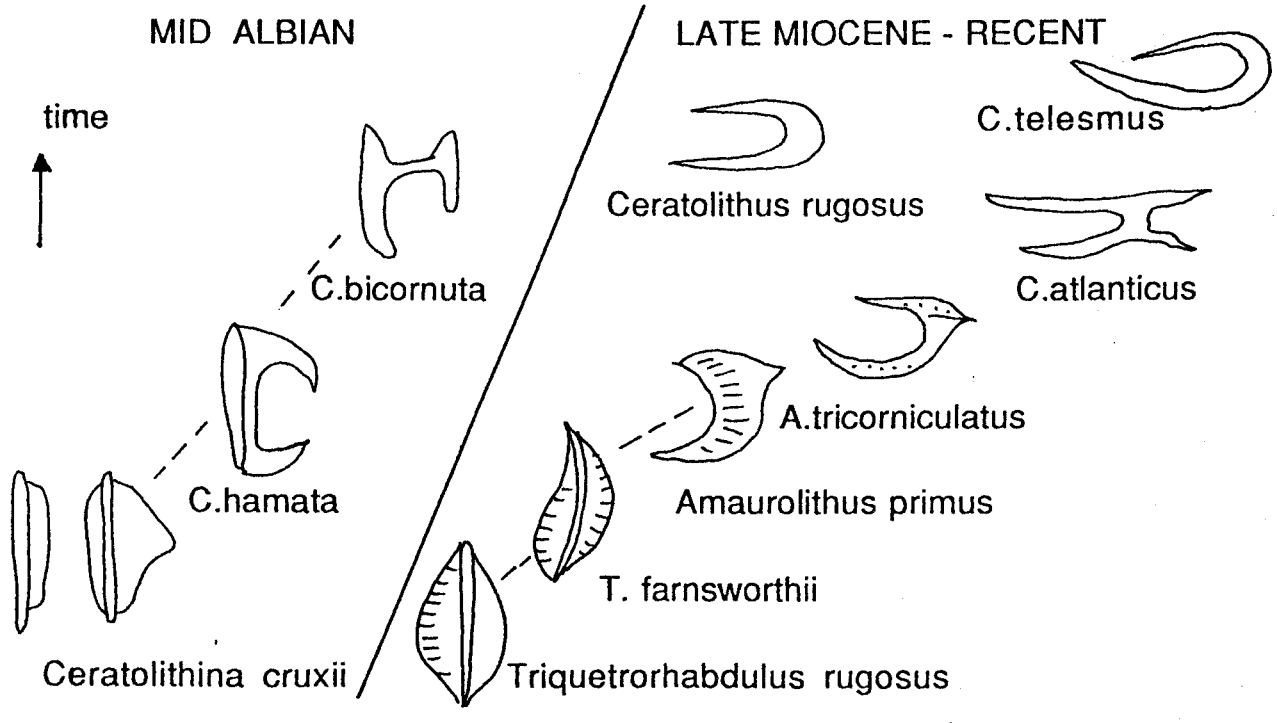
by K. PERCH-NIELSEN (Geological Institute ETH-Z, CH-8092 Zurich, Switzerland)

Horseshoe-shaped calcareous nannofossils may have evolved from rod-shaped forms twice: first during the Middle Albian (*Ceratolithina*) and then again during the Late Miocene (*Triquetrorhabdulus* - *Amaurolithus* - *Ceratolithus* , Fig.1). In both cases, deposition of large amounts of evaporites predates this evolution: in the South Atlantic during the Aptian/Early Albian and in the Mediterranean during the early Late Miocene.

Rod-shaped calcareous nannofossils can be found in Jurassic through Recent sediments. Some can be shown to be broken-off central processes of coccoliths whereas for others, this connection to the coccolithophorids can not be shown. It is two of the latter, *Ceratolithina* (Middle Albian) and *Triquetrorhabdulus* (Late Oligocene through Late Miocene) which are thought to have given rise to the horseshoe-shaped forms, while several others, like *Pseudolithraphidites* (Tithonian), *Lithraphidites* (Berriasian).

through Maastrichtian), *Pseudotriquetrorhabdulus* (Middle Eocene) and *Orthorhabdus* (Early Miocene) can not be linked to the remaining angular to horseshoe-shaped forms.

The evolution from rod- to horseshoe-shaped forms thus only occurred during the two intervals postdating the deposition of large amounts of evaporites.



TETHYAN AND BOREAL LOWER CRETACEOUS NANNOCONUS

by K. PERCH-NIELSEN (Geological Institute ETH-Z, CH-8092 Zurich, Switzerland)

The genus *Nannoconus* has long been assumed to be a form restricted to the tethyan realm. It is, however, also represented in high northern and high southern latitudes. In the boreal realm, it contains not only many species previously thought to be restricted to the Tethys, but also numerous species which have not yet been found in the tethyan realm.
The oldest species assignable to *Nannoconus* are known from the Tithonian in the Tethys. Diversity increases rapidly and by the Late Berriasian, tethyan and first boreal species appear in N. Europe.
Nannoconids are rare in both realms during the Early Valanginian sea level lowstand. Their diversity increases during the Hauterivian and Barremian in both places, but samples with other calcareous nannofossils but no nannoconids are also found in both realms.
In most samples, only one or two species of *Nannoconus* have been reported. The presence of more than one or two species in several tethyan sections has been correlated to the magnetic polarity pattern and seems to occur at the same time in all these sections. From the Late Valanginian through the Early Aptian, relatively high diversity in *Nannoconus* can be observed at about 1 million years intervals. This is about at the same order of magnitude as the small-scale sealevel changes shown by HAQ et al. (1987).
Aptian and Albian assemblages are often more diverse than earlier ones in the Tethys, but are usually scarce in the boreal realm.

SOUTHERN HIGH LATITUDE K/T BOUNDARY CALCAREOUS NANNOFOSSILS FROM ODP SITES 690 AND 752

by J. J. POSPICHAL (Dept. of Geology, Florida State U.,Tallahassee, FL 32306).

Recent drilling in the Southern Oceans by the Ocean Drilling Program has produced several Cretaceous/Tertiary boundary sequences. Before the onset of Southern Hemisphere drilling, little was known about calcareous nannofossils across the critical K/T interval at high southern latitudes. In the Weddell Sea, Leg 113, the first leg in a series legs which concentrated on drilling around the continent of Antarctica, recovered a biostratigraphically complete K/T boundary although heavily bioturbated. Leg 119 recovered a complete K/T boundary sequence on the southern Kerguelen Plateau and Leg 121 cored a biostratigraphically complete, but somewhat disturbed sequence on Broken Ridge in the eastern Indian Ocean.
Leg 113, Site 690, located at a latitude of 65° S on the Maud Rise in the Weddell

Sea was cored through sediments of Maestrichtian age. The K/T boundary is located in a heavily bioturbated zone at the contact between dark brown clay-rich Danian chalks and light cream colored chalks of Maestrichtian age. An Irldlum anomaly ls present ln the dark sedlments just above the K/T contact. The color contrast is sharp which aided in identifying several dark colored burrows within the light chalks. Burrows up to 1.3 m below the boundary were analyzed and found to contain Tertiary nannofossils. The lowest Danian subzone, CPla, is approximately 40 cm thick and the underlying, *Nephrolithus frequens* Zone is over 20 m thick. Quantitative analysis of nannofosslls across this interval revealed a turnover quite different in many ways to well studied Tethyan and other low latitude sequences, but similar from high northern latitude sequences. Highlights observed in this section were: an uppermost Maestrichtian acme of *Prediscosphaera stoveri* (*quadripunctata*); the first occurrence *Biantholithus sparsus* coincident with the boundary; an unprecedented *Hornibrookina edwardsii* bloom within CPla just above the boundary; a lack of forms such as *Biscutum parvulum, B. romeinii_,* and *Toweius petalosus* ; and no significant *Thoracosphaera* bloom until well above the boundary.

In the Indian Ocean, the K/T boundary was cored at Leg 121, Site 752 on Broken Ridge, which has an estimated paleolatitude of 55° S for that time. The boundary is located at the base of a 6 m layer of volcanic ash, which overlies well indurated ashrich chalks of Maestrichtian age. Shipboard analysis showed the thick ash layer to be the result of a series of ash falls and not just one event. In addition, the presence of this ash layer is not indicative of above normal volcanic activity at K/T time but of the drastic drop in carbonate production associated with the collapse of surface water productivity of the calcareous microplankton. This is extremely well illustrated in this section as analysis has shown that ash accumulation did not increase significantly across the boundary, and in fact, was on the decline from higher levels in the Maastrichtian.

Quantitative analysis of calcareous nannofossils across the boundary revealed similar assemblages as found at 690. The ash layer of Danian CPla contains rare to common moderately well preserved nannofossils. This initial Danian subzone (5 m) is fairly thick when compared to other deep sea sites, especially Site 690. The underlying, *Nephrolithus frequens* Zone is also quite thick at 58 m. Preservation is generally moderate to poor in this zone. Intervals of intense dissolution in the uppermost Maestrichtian chalks reduced nannofossil diversity to 4 or 5 robust forms such as *Micula decussata, Arkhangelskiella cymbiformis, Kamptnerius magnificus,* and *N. frequens.* Although fairly abundant in intervals of improved preservation, *Prediscosphaera stoveri* is not near as abundant as observed at Site 690.

In the Danian ash sequence, preservation improves dramatically but nannofossils are much less abundant. Reworking of Cretaceous forms is common and with improved preservation more forms can be identified. The initial CPla assemblage includes the "Survivor" forms, *Zygodiscus sigmoides, Biscutum castrorum, Markalius inversus, Neocrepidolithus, Cyclagelosphaera reinhardtii,* and *Thoracosphaera.* The most abundant form is *Z. sigmoides.*

Thoracosphaera is slightly more abundant at this site than at Site 690, but much less so when compared to some low latitude K/T sections. The forms *B. parvulum, B. romeinii,* and *Toweius petalosus* have not yet been identified. Rare *Cruciplacolithus primus* first occur several meters above the boundary. *Biantholithus sparsus* is also very rare and first occurs just above the boundary.

