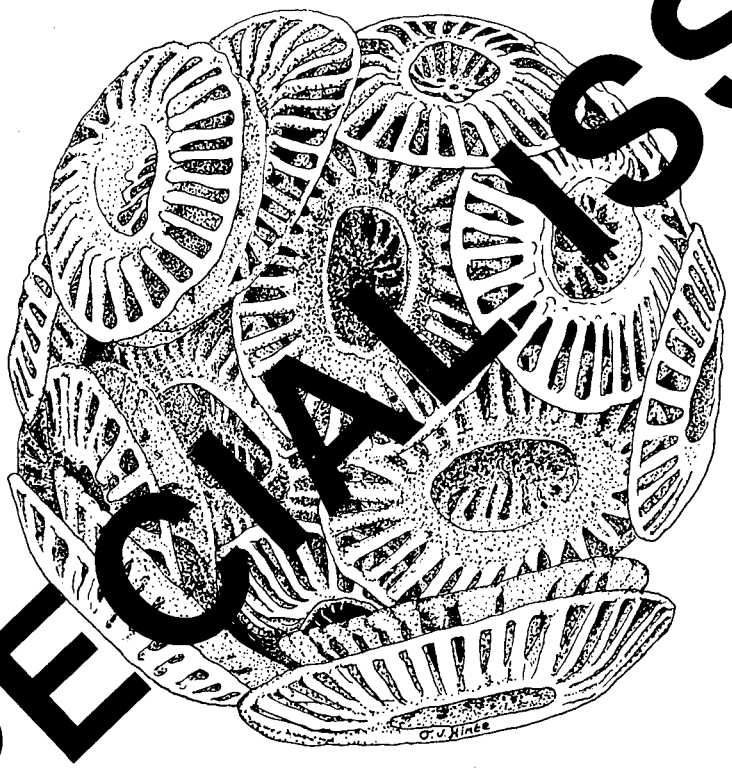
INA NEWSLETTER

SPECIAL ISSUE



INTERNATIONAL NANNOPLANKTON ASSOCIATION

VOLUME 9 NUMBER 2 1987

INTERNATIONAL NANNOPLANKTON ASSOCIATION

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!! NOTE !!

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- for non-members	£ 10.-	($15.-)
- for members	£ 5.-	($7.50)
- for student members	£ 2.50	($3.75)

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MEMBERSHIP

Applications for membership of the International Nannoplankton Association should be directed to the Secretary/Treasurer. Annual dues: £ 10.-/US$ 15.- Those who pay their dues in U.S. dollars are urged to send them to John Steinmetz (Marathon Oil, Expl. & Prod. Technology, P.O. 269, Littleton, Col., U.S.A.). Checks or money orders should be made out to INA; no account- or banknumber is necessary. Students can become a member for a reduced price (£ 5.-/US$ 7.50); please send a confirmation of your student-status when applying for membership.

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NEXT ISSUE

Contributions for the next issue of the INA Newsletter should be received before October 1987. Please send your contributions to: The editor of the INA Newsletter, S.E. van Heck (Address : see inside cover).

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INFORMATION TO CONTRIBUTORS

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INA MEETING, LONDON 1987

The stage is set for our next meeting, and judging by the abstracts it could be a very interesting one. This issue contains all the abstracts we have received to date, after we have postponed this issue for a month waiting for additional contributions. The abstracts are in alphabethical order (authors), followed by the excursion guide.

But first of all we gratefully acknowledge the financial support of our sponsors listed here in alphabethical order:

ARCO BRITISH
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A precise program will be made only at the last moment, but the outline will be as follows:

Wednesday August 19th:
08.30 - 09.30 hrs : registration and coffee
09.30 - 17.00 hrs : presentations: Cenozoic and posters
interrupted by breaks for refreshments and lunch.
19.00 - 23.00 hrs : conference party on M.V. Eltham with buffet and drinks.

Thursday August 20th:
09.00 - 17.00 hrs : presentations: Mesozoic and posters
interrupted by breaks for refreshments and lunch.

Friday August 21st:
09.00 - 17.00 hrs : presentations: Mesozoic and general, and workshops
interrupted by breaks for refreshments and lunch.

Saturday August 22nd
08.00 - 19.00 hrs : excursion
19.30 - ??.00 hrs : excursion dinner in the Falstaff Hotel, Canterbury.

This program is flexible, and it is even possible to organise extra workshops in the evenings if desired.

May we remind authors that manuscripts for the proceedings should be in BEFORE OCTOBER 1ST, 1987, to be sent to Shirley van Heck or Jason Crux. A guide to authors was printed in the previous Newsletter (vol.9.1).

SEE YOU IN LONDON

Shirley

PROBLEMS RELATED TO THE STUDY OF EVOLUTIONARY LINEAGES AMONG COCCOLITHOPHORIDAE AND CONSEQUENCES FOR OUR TAXONOMIC APPROACH.

By M.-P. Aubry, Woods Hole / Lyon

(No abstract)

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COCCOLITH DISTRIBUTION IN LATE QUATERNARY SEDIMENTS IN THE BANDA ARC REGION (INDONESIA).

By J.W. Biekart, *Institute of Earth Sciences, University of Utrecht, Budapestlaan 4, 3508 TA Utrecht, The Netherlands*

The coccolith flora from sediment cores obtained during the Dutch-Indonesian SNELLIUS II expedition has been studied quantitatively. The initial objective of the study was the reconstruction of paleoceanographical conditions of the seas of the Indonesian archipelago during the Late Quaternary, but attention has been gradually directed to the understanding of the ecological behaviour of coccolith species. In the course of the study two major obstacles were encountered which call for discussion, and are therefore presented at this meeting.

One obstacle is the complicated classification of the individual coccoliths of the Princiaceae, presently called Noelaerhabdaceae. A conspicuous case, for example, is the occurrence of two species, provisionally named *Reticulofenestra* sp. A and *Reticulofenestra* sp. B. Their coccoliths show a strong resemblance to those of *Gephyrocapsa oceanica* and *Gephyrocapsa* sp. cf. *G. ericsonii* respectively, but they do not have a bridge. Presumably the former taxa are morphotypes of the latter two species, and their bridgeless appearance is probably related to some ecological parameter. Dissolution effects cannot be excluded, but seem to be less probable. The minute species *G.* sp. cf. *G. ericsonii* and *Reticulofenestra* sp. B (less than 2 um in diameter) reach high frequencies in the cores studied.

Another problem is the outcome of the principal components and cluster analyses. These statistical methods were applied to the data of four cores. Using the computer programs BALANC and DENDRO (Drooger, 1982) the cluster analysis should give a more or less consistent grouping of species, while eliminating squeezing effects. However, grouping is very weak as correlation coefficients are low to very low, whilst the grouping in one core is not reproducible in another. The results of the principal component analysis have an only limited value, because squeezing effects reduce the actual number of species participating in the computations. Few, superabundant species control the components, and only one or two species load heavily on every "significant" component.

A discussion on both problems is given and set against the background of nannofossil oxygen isotope, carbonate and aragonite stratigraphy of the cores.

REFERENCE:

Drooger, M.M. (1982): Quantitative range chart analyses. -Utrecht Micropal. Bull., vol.26, 224 pp.

PRINCIPLES AND PROCESSES OF NANNOFOSSIL EVOLUTION WITH REFERENCE TO THE EARLY MESOZOIC.

By P. Bown, *Postgraduate Unit of Micropalaeontology, University College London, Gower street, London, U.K.*

The processes by which evolution takes place within coccolithophorids and other nannofossil/plankton groups are at present unknown. Our limited knowledge of extant forms, e.g. concerning coccolith function and cell reproduction, restricts our interpretation of evolution in the fossil record. At present we are thus reliant upon the observation of morphological change through time and recognition of general evolutionary principles. Research in the Early Mesozoic has included the development of a comprehensive evolutionary scheme. The construction of this scheme will be discussed with reference to the general patterns of evolution which emerged e.g. parallel evolution, homeomorphy and polyphyletic groups, and evolutionary trends including size increase, central area enlargement, distal extension, and fragmentation of rim elements to form new shield cycles. The significance of these observations early in the history of calcareous nannofossils will be discussed with reference to taxonomy and later evolutionary developments.

++

CONICAL NANNOFOSSILS IN THE UPPER TRIASSIC AND JURASSIC.

By P.R. Bown, *Postgraduate Unit of Micropalaeontology, University College London,* and M.K.E. Cooper, *Stratigraphic Services International Ltd, Guildford.*

The nannofossils *Conusphaera zlambachensis, Mitrolithus jansae* and *Conusphaera mexicana* all possess remarkably similar morphologies consisting of an outer casing of thin, vertical elements and an inner core of radially arranged lamellae. All three are abundant in Tethyan nannofossil assemblages but are rarely found outside the Tethyan Realm. At present these nannofossils are thought to have non-concurrent ranges in the Rhaetian, Lower Jurassic and Upper Jurassic respectively. The classification of these forms will be discussed in the light of their morphology, range, distribution and possible evolutionary links. These three examples highlight the problems of constructing a biological classification based on morphology in a group where homeomorphy often occurs and data are often stratigraphically and geographically limited.