INTEGRATED CRETACEOUS BIOSTRATIGRAPHY AND MAGNETO-STRATIGRAPHY FROM ITALIAN PELAGIC SEQUENCES.

by I. PREMOLI SILVA (Dipartimento di Scienze della Terra, via Mangiagalli 34, 20133, Italy), J. E.T. CHANNELL (University of Florida, 1112 Turlington Hall, Gainesville - Florida 32611), R. COCCIONI (Istituto di Geologia, via S. Chiara 27, 61029 Urbino, Italy); E. ERBA (Dipartimento di Scienze della Terra, via Mangiagalli 34, 20133, Italy), S. MONECHI (Dipartimento di Geologia e Geofisica, Bari), and G. PARISI (Dipartimento di Scienze della Terra, Piazza Universita', 06100 Perugia, Italy).

Cretaceous sediments widely outcrop throughout the Italian Peninsula from Southern Alps to Sicily. The most complete and better exposed sequences spanning the entire Cretaceous crop out in the Umbrian-Marche Basin (central Italy). There, characteristic formations are in stratigraphic order, the Maiolica (latest Jurassic-earliest Aptian), Scisti a Fucoidi (Early Aptian-Late Albian), Scaglia Bianca (latest Albian-Early Turonian), and Scaglia Rossa (Early Turonian to the Cretaceous-Paleocene boundary). Those formations consist primarily of pelagic limestones and calcareous marls, which before lithification could be identified as nannoconid oozes, calcareous nannofossil mudstones, and nanno-foraminiferal oozes, respectively. Although calcareous planktonic organisms are now contained in hard rocks, a complete succession of the major bioevents among the nannofloras, calpionellids, and planktonic foraminifera was recognized similar to that from other low latitude sequences. Consequently, standard zonal schemes have been applied to the Italian succession using mainly smear-slide and thin section techniques. In some cases, Italian sequences provided better biostratigraphic resolution than previously known such as in the Aptian-Albian interval where two new nannofossil biozones could be defined within the long interval represented by the *Parhabdolithus angustus* and *Praediscosphaera columnata* Zones. Dissolution andlor thin section technique caused uncertainty in placing some planktonic foraminiferal zonal boundaries, which, however, does not invalidate the overall continuous fossil record.

Several measured sections were also investigated paleomagnetically and a complete, even composite, geomagnetic polarity succession was reconstructed for the entire Cretaceous up to the Oligocene/Miocene boundary. The record of geomagnetic polarity reversals recognized in the Umbria-Marche sequence and in the Lower Cretaceous from Southern Alps closely matches that inferred from marine magnetic anomalies. Because magnetic measurements have been made from the same samples investigated for fossil content, then geomagnetic chrons could be directly calibrated to bioevents.

MORE THAN 200 MILLION YEARS OF COCCOLITH EVOLUTION

by B. PRINS (Shell Internationale Petroleum Mij, The Hague, The Netherlands).

Already the oldest coccoliths known from the late Triassic (Norian) of Austria are of an astonishing complexity. Although their appearance is less regular than that of younger Coccoliths, their architecture appears to be comparable. These basic units can be recognized: an outer unit (the rim area), an inner one (the plate area), both composed of modified and radially arranged calcite crystals with more or less equal crystallographical orientation, and a third unit (the wall) that connects the other two. The calcite cristals of this third unit have an orientation perpendicular to those of the rim and plate.
Especially in Mesozoic coccoliths the orientation of the calcite crystals in the three basic units is remarkably conservative. Even when the units themselves change their morphology drastically (i.e. during the Mesozoic and Cenozoic), the crystallographical orientation of the crystals in each of the units remains the same in many instances. This conservatism offers an attractive opportunity to follow the course of change in related morphotypes and to unravel many uncertainties about their relationships. Based on the crystallographical morphological evolution of the three basic units various taxonomic entities on family level and higher rank can be defined which, grouped together, result in a natural classification.

THE CALCAREOUS NANNOFOSSILS AND THE MINERALOGICAL FRACTION <25μ IN QUATERNARY AND LATE NEOGENE SEDIMENTS OF THE NORTHEASTERN SUBTROPICAL ATLANTIC OCEAN

by A. PUJOS (Departement de Geologie et Oceanographie - U.A. 197 Universite de Bordeaux I Avenue des Facultes - 33405 Talence Cedex - France).

Calcareous nannofossils have been studied in two sedimentary sections from the northeastern subtopical Atlantic ocean : the ODP Site 658 (Leg 108) and the Kullenberg core Midlante 74206. Environmental and hydrological conditions are different in the oceanic areas of the two sections : Site 658 is located at the vicinity of the African coast on the continental slope, with a complex system of seasonal upwellings, while surface and sub-surface currents bring waters of various qualities all over the zone. The core 74206 is located off Site 658 in the open sea and is not influenced by upwellings : thus the superficial hydrology of the area is more stable, and, in spite of some dissolution, the section can be used as a typical oceanic reference for the Site 658.
In the two sections, nannofossils are usually abundant and well diversified,

and some of them ("stratigraphical" taxa) allow to establish a high-resolution chronology, well supported by isotopic measurements made in shells of planktonic foraminifera, throughout most of the Pleistocene and during late Neogene.
Nannofossil "ecological" taxa show strong variations, which are different in the two sections. Count matrices of eight of these taxa were submitted to the Imbrie and Kipp's method of transfert function, and satisfying winter and summer temperatures and salinities were estimated for superficial waters.
Throughout the middle and late Pleistocene in Site 658, maxima of abundance of some "ecological" taxa (*Coccolithus pelagicus, Rhabdosphaera* sp., *Helicosphaera* div. sp.), mineralogical components (silts < 25 μ, organic matter, silica colloid) and small Diatoms (mostly *Thalassionema nitzschioides*) succeed one another, in a cyclical way. Their distribution, as well as the variations of temperatures and salinities, are related to the alternation of the glacial/interglacial stages, to the seasonal alternation of the hydrological systems linked to the upwellings, and to the periodic presence of the Canary current which brings northern cold waters to the coastal area. In the oceanic part of the studied area, the alternation of upwelling/quiet periods is totally absent.
The same method was applied to the late and middle-late Neogene sediments from the same area. Cyclical sequences of the same components were found, and, despite the complexity of the interpretation, they were used for trying to reconstruct paleohydrological environments.
Consequently, it is possible, by using few components from the organic and mineralogical fraction < 25μ (and especially some taxa of nannofossils) to sketch the history of the oceanic environment and of the surface and sub-surface hydrological changes of a complex area during the last millions years.

BIOSTRATIGRAPHIC RESOLUTION AND PRECISION ATTAINABLE IN THE EARLY PLEISTOCENE MARINE RECORD BY MEANS OF CALCAREOUS NANNOFOSSILS

by I. RAFFI (Istituto di Geologia, Università di Parma, Italy), D. RIO (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy), and J. BACKMAN (Department of Geology, Stockholm University, Sweden)

Recent papers by Gartner (1977), Rio (1982) and Rio et al. (in press) indicate that a high degree of biostratigraphic esolution is attainable in the early Pleistocene marine sediments by means of calcareous nannofossils. Specifically, the following events have been established in the time interval between the top of the Olduvai Subchron (1.66 Ma) and the top of the Jaramillo Subchron (0.91 Ma) in different areas:
1) First appearance of *Gephyrocapsa oceanica* sl. (event GO)
2) Last occurrence of *C. macintyrei* (event CM)

3) First appearance of *Gephyrocapsae* 5.5 μm (event LG)
4) Last occurrence of *Gephyrocapsae* 5.5 μm and temporary disappearance of normal sized *Gephyrocapsae* + last occurrence of *H. sellii* (event S1)
5) Reentrance of normal sized *Gephyrocapsae* and first appearance of *Gephyrocapsae* sp.3 (event S2)
These events are always in the same relative order in sequences from Mediterranean and Caribbean seas, equatorial Pacific, and northern Atlantic, and therefore they do not show major dichroneities.
In this work we have determined the position of the above mentioned events in sequences where oxygen stable isotope and/or magnetic stratigraphies were available (Core V 28-239, ODP Site 11-677, DSDP Hole 504, DSDP Hole 502, DSDP Hole 552A, Core V 12-18, ODP Hole 107-653A), for testing their precision in biostratigraphic correlation. The obtained results indicate that most of the events provide a precision within 0.1 my in correlating sequences over widely separated areas.

RESPONSE OF CALCAREOUS NANNOFOSSILS TO ORBITAL FORCING IN THE MEDITERRANEAN EARLY PLIOCENE TRUBI FORMATION

by I. RAFFI (Istituto di Geologia, Università di Parma, Italy), D. RIO (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy), and R.C. THUNELL (Department of Geology, University of South Carolina, Columbia, S.C. 29208)

The "Trubi" Formation of Calabria and Sicily is characterized by rhythmic alternations of limestone and marls. Each marl-limestone couplet has been shown to have a mean duration of about 19 ka and the deposition of these rhythmic sediments has been considered tuned by the processional orbital cycle (Zijderveld et al., 1986; Hilgen, 1987; Channel et al., 1988).
Quantitative and semiquantitative abundance patterns of selected calcareous nannofossils have been produced from a "Trubi" succession outcropping at Capo Spartivento (Calabria, Southern Italy) in order to investigate the response of calcareous nannofossil assemblages to Milankovitch type lithological cycles, and to contribute to the understanding of the causal mechanism of such cyclicity.
The time control in the sequence is provided by magnetostratigraphy and planktonic foraminifera biostratigraphy (Channel et al., 1988). The lithological cycles extend from the base of the sequence (corresponding with the restablishment of the open marine conditions in the Mediterranean) up to the base of the Nunivak Subchron.
A major change in the calcareous nannofossil assemblage is recorded at the base of the Thvera Subchron when a concomitant decrease of carbonate content occurs. Another change occurs just above the first common occurrence of *Globorotalia margaritae,* when an abundance cross over between *Dictyococcites* spp. and reticulofenestrids is recorded.
Coccolithus pelagicus and discoasterids fluctuate in abundance in

correspondance with the lithological cycles. Specifically, discoasterids show low abundances in high carbonate intervals or beds, whereas *C. pelagicus* shows an opposite trend.
These findings can be interpreted as related to relatively warmer and colder surface water conditions during marl and limestone deposition respectively. This in agreement with the fact that *Discoaster pentaradiatus* is the dominant discoaster in the marly intervals. However, recently Chepstow Lusty et al. (in press) have suggested that low abundances of discoasterids may indicate high nutrient level in the water masses. Accordingly, the low discoasterid abundances in limestone beds would indicate high productivity condition. This observation is in agreement with the high abundance, within the same limestone beds, of small Prinsiaceae, which have been suggested to be indicative of high productivity (Gartner et al., 1983).
Previously, the marl-limestone couplets have been interpreted as due to terrigenous dilution related to variable run-off (Hilgen, 1987).

A BIOSTRATIGRAPHIC SYNTHESIS OF THE JURASSIC NANNOFOSSIL EVENTS FROM CENTRAL ITALY, FRANCE, PORTUGAL AND HUNGARY

by V. REALE (Dipartimento Scienze della Terra, Firenze), S. MONECHI (Dipartimento di Geologia e Geofisica, Bari), A. BALDANZA and E. MATTIOLI (Dipartimento Scienze della Terra, Perugia)

A biostratigraphic synthesis of calcareous nannofossil events from Central Italy, Southern France and Hungary is given. The studied sequences span from the Lower Pliensbachian to Lower Bajocian and are the following: Rabaçal, Peniche, Ponta do Trovao, Cap Mondego in the Portuguese west-basin; Beaumont South and Beaumont West in the Digne Area (S.E France), and Monti Bakoni , M.Mecks and M. Vilany in Hungary . Semiquantitative analyses of the nannofloral content were performed at the light microscope. Calcareous nannofossils are always present and the preservation varies from moderate to poor, although a complete succession of events has been recognized in all the studied sequences. All the nannobiohorizons (mainly first occurrences) were calibrated with the ammonite zonation. The resolution is quite good for the interval studied. It has to be noted that several events are consistent in all the areas studied, namely the FO of *L. crucicentralis* occurs in the *Tenuicostatum* Zone, the FO of *Calyculus* spp. in the *Spinatum* Zone ; on the other hand many others are not coeval, such as the FO of *Mitrolithus jansae*, occurring in the *Jamesoni* Zone in Hungary, in the *Ibex* Zone in Portugal and in the *Stokesi* Zone in the Umbria-Marche area; the FO of *Biscutum finchii* occurring in the *Jamesoni* Zone in Portugal and Hungary, in the *Spinatum* Zone in the Umbria-Marche area ; the FO of *W. britannica* occurring in the Umbria-Marche area in the *Discites* Zone, while in France is in the *Laeviuscula* Zone; in Portugal is already present in the assemblages of the *Laeviuscula* Zone. These discrepancies could be related to the complex

Jurassic paleogeography.
It has to be noted that the FO of *Hexalithus magharensis* occurs in the *Concavum* Zone (Upper Aalenian) in the Umbria-Marche area and in France. This event was reported by Moshkovitz and Ehrlich (1976) as a marker of the Middle-Upper Bajocian in Israel.
Particular attention has been paid to the nannofloral assemblages of the Carixian and Toarcian anoxic sediments. The assemblage is mainly dominated by *Crepidolithus* spp., *M. jansae* and *Schizosphaerella* spp.

CALCAREOUS NANNOFOSSIL BIOCHRONOLOGY IN THE MEDITERRANEAN PLIO - PLEISTOCENE MARINE RECORD

by D. RIO (Dipartimento di Geologia, Paleontologia e Geofisica, Università di Padova, Italy), I. RAFFI (Istituto di Geologia, Università di Parma, Italy), A. BELLI (AGIP, S. Donato Milanese, Italy), E. DI STEFANO (Istituto di Geologia, Università di Palermo, Italy), A. NEGRI (Dipartimento di Geologia e Paleontologia, Università di Bologna, Italy), and G. VILLA (Istituto di Geologia, Università di Parma, Italy)

During the Pliocene-Pleistocene time the Mediterranean acted as a distinct bioprovince for calcareous plankton, and the timing of biostratigraphic events in the region need to be established by direct correlation to other non-paleontological time scales like the Geomagnetic Reversal Time Scale (GRTS) or Oxygen Stable Isotope Time Scale.
Until a few years ago, there were virtually no direct correlations of calcareous nannofossil biostratigraphy events to magnetic or stable isotope stratigraphy from the Mediterranean Neogene.
Leg 107 of the Ocean Drilling Program in the Tyrrhenian Sea (Western Mediterranean) recovered Pliocene - Pleistocene deep sea sediments in which, oxygen stable isotope stratigraphy (Site 653) and magnetic stratigraphy (Sites 652 and 654) has been established.
We have produced, by quantitative methods, the distribution pattern of selected calcareous nannofossils from these three deep-sea Mediterranean sequences to calibrate calcareous nannofossil events in the region. These results have been integrated with calibrations recently obtained in on land sections from southern Italy and Sicily (Urica, Capo Spartivento, Gela), and a comprehensive Plio-Pleistocene calcareous nannofossil bio chronology in the Western Mediterranean is presented.
Comparison of the timing of Pliocene-Pleistocene calcareous nannofossil events in the Mediterranean and in the open ocean indicates that many events are broadly syncronous between the two environments.

LATE CENOZOIC COCCOLITH ZONATION AND ITS APPLICATION TO THE PHILIPPINE SEA, JAPAN AND THE PLIOCENE/PLEISTOCENE BOUNDARY STRATOTYPE IN ITALY

by T. SATO, K. KAMEO (Teikoku Oil Co., Setagayaku, Tokyo, 157 Japan) and T. TAKAYAMA (Kanazawa University, Kanazawa, 920 Japan)

A total of 20 calcareous nannofossil datums was found in the Upper Pliocene and Quaternary sediments recovered from the ocean floor of the Northeast Atlantic during DSDP-IPOD Leg 94 (Takayama and Sato, 1987; Kameo, 1989). Correlations of these datums with the magnetostratigraphy which was established by Clement and Robinson (1987) based on the same cores at these sites were also carried out, and ages of all these datums were estimated by interpolation between magnetic reversals.

We describe in detail the calcareous nannofossil assemblages of the Late Cenozoic sediments in the Philippine Sea, at several areas in Japan and also at the Vrica section, Italy which is the Pliocene/Pleistocene boundary stratotype. As the result, it was proved that the most of calcareous nannofossil datums above mentioned are easily detected at these localities.

We also clarify the relation between these datums and the Pliocene/Pleistocene boundary at its stratotype. One of these datums, the first occurrence of *Gephyrocapsa caribbeanica* , which is 17m above the Pliocene/Pleistocene boundary and 30m above the top of the Olduvai Event at the Vrica section, is usable as the most reliable indicator to detect the Pliocene/Pleistocene boundary.

In conclusion, based on these calcareous nannofossil datums, we propose a new calcareous nannofossil zonal scheme which will be more practical approach to the Late Cenozoic sediments especially at middle and high latitudes.

ASSOCIATION OF LATE PLEISTOCENE CALCAREOUS NANNOFOSSIL ASSEMBLAGES AND $^{18}0$ AND ^{13}C ISOTOPIC CHANGES, ODP LEG 117, OMAN MARGIN, ARABIAN SEA

by S. A. SPAULDING (Department of Geology, 214 Bessey Hall, University of Nebraska, Lincoln, Nebraska, U.S.A.), and T. OBA (Department of Geology, College of Liberal Arts, Kanazawa University, Kanazawa, Japan).

Site 723 of the Ocean Drilling Program, located on the continental margin of Oman in the Arabian Sea, recovered a thick (175 meters), continuous section of Pleistocene sediment. This region of the world is unique in that every year during the summer monsoon associated upwelling brings deeper, colder waters enriched in nutrients to the surface. ^{18}Oxygen and ^{13}Carbon isotopic analyses of foraminiferal carbonate provides a detailed record of the glacial and interglacial history of the late Pleistocene in this area which can be correlated with nannofossil assemblage changes.

Calcareous nannofossils are abundant throughout the section, exhibiting good to moderate preservation. A total of 29,000 specimens of calcareous nannofossils was counted from 58 samples taken at approximately 1.5 meter-intervals. Two end-member assemblages have been recognized: I) *Gephyrocapsa oceanica - Neosphaera coccolithomorpha - Calcidiscus leptoporus,* and 2) *small Gephyrocapsa - Helicosphaera* spp.. The Milankovitch-mechanism may be responsible for overprinting a 20,000 year cyclicity of more intensive monsoonal upwelling which affects the composition of the nannofossil assemblages. The nannofossil counts reveal assemblages which may be characteristic of specific late Pleistocene isotopic stages. Although sediment time-averaging and nannofossil evolution add noise to the climatic signal, evidence suggests that assemblage 1 correlates with periods of warm surface water conditions while assemblage 2 seems linked to periods of upwelling.

CHANGES IN THE LATITUDINAL STRUCTURING OF NANNOFOSSIL ASSEMBLAGES: CRETACEOUS-HOLOCENE CONTRASTS.

by H. R. THIERSTEIN (Geological Institute, ETH-Zentrum, CH-8092 Zurich, Switzerland).