FROM TEGULALITHUS TO LITHASTRINUS: A USEFUL BIOSTRATIGRAPHIC LINEAGE?

By J. Burnett, *Micropalaeontology Unit, Department of Geology, University College London, Gower Street, London WC1E 6BT, U.K.*

The erection of a new genus, *Tegulalithus* Crux (1986), has stimulated a fresh interest in part of the family Polycyclolithaceae Forchheimer (1972). Forms belonging to the genera *Tegulalithus* Crux (1986), *Eprolithus* Stover (1966), *Polycyclolithus* Forchheimer (1972), *Radiolithus* Stover (1966) and *Lithastrinus* Stradner (1962), often erroneously grouped together under *Lithastrinus* because of their similarities in distal/proximal view, are examined. An evolutionary lineage is proposed for these forms, based on trends in rim construction and in central area structure, progressing from *Tegulalithus* (FO Late Hauterivian) through *Eprolithus* to *Lithastrinus* (LO Late Campanian). The results are commented upon in a biostratigraphical context for particularly the Late Cretaceous.

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NANNOFOSSIL PROVINCIALISM IN THE LATE JURASSIC / EARLY CRETACEOUS (KIMMERIDGIAN TO VALANGINIAN) PERIOD.

By M.K.E. Cooper, *SSI (UK) Ltd, Tannery House, Tannery Lane, Send, Working, Surrey GU23 7EF, UK.*

During the Late Jurassic / Early Cretaceous period many macro- and microfossil groups show evidence of provincialism and calcareous nannofossils are no exception. A number of localities were studied: the Norwegian shelf, England, Germany, France, North Africa and three Deep Sea Drilling Project Sites. At these localities it was found possible to recognise two distinct calcareous nannofossil "Realms": a low latitude Tethyan Realm and a northern high latitude Boreal Realm. Over 75% of all species found occurred in both realms and therefore the occurrence of individual species has only a limited use in the recognition of these realms. However, quantitative methods have revealed that there were differences in the dominance of the nannofossil families and important genera between these two realms.

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BOREAL EARLY CRETACEOUS NANNOFOSSIL BIOSTRATIGRAPHY (RYAZANIAN - BARREMIAN)

By J.A. Crux, *Stratigraphy Branch, BP Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, England.*

The nannofossils from the Lower Cretaceous sections of Speeton (Yorkshire) and the Hannover area have been studied in detail. This study has led to the erection of a new Boreal Early Cretaceous zonation, which is graphically summarised in figure 1. Seventeen biozones are used to divide Ryazanian to Barremian strata; these are correlated to the lithostratigraphy together with the standard ammonite and belemnite zonation schemes for the area. A new species, *Perissocyclus taylorae* is described.

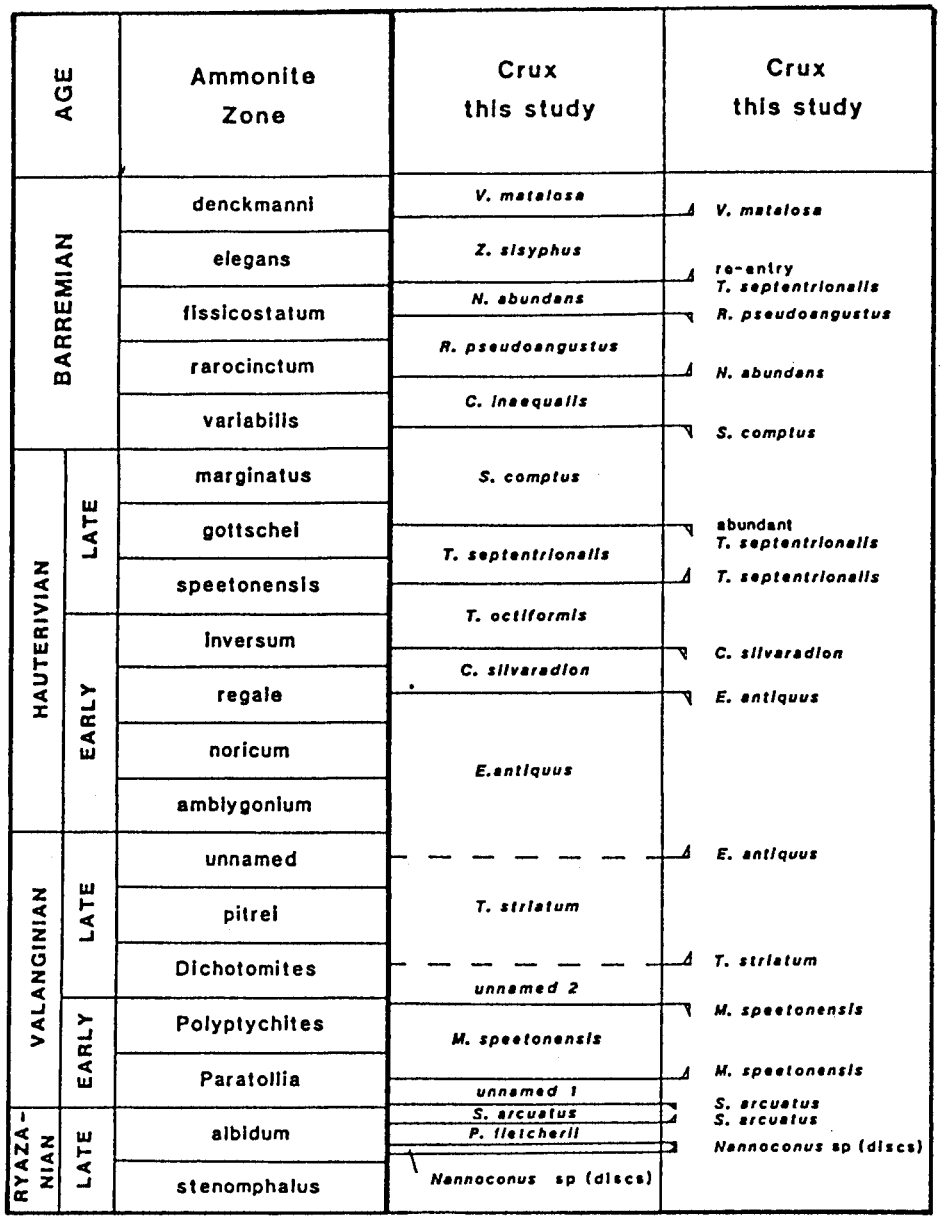

Figure 1 (Crux)

BIOSTRATIGRAPHIC SILICOFLAGELLATES ASSOCIATION FROM THE BETICAS (SPAIN). (poster)

By J.-A. Curto, *Dpt. Geol. Dinamica, Geofisica, Paleontologia, Universitat de Barcelona, Gran Via 585, 08007 Barcelona, Spain.*

At some time during the Tertiary (Upper Oligocene - Lower Pliocene) an important biogenic silico-carbonate sedimentation took place in some basins of the Western Mediterranean. Correlation between these basins has always been difficult to establish on account of the distance between the outcrops as well as the complicated paleogeography and tectonic history. Because of these difficulties and as a preliminary basis for further study, I have considered 10 silicoflagellate associations for biostratigraphy, and I have described four new species (*Dictyocha cioae, Dictyocha arcuata, Mesocena unda, Distephanus involutus*).

The ten associations are:
Association A (*Naviculopsis biapiculata* Zone - *Naviculopsis lata* Zone)
Association B (*Naviculopsis lata* Zone - *Naviculopsis quadrata* Zone)
Association C (*Naviculopsis ponticula* Zone)
Association D (*Naviculopsis ponticula* Zone - *Corbisema triacantha* Zone)
Associations E, F, G (*Corbisema triacantha* Zone, *Distephanus stauracanthus* Subzone)
Association H (*Dictyocha brevispina* Zone)
Association I (*Dictyocha brevispina* Zone - *Dictyocha fibula* Zone)
Association J (*Dictyocha fibula* Zone)

Most of these associations show a biostratigraphic significance while one of them (Association E) could have a paleoecologic origin.

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THE PHYLOGENY OF MESOZOIC HETEROCOCCOLITHS.

By H.J. Dockerill & K.M. Dockerill, *Department of Geology, Birkbeck College, University of London, 7-15 Gresse Street, London, U.K.*

General macroevolutionary trends in heterococcoliths are outlined from the Early Jurassic to Late Cretaceous. Coccolith families are delineated and their geological history described. Selected lineages are followed in detail. The development of certain important structures are traced and their taxonomic significance investigated. The taxonomic implications of several new observations are examined.

The mode and tempo of heterococcolith evolution is assessed. The main periods of increased evolutionary activity are noted.