Major changes in the biogeographic distribution patterns of calcareous nannofossils appear to have occurred in the late Mesozoic and must be considered in the framework of the evolutionary development of this major modern phytoplankton group. Currently available information is still mostly based on qualitative data (paleogeographic distribution of particular taxa) and only for a few time-slices (at the end of the Lower and at the end of the Upper Cretaceous) have quantitative species distribution and diversity studies been done. Differential preservational effects caused by dissolution before and after burial and by diagenetic recrystallization have imposed persistent difficulties in the interpretation of the observed abundance and diversity changes.
The development of bioprovincialism in calcareous nannofossil assemblages during the Cretaceous follows the globally observed dominance of *Watznaueria* sp. in the latest Jurassic, when calcareous phytoplankton remains became the major biogenous constituents of pelagic sediments. Since that time, ophiolite sequences have been overlain by carbonate deposits in contrast to the older, exclusively siliceous or terrigenous oceanic sequences. Qualitative data suggest the development of pronounced neritic-oceanic bioprovincial gradients and relatively weak paleolatitudinal structuring in the Lower Cretaceous. Quantitative global paleogeographic distribution patterns of calcareous nannofossils in the Aptian - Cenomanian interval indicate a broad tropical-subtropical belt with little latitudinal differentiation from 45°N to 50°S paleolatitude. Major differences in the taxonomic composition and diversity are observed between the eastern and western parts of the North and South Atlantic and across the equatorial Pacific. These patterns coincide with inferred oceanic paleofertility gradients, which are suggested from paleogeographic

settings, ocean circulation models and from sedimentological and geochemical studies. By the latest Cretaceous, the major bioprovincialism of the calcareous phytoplankton was paleolatitudinal, suggesting a transition of the dominant driving mechanism of phytoplankton provincialism from oceanic circulation (high/low fertility) about 100 million years ago to atmospheric circulation (temperature and/or salinity) about 70 million years ago.

NON-SYNCHRONOUS $\partial^{18}O$ STRATIGRAPHIES AND ^{14}C OFFSETS BETWEEN NANNOFOSSIL AND FORAMINIFERAL PELAGIC CARBONATES.

by H. R. THIERSTEIN , S. HILLS, G. BONANI, W. WOLFLI (ETH Zurich, CH-8092 Zurich, Switzerland), and C. K. PAULL (University of North Carolina, Chapel Hill, N.C. 27599-3315, USA).

Multiple stratigraphies in subtropical South Atlantic cores reveal significant stratigraphic discrepancies between the nannofossil and the foraminiferal carbonates. variations in the stratigraphic signals carried in the nannofossil-dominated <38 μm fraction and foraminifera-dominated >38 μm fraction were measured with detailed stratigraphies of $\partial^{18}O$, $\partial^{13}C$, ^{14}C, grain size, percent carbonate, percent aragonite, and taxonomic composition across the last deglaciation in INMD box core 111 #9. Three other cores (INMD box cores 113 & 115, and V22-174), also from the shallow flanks of the mid-Atlantic ridge in the South Atlantic (10° - 17° S), contain similar stratigraphies indicating that these cores represent regional patterns.

The onset of the deglacial $\partial^{18}O$ shift in foraminiferal carbonate occurs 6 to 20 centimeters deeper than the $\partial^{18}O$ shift in the nannofossil fraction. Nineteen accelerator mass spectrometer ^{14}C dates of various fractions (<38 μm, 38-62 μm, 62-150 μm, 150-250 μm, >355 μm and *G. ruber*) from INMD Box 111 show that the components within individual core slices differ by up to 4,900 ^{14}C years, with the <38 μm fractions giving younger ages than the >38 μm fractions. However, the sense of the ^{14}C offsets is inconsistent among individual planktonic foraminifera species and size fractions. Twelve traditional ^{14}C dates (determined by beta counting) of the >38 and <38 μm fractions from six levels in INMD Box 111 #6 confirm the large offsets. The observed isotopic offsets are not explained by an individual process, and suggest that multiple causes have left a lumpy stratigraphic record. However, the variability in the data illustrates the difficulty in accurately measuring the chronology of deglaciation, reopens the question of which components of pelagic sediment best monitor surface water conditions, and complicates the direct interpretation of benthic - planktonic age differences in terms of ocean ventilation changes.

VARIABILITY OF SPHENOLITHUS HETEROMORPHUS IN SOME TURBIDITIC SEQUENCES OF NORTHERN APENNINES

L. TOFACCHI (Dipartimento di Scienze della Terra, Firenze)

A detailed biostratigraphic study based on calcareous nannofossils from some turbiditic sequences of central Italy allowed to recognize and describe some morphologic variations of *S. heteromorphus*. The studied sequences are placed between Passo della Futa and Castiglione dei Pepoli (Emilian Apennine) and belong to the Cervarola-Falterona Unit (Lower-Middle Miocene) and to the Suviana sequence (Serravallian). The study was mainly carried by light microscope observations. The observations at the light microscope showed different optical characteristics of *S. heteromorphus*. It has been possible to recognize four different variations of *S. heteromorphus* which were distinguished on the basis of:
1) the size of the apical spine;
2) the relative difference of the size of the basal complex in comparison with the apical spine;
3) their different optic behaviour in cross-polarized light (0°/45°).
It has been possible to define a *S. heteromorphus* s.s.; *S. heteromorphus* var. 1; *S. heteromorphus* var.2 and *S. heteromorphus* var.3.
This forms appear following a well define order that has been verified in all sequences investigated. These events seem to have a biostratigraphic relevance in the Lower Miocene. The event succession is the following:
S. heteromorphus var. 1; *S. heteromorphus* var.2, *S. heteromorphus* s.s *and S. heteromorphus* var.3.

RELATIONSHIP BETWEEN CALCIUM CARBONATE CONCENTRATION AND NANNOFOSSILS ABUNDANCE IN THE MAASTRICHTIAN GOKDERE FORMATION, CENTRAL ANATOLIA, TURKEY

by V. TOKER and E.K. SAGULAR (Department of Geology, University of Ankara, 06100 Besevler, Turkey)

A detailed biostratigraphic study based on calcareous nannoplankton has been carried out on the sections of Maastrichtian well exposed sequence which is named Gokdere Formation (Central Anatolia, Turkey) .
Two stratigraphic sections were measured in the Gokdere Formation which consists of marl, siltstone, claystone with intercalating sandstone. The thickness of this formation is 783 m and it unconformably overlies the ophiolitic rocks and is unconformably ovelain by Lezgi Formation at the top.
Lithraphidites quadratus Zone has been described in this formation. A quantitative and qualitative study was made of the calcareous nannofossil association from this sequence.
The studied samples show some variations in lithology, caicium carbonate concentration and the distribution of nannofossils .

The total amount of nannofossils in the sediment and relative abundance between different species has been established for this region. The general distribution of the nannofossils reflect the main changes in lithology. Fourty-six nannofossils species was observed in the Maastrichtian sediment. The nannofossils of the two sections are daminated by *Watznaueria barnesae, Stradneria crenulata, Lucianorhabdus cayeuxii, Lithraphidites quadratus, Cribrosphaerella ehrenbergi, Prediscosphaera cretacea, Microrhabdulus decoratus, Zygodiscus spiralis, Eiffellithus turriseiffelii.* The percentage of nannofossil is relatively limited at the bottom of the sections, recording a maxicum of 2% and also carbonate concentration is 3%. At the middle part of the sections, nannofossils show on the increase more than 23 % (carbonate 45 %) in the uppermost samples to less than 15 % (carbonate 25 %).
The observed differences in nannofossil assemblage are related to the carbonate concentration.

LATE QUATERNARY CALCAREOUS NANNOPLANKTON ZONATION FOR THE NORTHERN ATLANTIC OCEAN

by J.W. VERBEEK (Geological Survey of The Netherlands, Haarlem, The Netherlands).

Quaternary calcareous nannoplankton has been the subject of biostratigraphic research for many years. The more or less globally applicable zonations (e.g. Martini, 1971; Gartner, 1977; Okada and Bukry, 1980) are based on first and last occurrences with exception of acmes of small *Gephyrocapsa* species and of *Emiliania huxleyi* in Gartner's zonation. To refine these zonations for the temperate North Atlantic and to test the reliability of the zonal boundaries, five piston cores from submarine highs near the Mid Atlantic Ridge have keen studied in detail. These settings were chosen to avoid the influences of turbidites and changes in the CCD on the fossil record. The zonations of Martini, Gartner and Okada and Bukry for the last 600 ky have been recognized, and can be refined on the basis of a cyclicity observed within the genera *Gephyrocapsa* and *Emiliania*. This cyclicity is based on an alternation of floras dominated by large and floras dominated by small species, which shows no direct relationship with climatic changes during the Quaternary. Its origin remains unexplained. In the upper part of the *Pseudoemiliania lacunosa* Zone, the *Gephyrocapsa caribbeanica* Subzone can be recognized, the *Gephyrocapsa oceanica* Zone is subdivided into the *Helicosphaera wallichi* and the *Cyclococcolithina leptopora* Subzones and the *Emiliania huxleyi* Zone into the *Helicosphaera kamptneri* and the *Gephyrocapsa margereli* Subzones. The proposed zonation is compared with other biostratigraphic studies on calcareous nannoplankton in the temperate North Atlantic (Pujos-Lamy, 1977; Br~heret, 1978; Weaver, 1983) and the polar North Atlantic (Gard, 1988) .
The recognition of the first occurrence of the genus *Emiliania* offers some problems when we consider this genus to be momospecific. This problem is

solved by the description of a new species within this genus, *E. pujosae*. This new species is distingnished by its larger size and it appears before *E. huxleyi*.

References
Bréhéret. J ., 1978b. Biostratigraphie du Pleistocène supérieur et de l'Holocène de deux carottes de l'Atlantique Nord à l'aide des coccolithes. C.R. Acad. Sci., 287, sér. D, p. 599-6O1.
Gard. G., 1988. Late Quaternary calcareous nannofossil biozonation, chronology and paleo-oceanography in areas north of the Faeroe-Iceland Ridge. Quaternary Sci. Rev., 7, p. 65-78.
Gartner. S., 1977. Calcareous nannoplankton biostratigraphy and revised zonation of the Pleistocene. Marine Micropal., 2, p. 585-599.
Martini E. . 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. Proc. 2nd. Planktonic Conf.. Roma, 197O, 2, p.
739-785 .
Okada, H. and D. Bukry, 198O. Supplementary modification and introduction of code numbers to the low latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975) . Marine Micropal . , 5, p. 321-325 .
Pujos-Lamy, A., 1977. *Emiliania* et *Gephyrocapsa* (nannoplancton calcaire): biométrie et interèt biostratigraphique dans le Pleistocene supérieur marin des açores. Rev. Española Micropal., 9, 1, p. 69-84.
Weaver. P.P.E. , 1983. An integrated stratigraphy of the Upper Quaternary of the King's Trough flank area NE Atlantic. Oceanol. Acta. 6, 4, p. 451-456.

COCCOLITHOPHORES IN CULTURE: A STUDY OF INTRASPECIFIC VARIATION IN EMILIANIA HUXLEYI

by J. R. YOUNG (Palaeontology Dept., The Natural History Museum, London SW7 5BD, UK . Work carried out at Leiden University).

Coccoliths of any given species grow according to a regular plan, but variation within this ylan can be caused by numerous factors. Attempting to discriminate these in fossil specimens, or even oceanographic material is fraught with problems owing to the lack of constraints on interpretation. Culture studies provide an elegant means of investigating coccolith variation. Strains are raised from single isolated cells and reproduction occurs by asexual binary fission, hence ontogenetic variation does not occur within single cultures, but can be studied between cultures. Similarly ecophenotypic effects can be studied by comparing cultures of single strains raised under different conditions; although with batch culturing some ecological variation inevitably occurs within single cultures due to maturation of the population.
A laboratory based project was carried out at Leiden University, using the species *Emiliania huxleyi* , with the following objectives: (l) To investigate the degree of variation that can occur within a single taxon. (2) To categorise styles of variation and associate them with mechanisms. (3) To identify controls on the mechanisms. (4) To develop hypotheses for explaining variation in morphology in oceanographic and fossil material.
The following types of variation can be recognised and shown to be essentially independent. Basic crystal unit plan, this is controlled by genotypic variation, it particularly effects distal shield and central area elements. Other processes

modify the crystal unit morphology but without effecting the basic plan. Degree of completion, this is an ontogenetic phenomenon, although ecological conditions influence the abundance of incomplete coccoliths in a culture. Size variation, which is related to both genotypic and ecophenotypic controls and has secondary effects on a wide range of aspects of coccolith morphology in particular the number of crystal units and central area ellipticity. Degree of calcification, this is an ecophenotypic effect with complex control, and which has several often independent expressions - including variable central area closure and proximal shield slitting. Malformation, departure from the regular growth pattern, a regrettably common phenomenon in cultures often producing bizarre coccoliths, it appears to be related to water quality.
Each of these types of variation will be described and illustrated and their potential in palaeoecological studies discussed.

COCCOLITHUS PELAGICUS IN THE LATE MIOCENE TO RECENT, TAXONOMY, SIZE VARIATION AND DEVELOPMENT OF THE BRIDGED FORM.

by J. R. YOUNG (Dept. of Palaeontology, The Natural History Museum, London SW7 5BD, UK), and J. STEINMETZ (Marathon Oil Company, PO Box 269, Littleton, Colorado 80160-0269, USA).

Coccolithus pelagicus is one of the best known and most common species of living coccolithophore. It also has one of the longest geological ranges of any coccolithophores occurring abundantly from the Palaeocene to the present. It is thus a particularly suitable species for the study of intraspecific evolutionary processes. Our work has three purposes (1) To document morphological variation within the lineage during the Late Miocene to Recent interval, and in particular the development of a form with a bridge in the central area. (2) To clear up various long standing nomenclatural problems. (3) To demonstrate that intraspecific evolutionary events can be biostratigraphically useful.
This is based on a study of the size variation and distribution of forms with and without bridges during the late Miocene to Recent in selected DSDP cores from the Atlantic and Indian Oceans. In addition the original slides from which Wallich (1877) described *Coccolithus pelagicus* and *Helicosphaera carteri* have been re-examined, in order to clarify his species concepts and designate lectotype specimens.

Reference.
Wallich G.C., 1877: Observations on the Coccosphere. Annals & Magazine of Natural History, series 4, vol. 19, p.342-350.

THE LIVING COCCOLITHOPHORES EMILIANIA HUXLEYI AND PLEUROCHRYSIS CARTERAE IN CULTURE.

by J. R. YOUNG (Dept. of Palaeontology, The Natural History Museum, London SW7 5BD,UK), K. LINSCHOOTEN, P. WESTBROEK (Biochemistry Dept., Leiden University, .2300RA Leiden, The Netherlands), and K. HAUSMANN (Protozoology, Zoological Institute, Berlin Free University, D-lOOO Berlin 33, West Germany).

Two species of coccolithophore have proven particularly amenable for culture studies; the common oceanic species *Emiliania huxleyi* and a sub-littoral motile species *Pleurochrysis carterae*. These species are taxonomically remote and so provide interesting contrasts in most biological features. 80th species have been maintained in culture in the Biochemistry Dept. at Leiden for more than ten years, during investigation of the biochemistry of coccolithogenesis. A by-product of this work has been the accumulation of a considerable body of knowledge on the biology of these species, some basic aspects of which are presented here.

A video was made in Nov. 1988 in the Berlin Protozoology Unit, in order to investigate the feasibility of filming coccolithogenesis. It is a trial piece of work rather than a professional product but does contain information of interest for nannofossil workers. The following biological features are seen. In *Emiliania huxleyi* : cell types (naked, with single layer coccospheres and multi-layer coccospheres); intracellular coccoliths. In *Pleurochrysis carterae*: motility; cell division; photo-response; coccosphere formation following decalcification; coccolith extrusion. The poster provides background information on these themes and on practical aspects of culture work. Live cultures will also be available for examination.

TURONIAN-MAASTRICHTIAN NANNOFOSSIL BIOSTRATIGRAPHY AND PALEOCEANOGRAPHY OF THE SOUTHERN OCEAN

by D. K., WATKINS (Dept. of Geology, Univ. of Nebraska, Lincoln, NE. 68588-0340), S. W., WISE, Jr., and J. J., POSPICHAL (Dept. of Geology, Florida State University, Tallahassee, FL. 32306).

Data from stratigraphic sections on Falkland Plateau (DSDP 36, 71), Maud Rise (ODP 113) and Kerguelen Plateau (ODP 120) allow a more refined biostratigraphic zonation for part of the Upper Cretaceous of the Southern Ocean as well as reveal paleoceanographic information on the development of the Indian and Atlantic sectors of the Southern Ocean. The Turonian on Falkland and Kerguelen is best subdivided by cosmopolitan zonal taxa plus the austral *Thiersteinia ecclesiastica*. Elevated abundances of *Eprolithus floralis*, common to Kerguelen and southwestern Australian sections, suggest somewhat restricted surface water conditions during much of the Turonian in the Indian sector. Significant differences in assemblage composition suggest partial isolation of the Indian and Atlantic sectors during the Santonian-Coniacian. Falkland assemblages contain sporadic *Marthasterites furcatus* which are absent from Kerguelen. Both Kerguelen and Falkland sections have floods of *Helicolithus trabeculatus* in the upper Santonian; biostratigraphic relationships suggest these "bloom" events are at least partially isochronous. Lowermost Campanian assemblages of the Atlantic and Indian sectors differ even more markedly, suggesting increased oceanographic detachment. The mid-Campanian appears absent from both the Falkland and Kerguelen. Evidence suggests an elevated CCD in concert with low productivity were responsible for this period of sediment starvation. Upper Campanian and Maastrichtian assemblages are very similar in the Atlantic and Indian sectors, with increased global provincialism yielding distinctly austral assemblages. Warm water incursions (indicated by sporadic *Quadrum* and *Watznaueria*) occurred in both sectors but were apparently more common in the Atlantic sector. A revised zonation for the Upper Campanian - Maastrichtian of the Southern Ocean utilizes cosmopolitan taxa in combination with several austral taxa whose biostratigraphic ranges have stabilized as a result of new data.

MORPHOMETRY OF DISCOASTER MULTIRADIATUS AND ITS BIOCHRONOLOGICAL UTILITY

by W. WEI (Department of Geology, Florida State University, Tallahassee, FL 32306, U.S.A.).

Investigation of samples from DSDP Sites 245, 361, 524, 528, 577, and 605, and from Pont Labau (France) shows that there is a general decrease in the mean ray number of *Discoaster multiradiatus* through time for all the sites examined. The mean ray number of *D. multiradiatus* decreases progressively from about 30 near its first occurrence level to about 17 near its last occurrence level. Calibration with the magnetostratigraphies in Site 524, 528 and 577 indicates a relatively consistent mean ray number vs. age relationship, especially for the interval of 58.0-58 . 7 Ma (Fig. l) . It also indicates a relatively consistent age (56.7 Ma) for the CP8/CP9 boundary (last occurrence of *Discoaster diastypus*) . Taken together with the data from other sites (Fig. 2), it can be concluded that *D. multiradiatus* with mean ray number less than 19 fall into Zone CP9 (younger than 56.7 Ma), those with mean ray number between 19 and 22 are within the vicinity of CP8/CP9 boundary, and those with mean ray number greater than 22 fall into Zone CP8 (older than 56.7 Ma). No apparent relationship was found between the ray number and the diameter of *D. multiradiatus* or between the mean diameter and age. There is not a general trend in the development of the central stems on *D. multiradiatus* , either through time or space.