NOMENCLATURE, DESCRIPTION AND CLASSIFICATION IN JURASSIC AND EARLY CRETACEOUS HETEROCOCCOLITHS.

By K.M. Dockerill & H.J. Dockerill, *Department of Geology, Birkbeck College, University of London, 7-15 Gresse Street, London, U.K.*

A comprehensive system of nomenclature and description is proposed for heterococcolith morphology. Several new terms are introduced to denote structures which are either unnamed or new. From a careful consideration of the complete spectrum of Mesozoic heterococcolith morphology a simple morphological classification is developed.

The limitations of a purely morphological classification are analysed; of these convergent evolution is perhaps the most significant, often causing completely unrelated taxa to have very similar morphologies. In a development of the classification this phenomenon of homeomorphy is taken account of. The resultant phylogenetic classification is discussed in detail with the application of the scheme being exemplified down to family level using Mesozoic heterococcolith lineages.

This system is considered to be a natural reflection of phylogeny and as such is an extremely logical method of classifying coccoliths. This is supported by the ease with which it lends itself to computer expert systems. The results of the authors experiments with artificial intelligence are discussed.

Finally the application of this system of classification is considered in relation to Tertiary coccoliths.

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BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE NOELAERHABDACEAE IN THE MEDITERRANEAN PLIOCENE.

By B. Driever, *Institute of Earth Sciences, University of Utrecht, Budapestlaan 4, 3508 TA Utrecht, The Netherlands.*

By means of a biometrical analysis with the light-microscope we tried to unravel the Pliocene part of the complex and seemingly continuous spectrum of coccolith morphologies within the family Noelaerhabdaceae (=Prinsiaceae). In the floras from sections in southern Italy and Crete, a combination of the parameter "coccolith size" with the parameters "presence of peripheral slits" or "presence of a cross-bar" yielded a clustering of morphotypes which allowed to distinguish the genera *Reticulofenestra*, *Pseudoemiliania* and *Gephyrocapsa*.

Within the Reticulofenestrids four species could be separated on the basis of the distribution of coccolith size, i.e. *R. minuta*, *R. minutula*, *R. antarctica* and *R. pseudoumbilicus*. The Pliocene Gephyrocapsids were assigned to one taxonomic category (*Gephyrocapsa* spp.) because their small size interferes with detailed light-microscopic morphometry. There are fluctuations in the diameter range of the Gephyrocapsid coccoliths. Within *Pseudoemiliania lacunosa* we distinguished an oval and a subcircular morphotype.

From the quantitative distribution of the individual taxa 12 major changes in the composition of the Pliocene/Early Pleistocene floras of the Noelaerhabdaceae can be inferred. The interpretation of these events in terms of paleoecological change is discussed. As very little is known about the paleoecology of the Noelaerhabdaceae the interpretation must be based primarily on data from additional sources (foraminifera, pollen and stable isotopes from foraminiferal carbonate). In turn, the result may be used to derive paleoenvironmental clues from some consistent features in the morphological spectrum of the Noelaerhabdaceae.

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MID-CRETACEOUS CYCLIC PELAGIC FACIES FROM THE UMBRIAN-MARCHEAN BASIN: WHAT DO CALCAREOUS NANNOFOSSILS SUGGEST?

By E. Erba, *Dipartimento di Scienze della Terra, Via Mangiagalli 34, 20133 Milano, Italy.*

The Aptian-Albian Scisti a Fucoidi (Fucoidi Maris), widespread in the Umbrian-Marchean Basin (Central Italy), consist of a spectacularly multicoloured sequence of pelagic marls, marly limestones, subordinate limestones and black shales rich in organic matter. This formation is strikingly cyclic; several authors interprete the cycles as the result of climatic oscillations driven by orbital cycles (Milankovitch theory).

In order to investigate the characteristics and the origin of these peculiar deposits a continuous 84 meter section was cored at Piobbico (Marche). Lithostratigraphy, biostratigraphy, palaeontology, organic and inorganic geochemistry and remnant magnetism of the core are being studied by a joint U.S.-Italian group.

Quantitative analyses were performed on calcareous nannofossils from three intervals of the core, selected as representative lithological end members. On the basis of absolute and relative fluctuations in abundance of the nannofloras and of the single species and of statistical manipulations (Principal Components and Factor Analyses) of nannofossil countings, three sets of parameters were identified:

DIAGENESIS INDEX: abundance of *W. barnesae* (% total nannoflora), total abundance, species diversity and abundance of micrite.

PRIMARY DISSOLUTION INDEX: high abundance of *W. barnesae* (% total nannoflora), low diversity, low total abundance and absence of micrite.

PALEOECOLOGICAL INDICES: INDEX A - *B. constans, D. rotatorius* and *Zygodiscus* spp. indicate high primary productivity associated with vigorous upwelling. INDEX B - *P. asper* and *L. carniolensis* indicate moderate primary productivity in warmer waters. INDEX C - nannoconids appear to record changes in carbonate productivity. Their abundance may be related to surface water fertility but a relationship with salinity can not be ruled out. INDEX D - *L. floralis* is an indicator of cooler water. INDEX E - *P. asper* is an indicator of warmer water.

Along with the more extended C-org and colour analyses and carbonate, foraminiferal and radiolarian content analyses, data obtained from the calcareous nannofossils provide new information about the paleoceanographic conditions which lead to the cyclic deposition and the black shale episodes through Aptian-Albian time.

Within the Scisti a Fucoidi a middle interval (Upper Aptian) is characterised by the occurrence of dominantly red lithotypes. The interval records fluctuations of carbonate productivity in a cooler oxygenated paleoenvironment. Both the preceding and the succeeding intervals record fluctuations in primary productivity resulting in deposition of cyclic black shale layers. Moreover, it is possible to identify different paleoceanographic regimes leading to the deposition of the anoxic sediments.

A few black shales, scattered throughout the core, record pulses of high primary productivity due to strong upwelling. It results in an accumulation of C-org > 4% t.w. Organic matter of marine origin accumulated because it was in excess of the oxygen available near the sea floor.

A second group of more common black shales seems to be related to rythmic pulses of primary productivity under globally warmer waters, resulting in an accumulation of C-org > 1% t.w. In this case organic matter of mixed marine and non-marine origin accumulated because of a possible increase in stagnation related to a weaker temperature gradient.

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APTIAN-ALNIAN CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE SCISTI A FUCOIDI DRILLED AT PIOBBICO (CENTRAL ITALY). (poster)

By E. Erba, *Dipartimento di Scienze della Terra, Via Mangiagalli 34, 20133 Milano, Italy.*

(No abstract)

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NANNOFLORA AND PLANKTONIC FORAMINIFERA IN THE TORTONIAN-MESSINIAN BOUNDARY INTERVAL OF EAST ATLANTIC O.D.P. SITES AND THEIR RELATIONSHIP WITH SPANISH AND MOROCCAN SECTIONS.

By J.-A. Flores & F.-J. Sierro, *Area of Paleontology, University of Salamanca, 37008 Salamanca, Spain.*

A quantitative and qualitative study was conducted on the nannoflora and fauna of planktonic foraminifera from several cores taken from the East Atlantic. The O.D.P. sites studied were 397, 544a, 334 and 410. The previously established biostratigraphic basis and characteristics of the site were the reason behind the study.

The main aim of the work was to check the amplitude in the area of the east Atlantic of a series of events (and their succession) that had been determined previously in the Guadalquivir basin (Spain) and the Oued Akrech basin (Morocco). The events recorded in the nannoflora were as follows: the start of the regular occurrence of *Eu-discoaster berggrenii*, the reversal of predominance of the *Reticulofenestra haqii / R. minutula* group over that of the small placoliths, the first occurence of *Amaurolithus* and a reduction in the proportion of occurrences of *Eu-discoaster berggrenii / E. quinqueramus*. These are accompanied by other events, also related to quantitative variations in different reticulofenestrids and asteroliths, the exact significance of which is pending several final analyses.

The events are correlated with those that are observed in the planktonic foraminifera, in particular in the species of the genus *Globorotalia*, that undergo important quantitative changes throughout the interval studied. Following the regular occurrence of *E. berggrenii* and almost synchronous with the level in which the reversal of predominance of *R. haqii / R. minutula* over that of the small placoliths occurs, a strong reduction can be seen in the first group of *"Globorotalia menardii"* (see FLORES & SIERRO, 1987; INA Meeting in Vienna). In a short interval the abundant presence of the second group of *"G. menardii"* was recorded, a group that is replaced by *Globoratalia miotumida* at the Tortonian/Messinian boundary. Among these latter two events of foraminifera the first occurrence of *Amaurolithus* is noted. Finally, the reduction in numbers of *E. berggrenii / E. quinqueramus* coincides approximately with a rapid series of changes in the planktonic foraminifera (change in the coiling direction of *Neogloboquadrina acostaensis*, a reduction in the *G. miotumida* group and the common occurrence of *Globorotalia margaritae* s.s.).