Acknowledgements: I thank Dr. Jan Backman for lending me the slides made from Sites 528 and 577 material. Samples were provided by the Deep Sea Drilling Project.

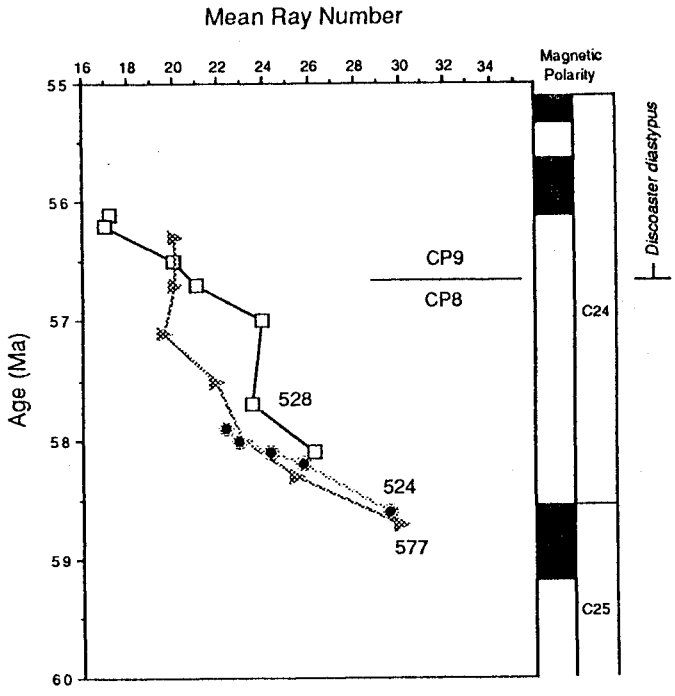


Fig. 1. Correlation of the mean ray number changes of *Discoaster multiradiatus* with magnetostratigraphy in DSDP Sites 524, 528, and 577.

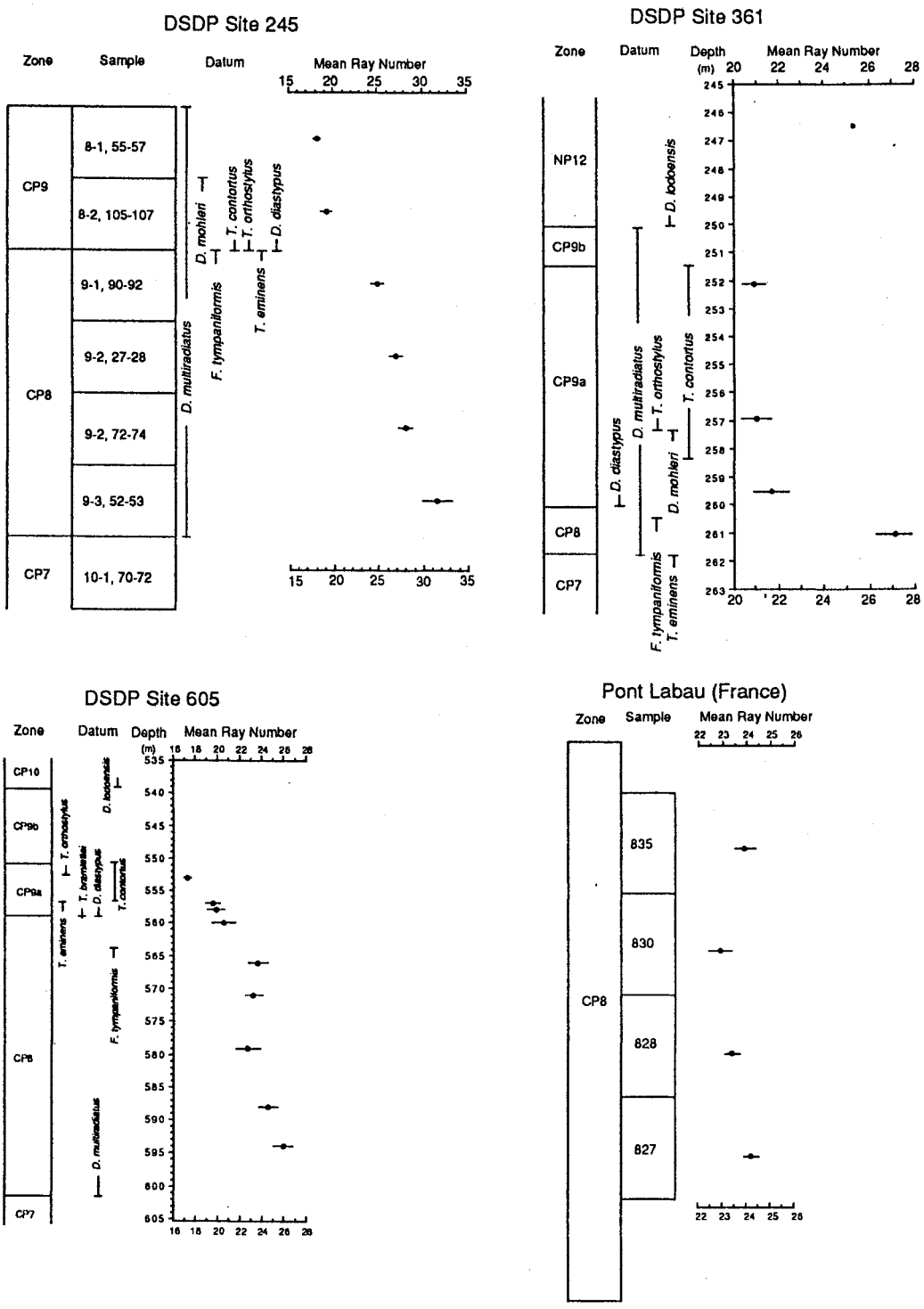


Fig. 2. Mean ray number changes of *Dsicaoster multiradiatus* through time in DSDP Sites 254, 361, and 605, and in Pont Labau (France)

BIOGEOGRAPHIC GRADIENT OF LATE PALEOGENE CALCAREOUS NANNOPLANKTON IN THE SOUTH ATLANTIC OCEAN

by W. WEI and S. W. WISE (Department of Geology, Florida State University, Tallahassee, FL 32306, U.S.A.).

Late Paleogene calcareous nannoplankton have been analyzed quantitatively for eight DSDP and ODP sites ranging from the equatorial zone to 65°S latitude in the South Atlantic Ocean. There is a general decrease in species diversity of the calcareous nannoplankton through time for the late Paleogene, and species diversity also decreases toward the higher latitudes. Similar to findings of other studies, the drop of the species diversity of calcareous nannoplankton across the Eocene/Oligocene boundary is not drastic. Delineation of latitudinal distribution patterns of individual species or groups and R-mode cluster analysis, however, permit the classification of warm-water taxa (*Coccolithus formosus*, discoasters, helicosphaerids, and sphenoliths), temperate-water taxa (*Coccolithus pelalicus, Cyclicargolithus floridanus group, Reticulofenestra bisecta, Reticulofenestra samodurovii/ Reticulofenestra umbilica*) , and cool-water taxa (*Chiasmoliths, Isthmolithus recurvus*, and *Reticulofenestra daviesii* group). The abundance of warmwater taxa plummets whereas the abundance of cool-water taxa sharply increases across the Eocene/Oligocene boundary at the middle- and high-latitude sites, reflecting a profound cooling event in these areas. Polar ordination analysis and similarity analysis reveal that high latitudinal biogeographic gradients had been established at least by the middle Eocene. The gradient greatly increases near the Eocene/Oligocene boundary, indicating more severe and permanent cooling at the high latitudes. The biogeoraphic gradient data of this study conflict with the widely accepted inference from the oxygen isotopic data that the thermal gradients between mid latitudes and high latitudes are low or nearly flat for the Paleogene oceans. Lower surface water salinities in the high latitudes may have lowered the $\partial^{18}O$ values of the planktonic microfossils, but apparently did not affect the distribution of the calcareous nannoplankton, which offer an independent means for estimating latitudinal thermal gradients.

COCCOLITHOPHORES AND GLOBAL CO_2

by A. WINTER and J. BRIANO (University of Puerto Rico, Mayaguez, PR 00709)

We have estimated the amount of carbon that is removed from the atmosphere by organisms that precipitate calcium carbonate in the oceans. Because of their short life span these organisms are much faster in cycling CO_2 than nearly all of their terrigenous counterparts, including tropical rain forests.

Approximately 10^{15} grams of C are taken out of the atmosphere by calcareous organisms living in the oceans. Of these coccolithophores and planktonic foraminifera are the most important. However, coccolithophores get buried much more efficiently than foraminifera and thus are one of the major sinks for C (10^{14} grams per year). Nearly nothing is known about coccolithophore vertical and horizontal distribution in time and space, even though coccolithophores are probably the most important primary producers in the low and middle latitudes. Therefore, field work on coccolithophores should be just as intense as that being undertaken in tropical rain forests.

SILICOFLAGELLATE VARIABILITY: A HISTORICAL PERSPECTIVE

by S. W. WISE, Jr. (Dept. Geology, Florida State University, Tallahassee, CA 32306), D. M. HARWOOD (Department of Geology, Univ. Nebraska, Lincoln, NE 68588), K. McCARTNEY (Div. Math. & Science, Univ. Maine at Presque Isle, Presque Isle, ME 04769), and R. GERSONDE (Alfred Wegener Inst. Polar Res., D-2850 Bremerhaven, FRG)

To the chagrin of most taxonomists, silicoflagellates are notoriously variable in their skeletal morphology, a situation which has pitted "lumpers" against "splitters" more often for this group than perhaps for any other among the microfossils. The discovery of a well-preserved lower Albian silicoflagellate assemblage at Ocean Drilling Program Site 693 in the Weddell Sea on the margin of East Antarctica provides evidence to suggest that the ancestral silicoflagellates were extremely variable, but that through the remainder of Cretaceous time, variability tended to decrease while symmetry among the various forms increased.