Wherever possible attempts were made to make a tentative correlation of the cores with the magnetostratigraphic scale.

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RETICULOFENESTRA : A CRITICAL REVIEW OF TAXONOMY, STRUCTURE AND EVOLUTION.

By L.T. Gallagher, *Micropaleontology Unit, Dept. of Geology, University College London, Gower Street, London WC 1E 6BT, UK.*

In 1966 Hay, Mohler and Wade introduced the generic name *Reticulofenestra*. Since then numerous authors have used and adapted this original description in various ways without formal emendation of the type description. The taxonomic significance of such features as central area grill, tube cycle and rim structure is discussed with respect to previously published observations and the author's personal research.

A formal emendation of the genus is made together with a comprehensive classification of key *Reticulofenestra* species. In addition, tables listing relevant comments on size and shape, rim structure, central area structure and age range are produced. The terminology employed in these tables has been standardised in order that cross-referencing of species is facilitated.

Scanning electron microscope analysis of reticulofenestrids at various stages of mechanical breakdown has revealed details of the ultrastructure of these forms, complementing the transmission electron microscope work of Edwards (1973) and other scanning electron microscope work. Appreciation of the ultrastructural detail enables comment to be made on possible lines of evolution, both within the genus *Reticulofenestra* and between members of the family Prinsiaceae.

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QUATERNARY ARCTIC NANNOFOSSIL DATUM EVENTS AND PALAEOCEANOGRAPHIC IMPLICATIONS

by G. Gard, *Quaternary Research Unit, Royal Holloway and Bedford New College, University of London, Egham Hill, Surrey TW20 0EX, England.*

Calcareous nannofossils have been studied using semi-quantitative methods in short sediment cores from the Norwegian and Greenland Seas and the European Arctic Ocean. A high resolution nannofossil biozonation scheme based on abundance fluctuations (total amount of nannofossils in the sediment and relative abundance between different species) has been established for the area. Absolute ages have been calculated by correlating the alternating barren and nannofossil bearing sediments to known climatic fluctuations and to oxygen isotope stratigraphy. World-wide nannofossil datums are used as calibration levels.

The results show that the maximum age of the cores is about 500 kyrs (oxygen isotope stage 13). However, no core from the European Arctic Ocean is older than about 250 kyrs (oxygen isotope stage 8). Nannofossils are absent during glacial stages but return during more favourable conditions. The total abundance of nannofossils in the sediments is a combination of biogenic production and input of ice rafted material.

A glacial regime has prevailed in the study area, characterised by permanent sea-ice cover and the absence of the Norwegian - West Spitsbergen current system. However, this current has established itself for short periods on at least 5 occasions during the past 500 kyrs.

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A MORPHOMETRIC ANALYSIS OF THE ARKHANGELSKIELLA CYMBIFORMIS GROUP AND ITS STRATIGRAPHIC SIGNIFICANCE.

by M.H. Girgis, *Robertson Research International Ltd., Llandudno, Gwynedd, U.K.*

A detailed morphometric analysis of the *Arkhangelskiella cymbiformis* group from two sections around St Paul's Monastry, Gulf of Suez region, Egypt is made. It reveals a gradual increase in the mean length (M) of the group during the Maastrichtian. The range in the M values are characteristic for most of the Maastrichtian zones. Similar changes in the mean length are noted in the Middle East, North and West Africa and to some extent in the North Sea region. These changes have proved to facilitate the recognition of the Maastrichtian zones and are used as alternative markers in case of the absence of conventional index species. Based on morphometric/ quantitative analyses of this group a new criterion to distinguish the Campanian/Maastrichtian boundary is proposed.

CRETACEOUS CALCAREOUS NANNOFLORAS OF TANZANIA AND THEIR REGIONAL SIGNIFICANCE.

By M. Hojjatzadeh, *London*

(No abstract)

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NANNOPLANKTON FROM INDIAN OCEAN AND RED SEA SURFACE WATERS; SNELLIUS II EXPEDITION.

By A. Kleijne, *Amsterdam*

(No abstract)

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EARLY - MIDDLE JURASSIC CALCAREOUS NANNOFOSSILS AT THE VALDORBIA SECTION (CENTRAL APENNINES, ITALY).

by S. Monechi & R. Viviana, *Dipartimento Scienze della Terra, Universit$ di Firenze, Firenze, Italy.*

A detailed biostratigraphic study based on calcareous nannofossils has been carried out on the Early - Middle Jurassic interval at the Valdorbia section in the Umbrian area (Central Apennines, Italy). The Valdorbia section is located along the valley of the Sentino river. In this section a particularly well exposed and continuous Jurassic sequence occurs. The formations studied are from bottom to top: The "Corniola" (Domerian), a pelagic calcareous unit characterised by pink nodular limestones (partial thickness 15 m) overlain by the "Marne di Monte Serrone" (Monte Serrone Marls, Domerian - Toarcian), which consist of marls with intercallations of marly calcareous turbidites (thickness 10 m). This formation is followed by the "Rosso Ammonitico" (Toarcian - Aalenian), a red nodular limestone with red marlstones (thickness 30 m). The transition to the overlying "Calcari diasprigni" (Cherty limestones, Bathonian - Tithonian) is characterised by well bedded white limestone bearing grey nodules of chert and "Filaments" (*Bositra* sp., partial thickness 20 m).

From the calcareous nannofossil assemblage it has been possible to define a succession of events from the Domerian to the Early Bathonian. The nannofossil content shows a variety of preservational degrees due to the different lithology of the sediments. The best preservation occurs in the marls of "Monte Serrone" and "Rosso Ammonitico". The nannofossil assemblage consists mainly of *Schizosphaerella punctulata, Crepidolithus crassus, C. cavus, Crucirhabdus primulus, Parhabdolithus liassicus* and *Lotharingius crucicentralis*. Few species described by Jafar (1983) in pre-Jurassic sediments have been recognised. Particular attention has been paid to the early evolution of *Ellipsagelosphaera, Biscutum* and *Discorhabdus*.

The nannofossil stratigraphy has been correlated with the magnetostratigraphy and the ammonite zonation after Channel, Lowrie, Pialli and Venturi (1984).

OPTICAL PROPERTIES AND ULTRASTRUCTURE OF ARKHANGELSKIELLACEAE AND SOME OTHER LATER CRETACEOUS CALCAREOUS NANNOFOSSILS.

By S. Moshkovitz, *Geological Survey of Israel, 30 Malkei Israel Street, Jerusalem, Israel.*

Results combining light microscope (polarised light, birefringence colours) with scanning electron microscope studies of some Late Creataceous nannofossils (e.g. *Bukryaster, Quadrum, Micula*, representatives of Arkhangelskiellaceae etc.) are presented. Problems concerning their micro-crystallography, orientation and evolutionary trends are discussed.

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TEMPERATURE CONTROLLED MIGRATION OF CALCAREOUS NANNOFOSSILS IN THE NW-EUROPEAN APTIAN.

By J. Mutterlose, *Institut für Geologie und Palaeontologie, Universität Hannover, Callinstr. 30, D-3000 Hannover 1, W. Germany.*

A threefold subdivision can be used to describe the lithology of the NW-European Aptian: dark clays in the lowermost part ("Bedoule"), pale and varicoloured marls in the middle part ("Gargas", *ewaldi-, clava-* and *inflexus*-marls of NW-Germany and Speeton, Sutterby Marl of Lincolnshire) and black clays in the uppermost Aptian ("Clansyes", *jacobi-, nolani*-clays) which extend into the Lower Albian.

The calcareous nannofossil assemblages from these beds show a corresponding tripartite distribution pattern. While the black clays of the lowermost and uppermost Aptian (+ Lower Albian) are characterised by relatively sparse, low diversity assemblages, the flora of the intercalated marls is rich and diverse. The genus *Nannoconus* is common throughout the middle Aptian, although absent in the under- and overlying dark clay facies. This influx of a nannofossil group, which is quite common in the Tethys, is here explained by a combination of palaeogeography and the influx of a warm oceanic current system. This idea is strongly supported by micro- and macropalaeontological observations (forams, belemnites) from the well-studied NW-German sections.

The introduction of warm water nannofossils from the Tethys is not restricted to the Aptian of NW-Europe (NW-Germany, Helgoland, E. England). Similar nannoplankton assemblages have been observed in the Upper Aptian of the Falkland Plateau (DSDP Site 511). The planktonic forams of this site indicate a warm water influx for the same interval.

Thus it is suggested that *Nannoconus* is a basically Tethyan derived genus, which characterises warm water ingressions into the boreal and anti boreal realms. Furthermore the warm water impulse of the Upper Aptian could be a synchronous world wide phenomenon.

GEOLOGIC PROCESSES AND EVENTS AND NANNOFOSSIL DISTRIBUTION

By K. Perch-Nielsen, *17 Orchard Rise, Richmond, Surrey TW10 5BX, UK.*

Geologic events and processes such as openings and closings of ocean barriers, fast or slow ocean-ridge spreading rates, excess volcanism and extraterrestrial impacts influenced the environment in which the nannoplankton and -benthos lived in many ways. While we are not yet able to give answers to all the questions that can be asked, we may guide some research into themes sofar neglected by asking them in the first place.

ORIGIN: Early coccoliths are small, but show already a complex structure. Is the fact that unicellular planktic algae for the first time developed calcareous "plates" that could be preserved related to the chemical state of the oceans after the deposition of vast amounts of evaporites during the Permian and the Triassic? If so, should we expect to see effects on the evolution of calcareous nannoplankton also during or following other times of higher than normal evaporite deposition (late Early Cretaceous, Late Miocene)?

SPEED OF EVOLUTION: How long did it take for the first 10 or 20 species and genera to evolve in the Late Triassic/Early Jurassic? How long did it take for the same number of species and genera to evolve during various time intervals and how long after the Cretaceous/Tertiary boundary event(s)? Which geologic events/processes speed up the extinction, which the appearance of new species?

MASS MORTALITY - MASS EXTINCTION: Species considered to be typical Cretaceous species and to become extinct at the K/T boundary, such as *A. cymbiformis, E. turriseiffelii, C. ehrenbergii, P. cretacea, A. octoradiata* and many others in fact are also found in the upper part of the so-called boundary clay and up into the Upper Danian. While some authors suggest this fact to be due to reworking, others propose that calcareous nannoplankton suffered mass mortality at the end of the Cretaceous and that the extinction of the Cretaceous species followed over several 100,000 to even 1 or 2 my. What effect would a mass mortality of calcareous nannoplankton have on the global O_2 - CO_2 balance and on the food chain in the oceans? Do we know how acid rain effects the living calcareous nannoplankton and could it be causing a mass mortality or even mass extinction, as suggested by authors favouring an "excess volcanism" or an "extraterrestrial event" scenario for the K/T boundary event(s)?

MONOSPECIFIC ASSEMBLAGES: What conditions are responsible for the occurrence (and preservation) of monospecific assemblages?

DIVERSITY: Diversity in living calcareous nannoplankton is highest in low latitudes. It seems, however, that during parts of the Early Cretaceous diversity was higher in the high (boreal) than in the low (Tethyan) latitudes. Is this an artefact of preservation or investigation or a result of geologic conditions, where the present is not the key to the past?

SILICEOUS NANNOPLANKTON AT THE K/T BOUNDARY: Why have we not yet found a single K/T boundary section where silicoflagellates are present? Which geologic conditions are responsible for this lack of preservation? We have no record of silicoflagellates closely under or over the K/T boundary - there are several my of their history missing completely, but we know that, as a group, they survived. A mass mortality, leaving too few to be preserved? Unfavourable conditions for preservation, such as the "wrong volcanism", since silicoflagellates are often found in sediments containing volcanic ashes?

PHYLOGENETIC STRATEGIES IN CALCAREOUS NANNOPLANKTON: NOT A BLACK AND WHITE PICTURE.

By B. Prins, *Shell Intern. Petrol. Mij, EPX/36, Carel van Bylandtlaan 30, Postbus 162, 2501 AN Den Haag, The Netherlands.*

Theories about evolutionary processes are manifold and sometimes contradictory. Although several authors have attempted to tie the extremes together, a black and white picture quite often emerges from recent publications dealing with the subject. In many instances one gets the impression that only two possibilities exist, between which a choice has to be made. On the one hand the theory of punctuated equilibria is advocated in which periods of an evolutionary standstill are interrupted by short intervals with an evolutionary turnover. On the other hand the validity of phyletic gradualism is defended in which evolution is a continuous and gradual process, although the evolutionary speed may vary through time.

In calcareous nannoplankton, however, several evolutionary processes were operating simultaniously. Gradual and stepwise changes have taken place side by side, sometimes even in the same taxonomic unit, whilst in other taxa long periods of stasis alternated with intervals during which the rate of evolution increased dramatically. Clustering of origination or extinction events can be recognised throughout the history of calcareous nannoplankton. It may well be that this phenomenon is related to rather sudden and severe changes in the regional or worldwide environment, giving rise to a punctuated overall impression of nannoplankton evolution. Although the existence of nannofloral turnovers and periods of stasis is thus undeniable, gradual changes over periods of many millions of years did also occur in several groups of nannofossils. The term "punctuated gradualism" introduced by Malmgren, Berggren and Lohmann in 1983, as a common norm in the evolution of planktonic foraminifera, may therefore also be the proper term to describe the total of phylogenetic strategies active in calcareous nannoplankton.

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ARE THE NANNOFLORAL SUCCESSIONS IN THE EARLY JURASSIC OF WESTERN EUROPE RELATED TO GEOLOGICAL EVENTS?

By B. Prins and J.A.M. Driel, *Shell Intern. Petrol. Mij, EPX/36, Carel van Bylandtlaan 30, Postbus 162, 2501 AN Den Haag, The Netherlands.*

Light microscopical counts of nannofossils in a number of Lower Jurassic sections from England, France and Germany show a characteristic consistent succession of nannofloras. The most obvious floral changes occurred at the following levels:

1. around the Hettangian - Sinemurian boundary, where the little diverse *Staurorhabdus primulus* nannoflora is replaced by a more diverse one with *Staurorhabdus thiersteinii* and *Parhabdolithus marthae* as the most characteristic elements.

2. in the latest Pliensbachien, where the *Staurorhabdus - Parhabdolithus* assemblage is succeeded by a *Lotharingius - Palaeopontosphaera opaca* assemblage.

3. In the Early Bajocian, with a change from *Lotharingius*-dominated to *Ellipsagelosphaera*-dominated nannofloras.

The nannofloral successions seem to correlate quite well with transgressive - regressive cycles, recognised in this area. These cycles may be induced either by regional tectonism or by eustatic sealevel changes, connected to large - scale plate movements.

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DEVELOPMENTS IN THE FAMILY ARKHANGELSKIELLACEAE AND THE SPECIES CONCEPT IN CALCAREOUS NANNOPLANKTON.

By B. Prins and H.J. Roersma, *Shell Intern. Petrol. Mij, EPX/36, Carel van Bylandtlaan 30, Postbus 162, 2501 AN Den Haag, The Netherlands.*

G. Lauer was the first to draw our attention (Kiel, 1974) to the complex evolutionary developments in the Arkhangelskiellaceae and their stratigraphical usefulness. In a short note, published in 1975, he focussed his attention mainly on the genera *Arkhangelskiella, Broinsonia* and *Gartnerago*, but in an unpublished report he considered the entire spectrum of morphotypes recognised by him in the interval from the Santonian to the Maastrichtian. In accepting a strict morphological approach he avoided the use of formal species names. Instead he used a numbersystem, enabling him to include the many transitional types by combining numbers of related morphotypes.

During a reappraisal of Lauers work and an extension of his study into the Aptian, it was tried to replace Lauers numbers by formal species names. However, it became clear very soon that this excercise was hampered by the existing nomenclatural chaos and by the impossibility of the Linnaean binary system to cope with the complex phylogenetic relationships within the Arkhangelskiellaceae, a problem also recognised in other groups of nannofossils. In this presentation the evolution of the family will be discussed and several solutions of the taxonomic problems proposed.

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THE USE OF A TRANSFER FUNCTION FROM COCCOLITH ASSEMBLAGES: ESTIMATION OF QUATERNARY TEMPERATURE AND SALINITY IN THE CARIBBEAN AND TROPICAL ATLANTIC.

By A. Pujos, *Département de Géologie et d'Océanographie, Université de Bordeaux I, Avenue des Facultés, 33405 Talence, France.*

Most of the coccoliths from Quaternary sediments are currently used for stratigraphical studies; they consist of the genus *Gephyrocapsa* with *U. irregularis, E. huxleyi, P. lacunosa, C. macintyrei* and *H. sellii*, and they often constitute more than 90% of the associations. They can be considered as THE Quaternary markers.

Estimating paleoenvironmental factors -as IMBRIE and KIPP did with planktonic foraminifera- must be possible with calcareous nannofossils, which live in the uppermost layer of the oceans, but until now results were not very convincing. The main problem can be named the "analogous / non-analogous problem": to use the IMBRIE and KIPP method it is necessary to find in recent assemblages the analogous of the fossil assemblages. However, most of the Quaternary coccoliths belong to the "stratigraphical" species I mentioned above, which are not all present in recent and past assemblages: they are non-analogous and they cannot be used for a paleoecological purpose. It therefore becomes necessary to use the other taxa, which are considered as "ecological" taxa.