The assemblage from Site 693 consists of three taxa, two of which have been reported previously in the literature of *Cornua aculeifera* Deflandre and *Vallacerta hannai* Deflandre. The first of these is considered the most primitive, and is also the most variable in its morphology, consisting of irregularly-shaped, spinose skeletons consisting of 3 to 6 or more main branches, usually not in the same plane; the branches may bifurcate or trifurcate before terminating in points. Related to this form is a third taxa described as new because of a rudimentary polygonal symmetry and the fact that apical and adapical directions can be defined. This new form may have given rise to *Vallacerta hannai*, whereas the form known as *C. aculeifera* may have given rise to *Lyramula* and other species of *Cornua*. The genus *Corbisema* probably developed from the latter stock.

Although less common than in the middle Cretaceous assemblage, extreme variability is sometimes seen in Cenozoic silicoflagellates, as exemplified by a group we term the "*pseudofibula* plexus". In the lower Pliocene of many Southern Ocean sites, this plexus is expressed by up to five morphotypes of *Distephanus speculum speculum* . Members of this plexus bloomed during the final phases of the severe late Miocene-earliest Pliocene glaciations of Antarctica, and we believe their variability was induced by ecologic stress or

unusual paleoenvironmental conditions. Several of these same morphologies have been reported elsewhere in the world in Miocene and even Eocene assemblages.

PROBING THE LIMITS OF NANNOFOSSIL STRATIGRAPHIC RESOLUTION IN THE SOUTHERN HIGH LATITUDES

by S. W. WISE, Jr., J. J. POSPICHAL, and W. WEI (Dept. Geology, Florida State Univ., Tallahassee, FL 32306).

The recovery of two nearly 300 m-long Maestrichtlan to Miocene carbonate sections at 65° South Latitude cored at water depths between 2100 and 3000 m on Maud Rise in the Weddell Sea has provided an unprecedented opportunity to assess the extent to which commonly used low to mid latitude calcareous nannofossil zonations can be extended into the hiqh latitudes. Previous studies of abbreviated sections at 50° South (Falkland Plateau) in the South Atlantic had indicated that lower latitude Cenozoic zonations might have quite limited application at such high latitudes, but this is not the case for those intervals characterized by equitable, non-glacial global climates, particularly the Paleocene through lower Eocene intervals.

On Maud Rise, all of the Paleocene zones of Okada and Bukry (CPl to CP8) can be recognized or approximated, but there are some problem intervals. As in most deep sea sections, *Ellipsolithus macellus* (base of CP3) is not present, and the alternate markers *Neochiastozygus saepes* and *Prinsius martinii* are used to approximate that datum level. The first discoaster to appear, *D. mohleri* , is sporadic in its occurrence and the boundaries of this zone are difficult to delineate. All other zonal markers are present, and discoasters reach their maximum diversity of about 5 species during warm intervals in Zone CP8, despite the fact that the overall assemblage has a distinctly cool water, high latitude composition.

The earliest Eocene Zone CP 9 is delineated by rare *Tribrachiatus bramlettei* and *T. contortus* , an unexpected find at this deep sea locality, which is located 700 km north of the East Antarctic Continental margin. The distribution of these taxa is apparently limited more by paleo water depth than by the proximity of land. As at most localities elsewhere, Zones CP10-ll are combined. Zones CP12-13 are also combined due to the sporadic occurrence of *Discoaster sublodoensis, D. lodoensis* and *Nannotetrina fulgens.* At this point, the low to mid latitude zonation begins to breakdown due to the apparent absence of taxa such as *Chiasmolithus gigas,* which is present in the region of the Falkland Plateau. Also absent are *Rhabdosphaera inflata, R. gladius* and *D. saipanensis.*

The remainder of the middle Eocene, the upper Eocene and the Oligocene can be subdivided using a broad zonal concept, but only by using temperate markers supplemented by additional datums. Nine zones are recognized for the interval from CP14a to CP17/18 using first or last occurrences of various species of *Reticulofenestra* and *Chiasmolithus* plus *Isthmolithus recurvus.*

No discoasters were present in this interval, thus the Eocene/Oligocene boundary could not be delineated; nor was *Clausicoccus fenestratus* useful as it was latitude. Last, the Oligocene/Miocene boundary could not be approximated by the LO of *Reticulofenestra bisecta*, which was rarely present in the upper Oligocene. The LO of this taxon is strongly time transgressive toward the higher latitudes, and crosses that of *Chiasmolithus* altus between the Falkland Plateau and Maud Rise. As on the Falkland Plateau, the no useful zonation of the Miocene is possible, due to the very low diversity (less than 3 or 4 species throughout). Despite such difficulties, the middle Eocene to Oligocene zonation is sufficient to allow the nannofossil assemblages to be used for paleoenvironmental analysis, and Maud Rise will serve as the southern anchor for all such studies in the South Atlantic (see Wei and Wise, these abstracts).

CALCAREOUS NANNOFOSSILS AND THE CONDENSED SECTION IN SEQUENCE STRATIGRAPHY

by W. W. WORNARDT Jr. (Micro-Strat INC., Huston, U.S.A.)

The third order maximum flooding surface and its depositional facies, the condensed section, is a very valuable biostratigraphic and chronostratigraphic element in sequence and seismic stratigraphy. The condensed section depositional facies consists of thin, marine, hemipelagic to pelagic sediments, deposited at a very slow rate, during sediment starvation and rapid rise of relative sea level during transgression of the shoreline. It is associated with authigenic minerals, gamma peaks, and maximum abundance peaks of planktonic calcareous nannofossils and is the time-stratigraphic correlation tool that links together deep and shallow water packages of sediments. This is demonstrated in a transect from shallow to deepwater in the Galveston-High Island-East Breaks Areas, offshore Texas, Gulf of Mexico. Important chronostratigraphic species within the condensed sections permit an absolute age to be assigned to each third order condensed section. These condensed sections, along with third order sequence boundaries, are very important elements in sequence stratigraphy analysis because they correlate with regionally continuous, parallel, high amplitude seismic reflectors on a seismic record section. These seismic reflectors can be dated in millions of years on the basis of chronostratigraphically significant calcareous nannofossils present in the sediments. Thus the micropaleontologist, geologist and geophysicist are directly dependent upon each other through the condensed section in sequence stratigraphy analysis.

LIST OF PARTECIPANTS

Abdi Salah Hussein
Dipartimento di Scienze della Terra
Via LA Pira, 4
50121 Firenze
Italy

Amore Ornella
Dipartimento Scienze della Terra,
Largo S.Marcellino, 10
80138 Napoli
Italy

Attanasio Cecilia
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Aubry-Berggren Marie-Pierre
W.H.O.I., Clark 117,
Woods Hole MA 02543
USA

Backman Jan
University of Stockholm,
Department of Geology
S-106 91 Stockholm
Sweden

Baldanza Angela
Dipartimento di Scienze della Terra,
Piazza Universita'
Perugia
Italy

Barberis Alessandro
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Barbin Vincent
Univer. Bern, Geologische Institut,
Baltzerstrasse 1
CH-3012 Bern
Switzerland

Beaufort Luc
W.H.O.I. Woods Hole
Mas 02543
USA

Bonci Maria Cristina
Dipartimento di Scienze della Terra,
Corso Europa, 25
16126 Genova
Italy

Bown Paul
University College London,
Dept. of Geological Sciences,
Gower Sreet
London WCIE 6BT
Great Britain

Burnett Jackie
Micropaleontology Unit, Geology Dept.,
University College London,
Gower Street
London WCIE 6BT
Great Britain

Cachao Mario
Museu Mineralogia e Geologia
Faculdade de Ciencias Lisboa
Rua da Escola Politecnica, 58
1200 Lisboa
Portugal

Castradori Davide
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Catrullo Donata
Agip S.P.A. P.O. BOX 12069
20120 Milano
Italy

Cepek Pavel
Bundesanstalt fur Geowissenschaften
und Rohstoffe Postfach 510153
D-3000 Hannover 51
Germany

Chepstow-Lusty Alex
Cambridge University,
Godwin Laboratory,
Free School Lane
Cambridge
Great Britain

Cobianchi Miriam
Dipartimento di Scienze della Terra,
Corso Strada Nuova, 65
Pavia
Italy

Cooper Maurice K.E.
Stratigraphic Services International
Chancellor Court, 20 Priestly Road,
Guildford, Surrey GU2 5YL
Great Britain

Cosentino Domenico
Dip. Scienze della Terra
Universit "La Sapienza"
Piazzale Aldo Moro,5
00100 Roma
Italy

Crepin Zevounou
113, Leninskij Prospekt
Bloc 10, ch. 14.01
Mosca B 198
URSS

Crux Jason A.
BP Exploration Inc,
9401 SW Freeway
Houston, Texas 77074
USA

De Capoa Paola
Dipartimento Scienze della Terra,
Largo S.Marcellino, 10
80138 Napoli
Italy

De Kaenel Eric
University of Neuchatel,
Ist. of Geology,
Rue Emile Argand 11
2000 Neuchatel
Switzerland

Depoli Antonella
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Di Gianni Nieves
Total Compagnie Francaise des Petroles
Laboratoires Exploration-Groupe
218-228 Av Du Haut Leveque
33605 Pessac cedex
France

Di Stefano Enrico
Dip. di Geologia e Geodesia,
Corso Tukory 131
90134 Palermo
Italy

Ehrendorfer Thomas
W.H.O.I., Clark 117, Woods Hole
MA 02543
USA

Eide Linda Karin
Institute for Marine Biology
University of Bergen
5065 Blomsterdalen
Norway

Erba Elisabetta
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano 20133
Italy