I used 22 of the "ecological taxa" I found in the tropical assemblages. Most of them are very rare and their presence is discontinuous in the Quaternary sections, but some others are much more abundant. This quantitative disproportion may distort results and I used various methods for attenuating this distortion. It is possible to use the absolute counts of all the species, or to select some of them (the most abundant, or the most widely distributed in the ocean), or else to transform the count matrices (in using a class system, or the percentage transformation system). These methods were applied to the recent as well as to the fossil associations.

The choice of the geographic area also was difficult. *A priori* it seemed that the impact of the polar front on nannofossil associations from high latitudes (northern Atlantic for instance) would give better results, but "cold" nannoplankton is poor and often even completely absent. I therefore chose top cores from tropical areas where coccoliths are abundant and well diversified. I also had the opportunity to study nannofossils from cores from the Caribbean (P.6304-4 and TR.75231) and from the eastern part of the tropical Atlantic (IGBA.74206 and DSDP Leg 108).

The different kinds of matrices I described above were submitted to the IMBRIE and KIPP method. Temperature estimations were compared with those published by IMBRIE and KIPP from the Caribbean and results are encouraging. Until now I have obtained the best results in using matrices of absolute counts of 9 species. I also tried to estimate salinity in the Caribbean and I found that it was lower in summer than in winter. I estimated salinity for the entire Pleistocene as well: there was a strong decrease of the surface summer salinity during EMILIANI's odd climatic stages. These phenomena are attributed to the Amazonian water coming into the Caribbean during summer and during the Quaternary warm periods.

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MORPHOMETRICALLY BASED PHYLOZONATION: APPLICATION OF THE GEPHYROCAPSA GROUP IN THE LOWER PLEISTOCENE. (poster)

By I. Raffi, *Istituto di Geologia, Via Kennedy 4, Parma 43100, Italy*

(No abstract)

QUANTITATIVE DISTRIBUTION PATTERNS OF DISCOASTERS AND COCCOLITHS IN THE MEDITERRANEAN PLIO-PLEISTOCENE: BIOSTRATIGRAPHIC AND PALEOECOLOGIC IMPLICATIONS. (poster)

By D. Rio, *Istituto di Geologia, Via Kennedy 4, Parma 43100, Italy*

(No abstract)

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STANDARD PALEOCENE-EOCENE CALCAREOUS NANNOPLANKTON ZONATION OF TURKEY.

By V. Toker, *Department of Geology, University of Ankara, 06100 Ankara, Turkey.*

An investigation of calcareous nannoplankton from Turkey has resulted in the determination of seven Paleocene and eleven Eocene biostratigraphic zones. Study material comes from the Haymana, Adiyaman, Sarkisla, Zonguldak, Kaman, Thrace and Antalya regions of landsections that are represented lithologically by marl, shale, sandstone and a variety of limestones.

A 1200 samples taken from these regions were examined for their contents of nannoplankton. 99 Species were described in the Paleocene - Eocene range. In most of the sections nannoplankton zones were correlated with planktonic foraminifera zones in the same sections to arrive at a more accurate stratigraphic position. The following zones were determined:

Paleocene : the *Cruciplacolithus tenuis, Chiasmolithus danicus, Ellipsolithus macellus, Fasciculithus tympaniformis, Heliolithus kleinpellii, Discoaster mohleri* and *Discoaster multiradiatus* Zones.
Eocene : the *Tribrachiatus contortus, Discoaster binodosus, Tribrachiatus orthostylus, Discoaster lodoensis, Discoaster sublodoensis, Nannotetrina fulgens, Discoaster tanii nodifer, Discoaster saipanensis, Chiasmolithus oamaruensis, Isthmolithus recurvus* and *Sphenolithus pseudoradians* Zones.

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PALEOCENE CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY.

By O. Varol, *Robertson Research International, Ty-n-Coed, Llandudno, Wales.*

Quantitative calcareous nannofossil analysis has been carried out on Paleocene outcrop samples and wells from Turkey and the North Sea respectively to zone the Paleocene using both extinction and abundance levels in certain species. For nannoplanktonologists working in the oil industry, extinction datums are of great significance for age assignment in order to overcome the inherent problems associated with the examination of ditch cutting samples. An attempt has also been made to further subdivide the existing Paleocene zones by using the evolutionary appearance of selected species when outcrop, conventional core and sidewall core samples are to be examined.

COCCOLITHOPHORIDS AND THE INTEGRATION BETWEEN EARTH AND LIFE SCIENCES.

By P. Westbroek, *Geobiochemistry Unit, Dept. of Biochemistry, University of Leiden, The Netherlands.*

The concept of 'Life as a geologic force' will be briefly introduced and special attention will be given to the role of coccolithophorids as a geological forcing factor. Coccolithophorids are particularly important because their evolution has lead to an expansion of the domain of limestone deposition from the shelf seas to the open ocean.

Biochemical and cell biological aspects of coccolith biosynthesis in *Emiliania huxleyi* will be highlighted. The coccoliths are formed inside a specialised intracellular vesicle. A complex acidic polysaccharide is thought to play an important role in the process of calcification. The close association of the macromolecule with the mineral phase, and its localisation inside the cell is demonstrated using immunocytochemical techniques.

Using immunological techniques, it has been demonstrated in our laboratory that the chemical structure of parts of macromolecules associated with biominerals may be preserved over considerable periods of geologic time (more than 70 Ma. and probably more than 170 Ma). This finding suggests that an untapped source of biochemical information may be present in the geological record, and that immunology is the most appropriate technology presently available to retrieve that information. Possible future implications of this approach for the study of nannoplankton, both fossil and recent, will be discussed.

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LOWER CRETACEOUS CALCAREOUS NANNOFOSSILS FROM CONTINENTAL MARGIN DRILL SITES OFF NORTH CAROLINA (DSDP LEG 93) AND PORTUGAL (ODP LEG 103): A COMPARISON.

By S.W. Wise, J.L. Applegate, J.A. Bergen and J.M. Covington, *Dept. of Geology, Florida State University, Tallahassee, Florida 32306, U.S.A.*

Extensive Lower Cretaceous sequences drilled off the continental margins on opposite sides of the North Atlantic during DSDP/ODP Legs 93 and 103 provide an opportunity to study the introduction of neritic calcareous nannofossil taxa into the deep-sea environment, a phenomenon that appears to have been widespread within the circum-North Atlantic during Neocomian times.

DSDP Leg 93 Site 603 on the lower continental rise off North Carolina penetrated a siliciclastic deep-sea fan complex characterised by sharp vertical facies changes and alternations of lithology. Well preserved assemblages in dark, carbonaceous claystones were probably displaced from the oxygen minimum zone along the upper slope or outer shelf; neritic taxa include the holococcolith *Zebrashapka vanhintei, Lithraphidites alatus magnus, Pickelhaube furtiva*, and a host of nannoconids and micrantholiths, all of which are few or absent in the interbedded pelagic, bioturbated carbonates.

ODP Leg 103 Sites 638 to 641 drilled along the Galicia Bank off Portugal penetrated pre-rift, syn-rift, and post-rift sediments often characterised by siliciclastic turbidites and calcareous microturbidites. *Micrantholithus*, *Nannoconus*, and *Lithraphidites* again dominate the displaced nannofossil assemblages. *Pickelhaube* is common in a Barremian shell lag where the excellent preservation of the entire assemblage demonstrates the minimal damage that nannofossils experience during transportation by turbidites. Holococcoliths, however, are absent, and a different lithraphiditid assemblage is present compared to Site 603. A modification of the Sissingh zonation proved most useful in subdividing the section.

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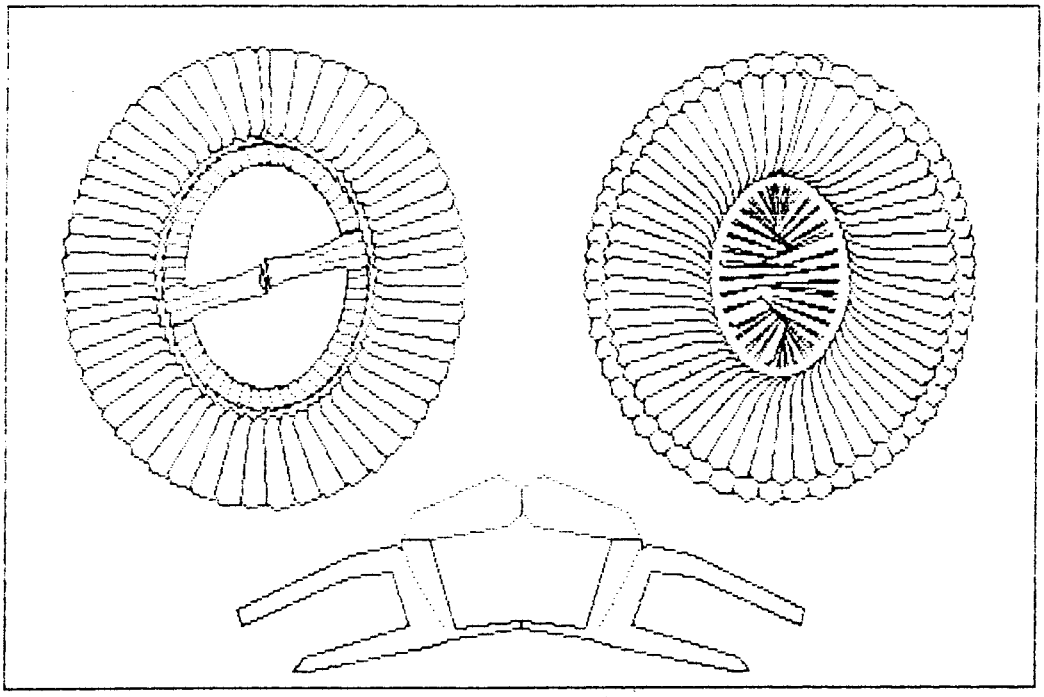
CONSTRUCTION AND ONTOGENY OF LIVING AND NEOGENE COCCOLITHS.

By J. Young, *Geology Department, Imperial College, Prince Consort Road, London, U.K.*

One of the most interesting observations arising from the work by biologists on coccolithogenesis is that it does not occur by calcification of a preformed template. Instead it is a developmental process, with the elements growing radially, and with this growth strongly influencing the final form. This pattern has, inevitably, only been observed in a very few species, but observations on the morphology and geometry of other coccoliths strongly suggests that it is the general mode of development of heterococcoliths. As such it provides a valuable perspective for elucidating the detailed form of coccoliths. In particular this approach has been applied to Neogene coccoliths (Prinsiaceae and Coccolithaceae). It has been used to help understand the detailed ultrastructure of individual coccoliths, morphological variation within species and evolutionary relationships at the generic level.

The model of radial development has also been applied (and so indirectly tested) as the geometrical basis of a computer program for illustrating coccolith morphology (example below).



THE CRETACEOUS AND PALAEOCENE OF EAST KENT - A FIELD GUIDE

by

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INTRODUCTION

The field excursion will visit three localities on the east Kent coast, with opportunities to collect samples from mid and Late Cretaceous and Palaeocene sediments. A brief background to the geology of the area with selected references, is presented here. Stratigraphical logs are provided to facilitate sampling.

East Kent is positioned on the northern limb of the Weald anticline, an inversion structure of Late Cretaceous and Tertiary age (fig. 1).

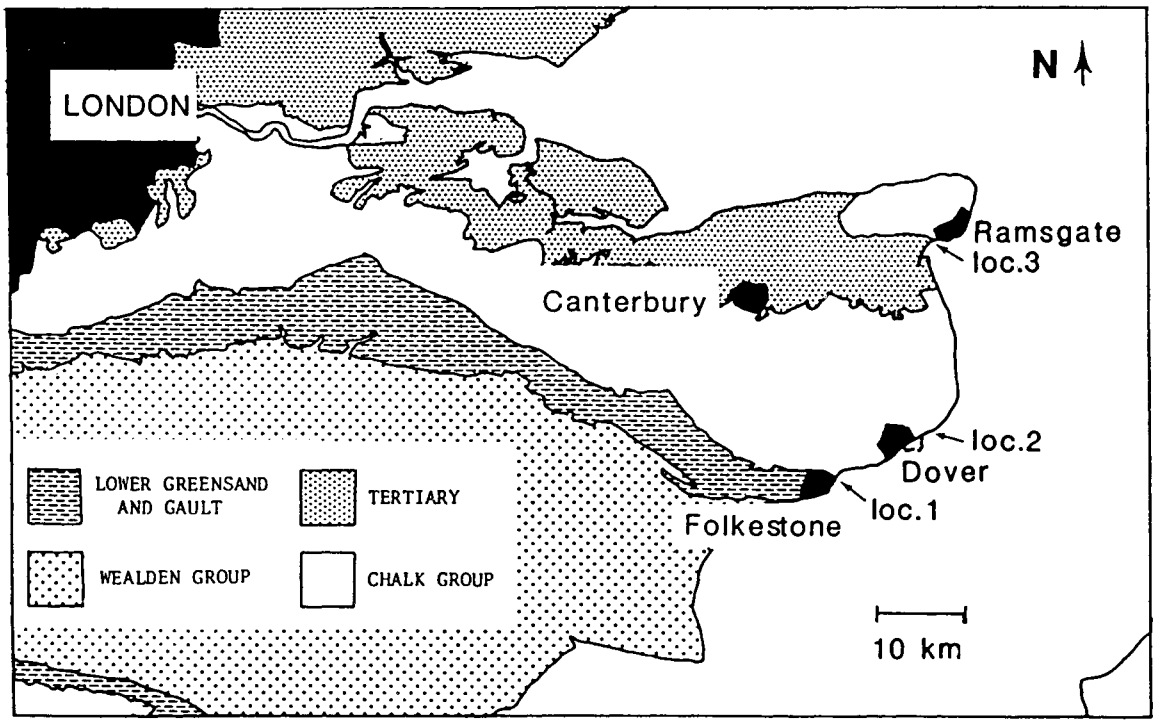


Fig. 1. Geological map of east Kent showing localities visited on field excursion.

Early Cretaceous (Ryazanian to Barremian) sedimentation took place in a non marine or brackish environment, the highlands of the London Platform to the north were the source of clastic detritus which was swept southwards by braided streams. The resulting succession, several hundred metres in thickness, consists of interfluvial clays and silts and channel-deposited sandstone bodies known collectively as the Wealden Group (Allen 1976).

In the Early Aptian, an important marine transgression joined the North Sea to the Atlantic along the line of the English Channel. Glauconitic sands and clays of the Lower Greensand Group (Aptian-Lower Albian) were deposited in a shallow sea which still received sediment from the London Platform. The top of the Lower Greensand, the Folkestone Sand Formation, will be examined at Copt Point, Folkestone (locality 1). The overlying Gault Clay (Middle and Upper Albian) reflects a further deepening of the mid-Cretaceous sea. The Gault Clay at Folkestone is famous for its well preserved macro- and microfaunas, and microfloras.

The great transgressions of the Late Cretaceous (Hancock and Kauffman 1979) resulted in the submergence of much of northern Europe beneath the Chalk sea. Very little land remained (the Highlands of Scotland, the Baltic Shield) and the climate was arid with little runoff, this is reflected in the very low clastic content of the Chalk. The Turonian-Santonian White Chalk Group consists of over 99% calcite, of which the bulk is coccoliths and their fragments (Hancock 1976). Coarser bioclastic detritus, in the form of bivalve debris (*Inoceramus* prisms) and echinoderm ossicles, occurs in varying abundance. Locality 2, to the north of Dover, is a classical White Chalk section, from which Rowe collected the heart-urchin *Micraster* for his evolutionary study of the genus.

Early inversion of the Wealden axis resulted in Early Tertiary erosion of the Chalk, and the development of a major stratigraphical hiatus. The earliest Tertiary sediments in England are the Thanet Formation (Palaeocene) which at Pegwell Bay (locality 3) rest unconformably on a peneplaned surface of Late Santonian White Chalk. The silts and sands of the Thanet Formation were deposited in a southerly embayment of the North Sea. Their basal bed contains glauconite-coated flints derived from the Chalk.

COPT POINT, FOLKESTONE - FOLKESTONE SANDS AND GAULT CLAY (LOCALITY 1)

The section accessible at Copt Point, Folkestone (Grid ref. TR 243 366) is shown in fig. 2. At the base of the section, the top of the Folkestone Sands is visible. This consists of strongly bioturbated muddy glauconitic sand which locally display cross-bedding, and contain large concretions and phosphatic nodules. Above, the Gault Clay forms crumbling cliffs behind extensive mudflows. This section of the Gault Clay is one of the best in England, it was well described in the last century by Price (1879), who numbered the beds I - XIII, and recently by Owen (1971, 1976). A detailed succession of ammonite faunas allows the Gault to be correlated internationally.