Farinacci Anna
Dipartimento di Scienze della Terra,
Universita'La Sapienza
Piazza A. Moro, 5
Roma 00100
Italy

Fiorentino Andrea
c/o Prof. Farinacci Dip. Scienze della Terra
Universita'La Sapienza, P.zza A. Moro 5
Roma
Italy

Fioroni Chiara
Istituto di Geologia,
Corso Vittorio Emanuele, 59
Modena
Italy

Firth John
Department of Geology
Florida State University
Tallahasseee, Florida
USA

Flores Jose- Abel
Departamento de Geologia
Area de Paleontologia
Universidad de Salamanca
37008 Salamanca
Spain

Fornaciari Eliana
Istituto di Geologia,
Viale delle Scienze
43100 Parma
Italy

Fossati Stefano
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Gallagher Liam Thomas
Postgraduate Unity of Micropaleontology,
University College London,
Gower Sreet
London WCIE 6BT
Great Britain

Gardin Silvia
Dipartimento di Scienze della Terra,
Via La Pira, 4
Firenze
Italy

Garratt Jane
School of Geological Sciences,
Kingston Polytecnic, Penrhyn Road
Kingston-upon-Thames
Surrey, KTI 2ee
Great Britain

Gavtadze Tamara
Geological Institute of Acad.
of Sc. of Georgian SSR
Z.Rukhadze 1, build. 9
Tbilisi, 380093
USSR

Giraudeau Jacques
Lab. de Micropal,
Dept. Geol. et Oceanog.
Av. des Facultes
Talence 33405
France

Gomez Anne-Marie
25 Rue Boura
64100 Bayonne
France

Gorostidi Amalia
Univ. del Pais Vasco, Paleontologia,
Fac. de Ciencias, Apartado 644
E-48080 Bilbao
Spain

Guasti Guido
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Hamrsmid Bohumil
Department of Mikropal.
MND Hodonin
Hodonin 69530
CSSR

Hine Nicolette Marie
School of Enviromental Sciences,
University of East Anglia
Norwich NR4 77J
Great Britain

Hiramatu Chikara
Japan Petroleoum Exploration Co.,
Ltd. JAPEX Research Center
1-2-1, Hamada
Chiba 260
Japan

Hulme Neil A.C.
Gearhart Geo Consultants LTD,
Howe Moss Place, Kirkhill Ind. Est.,
Dyce, Aberdeen AB2 OGS
Great Britain

Jafar Syed A.
Birbal Sahni Institute of Paleobotany,
53 University Road
GPO BOX 106
Lucknow-226
India

Janin Marie Christine
Laboratoire de Stratigraphie
4, Place Iussien (Tour 15- Etage 4)
75252 Paris
France

Jordan Richard
Geophysics Division, British Antartic
Survey, High Cross, Madingley Road
Cambridge, CB3 OET
Great Britain

Kale Anand S.
Department of Geology,
University of Poona
Pune 411 007
India

Kapid Rubiyanto
Universit de Reims, Facult des Sciences
Laboratoire des Sciences de la Terre B.P. 347
51062 Reims Cedex
France

Kechrid Afifa
E.T.A.P. 27 bis Avenue Khereddine Pacha
Tunis 1002 BP 367
Tunisia

Kilasonia Eteri
Geological Institute of Acad. Sci.
of Georgian SSR, Z.Rukhadze str. 1
bild 9
Tbilisi, 380093
USSR

Knappertsbusch Michael
Geologisches Institut, ETH
Sonneggstrasse 5
8006 Zurich
Switzerland

Lord Minoo
11 Glenilla Road
London NW3 4AJ
Great Britain

Lottaroli Fabio
Dipartimento di Scienze della Terra,
Via Mangiagalli, 34
Milano
Italy

Macias Vazquez Jose' L.
Dipartimento Scienze della Terra
Via La Pira,4
50121 Firenze
Italy

Madile Marina
Dipartimento di Scienze della Terra,
Via La Pira, 4
Firenze
Italy

Manivit Helene
B.R.G.M. Avenue de Concyr
B.P. 6009
45060 Orleans Cedex 2
France

Marroni Michele
Dip. Scienze della Terra
Via S.Maria,53
Pisa
Italy

Matias i Sendra M. Isabel
Facultat de Geologia,
Zona Universitaria de Pedralbes
08028 Barcellona
Spain

Matsuoka Hiromi
Graduate School of Natural Sciences
and Technology Kanazawa University
Marunouchi 1-1
Kanazawa 920
Japan

Mattioli Emanuela
Dipartimento di Scienze della Terra,
Piazza Universita'
Perugia
Italy

Minashvili Tsitsino
Geological Institute of Acad.
of Sci. of Georgian SSR.
Z.Rukhadze 1, build. 9
Tbilisi
USSR 380093

Monechi Simonetta
Dipartimento di Geologia e Geofisica,
Via Re David
Bari
Italy

Moshkovitz Shimon
Geological Survey of Israel, t.
30 Malkhei Israel St.
Jerusalem 95501
Israel

Naji Fawzy
Petroleoum Department
Natural Resources Authority
P.O. Box 7, Amman
Jordan

Negri Alessandra
Via D.G. Verita' 10
40026 Imola
Italy

Noel Denise
CNRS Museum National d'Histoire Naturelle
Laboratoire de Geologie du Museum
43 Rue de Buffon
75005
France

Okada Hisatake
Department of Eart Sciences,
Yamagata University,
1-4-12 Kojirakawa-Cho
Yamagata 990
Japan

Olafsson Gunnar
Department of Geology,
University of Stockholm
S-10691 Stockholm
Sweden

Ozkan Seving
University College London,
Department of Geol. Sciences,
Gower Sreet
London WC 1E 6BT
Great Britain

Patacca Etta
Dip. Scienze della Terra
Via S.Maria,53
Pisa
Italy

Perilli Nicola
Dip. Scienze della Terra
Via S.Maria,53
Pisa
Italy

Pirini Radrizzani Camilla
Dipartimento di Scienze della Terra,
Sezione di Geologia
Corso Europa, 26
16132 Genova
Italy

Pospichal James J.
Dept. of Geology
Florida State University
Tallahassee, Fl 32306
USA

Prins Ben
Shell International Petroleum My. B.U.
Diu. EPX/36 Stratigraphical Service, PO BOX 162
2501 AN DEN HAAG
The Netherlands

Proto Decima Franca
Dip. Geol. Pal. Geofisica
Via Giotto 1
Padova
Italy

Pujos Annick
Dept. de Geologie et Oceanogr.
Universit de Bordeaux I,
Avenue des Facultes
33405 Talence Cedex
France

Rabindranath Sivaramakrishnan
Department of Earth Sciences,
Indian Institute of Tecnology, Powai
Bombay 400076
India

Raffi Isabella
Ist. di Geologia,
Universita'di Parma
Viale delle Scienze
43100 Parma
Italy

Reale Viviana
Dipartimento Scienze della Terra,
Via La Pira, 4
Firenze
Italy

Rio Domenico
Dip. Geol. Pal. Geofisica
Via Giotto 1
Padova
Italy

Rodriguez-Saavedra Alfredo
Gis Oceanologie et Geodynamique
Universite de Bretagne Occidentale
6, Av. Le Gorgeu
29287 Brest Cedex
France

Rossi Mariagrazia
Servizio Geologico D'Italia,
Largo S.Susanna, 13
00187 Roma
Italy

Salis Perch-Nielsen Katharina
Geol. Inst. ETH-Z
CH-8092 Zurich
Switzerland

Sato Tokiyuti
Technical Reaserch Center,
Teikoku oil Co., 9-Chome,
Kita-Karasuyama
Setagaya-ku, Tokyo 157
Japan

Scandone Paolo
Dip. Scienze della Terra
Via S.Maria,53
Pisa
Italy

Spaulding Stacia
Department of Geology,
241 Bessey Hall,
University of Nebraska
Lincoln, Nebraska 68588-0340
USA

Sucunza Berasain Maria Teresa
Departamento de Paleontologia
(seccion Geologicas)
50009 Zaragoza
Spain

Takayama Toshiaki
Department of Geology
College of Liberal Arts
Kanazawa University
Kanazawa
920 Japan

Thierstein Hans
Geological Institute, ETH-Zentrum
CH-8092 Zurich
Switzerland

Toker Vedia
A.U. Fen Fakultesi Jeologji
Muhendisligi Bolumu
06100 Besevler-Ankara
Turkey

van Heck Shirley E.
EPXI 36, PO BOX 162
2501 AN Den Haag
The Netherlands

van Niel Brigitta
Micropaleontology Unit,
University College London
Gower Sreet
London WCIE
Great Britain

Verbeek Joost W.
Geology Survey of Netherlands, PO BOX 157
2000 AD Haarlem
The Netherlands

Villa Giuliana
Ist. di Geologia,
Universit di Parma
Viale delle Scienze
43100 Parma
Italy

Watkins David K.
Department of Geology, 330 Bessey Hall,
University of Nebraska
Lincoln, Nebraska 68588-0340
USA

Weaver Philiph P.E.
Institute of Ocean Sciences,
Brook Rd., Wormley, Godalming
Surrey Gu 8 Sub
Wormley
Great Britain

Wei Wuchang
Dept. of Geology
Florida State University
Tallahassee, Fl 32306
USA

Winter Amos
University of Puertorico
Dept. of Marine Sciences
P.O. Box 6041
Mayaguez PR 0079
U.S.A.

Wise Sherwood W.
Department of Geology,
Florida State University
Tallahassee Fl 32306
USA

Wornardt Walter W.
Micro-stratigrafic Inc.,
8401 Westheimer Sente 110
Huston, Tx 77063
USA

Young Jeremy
Paleontology British Museum (Natural History),
Cromwell Road
London SW7 2BP
Great Britain

Zivieri Patrizia
Istituto di Geologia
Universita di Parma
Viale delle Scienze
43100 Parma
Italy