The Gault Clay is composed dominantly of illite. It contains many phosphatic concretions, light buff to black in colour, which are concentrated in thin beds. These nodule beds represent erosional episodes which exhumed and concentrated the nodules by winnowing away

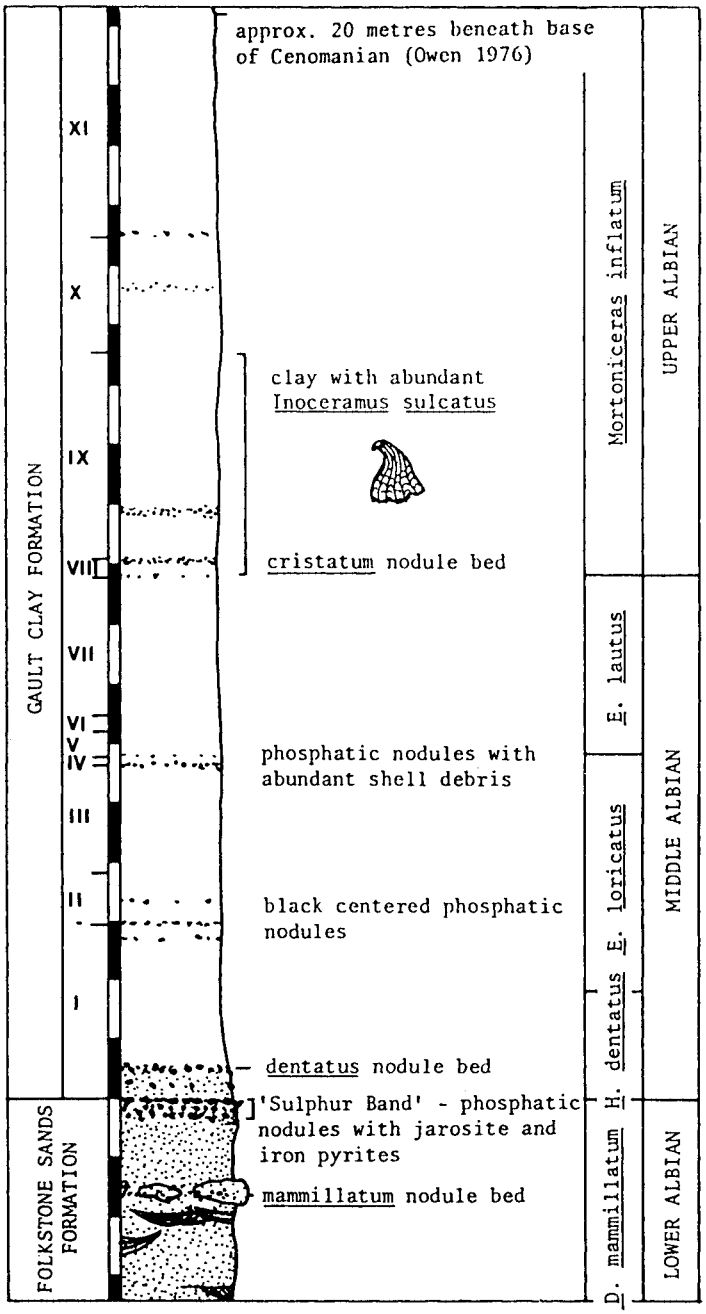


Fig. 2. Section of the top Folkestone Sands and Gault Clay (Albian) exposed at Copt Point, Folkestone (locality 1). Horizons of phosphatic nodules are indicated. The scale on the left of the column is in metres. The roman numerals refer to the bed classification of Price (1879).

the clay matrix. Also present in the clay are seams full of iridescent aragonite shells, mostly of ammonites and bivalves. Certain of the phosphatic nodule beds are laterally continuous and are used as marker horizons (fig. 2). All but the highest beds of the Gault are accessible at Copt Point.

The Gault Clay contains rich nannofloras; published descriptions of these include Black (1972, 1973, 1975), Thierstein (1973) and Taylor (1982). Rare specimens of Boreal restricted? Albian nannofossils occur in the lower part of the Copt Point section, these include *"Parhabdolithus" boletiformis* Black 1972, *"Parhabdolithus" judithae* Black 1972 and *Ceratolithina hamata* Martini 1967. These occurrences are sporadic and rare compared to the more common occurrences recorded in Cambridgeshire and Bedfordshire to the north (Black, 1972 and Crux study in progress).

LANGDON STAIRS, DOVER - WHITE CHALK GROUP (LOCALITY 2)

The zig-zag cliff path at Langdon, several km north of Dover (fig. 3, Grid ref. TR 345 425), was constructed during the Napoleonic wars, and affords a superbly air-weathered section through Turonian to Coniacian Chalk. The lithostratigraphy and marker bed succession was recently described by Robinson (1986), the more important markers are shown in fig. 4. Beds of black flint nodules are conspicuous and stick out of the weathered surface. Flints formed from redistribution of organic silica

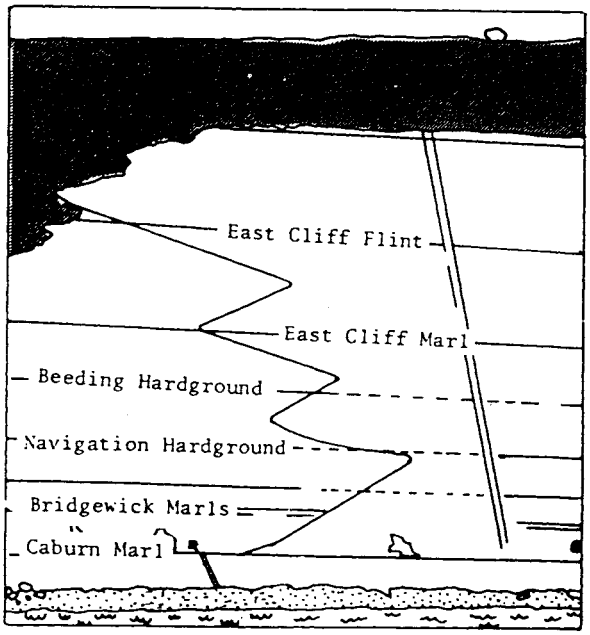
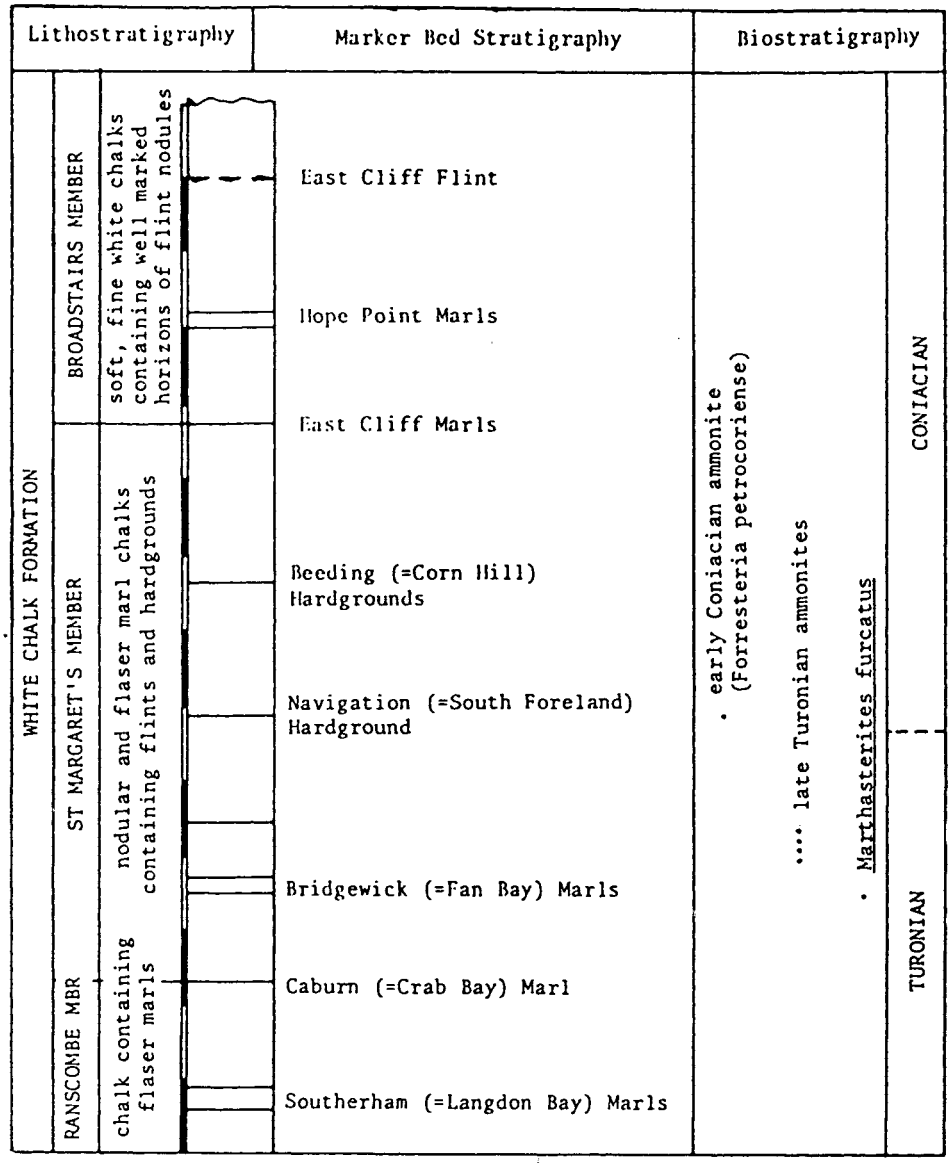


Fig. 3. Sketch of White Chalk (Turonian-Coniacian) section accessible on zig-zag cliff path at Langdon, near Dover (locality 2). Only conspicuous marker beds are shown.

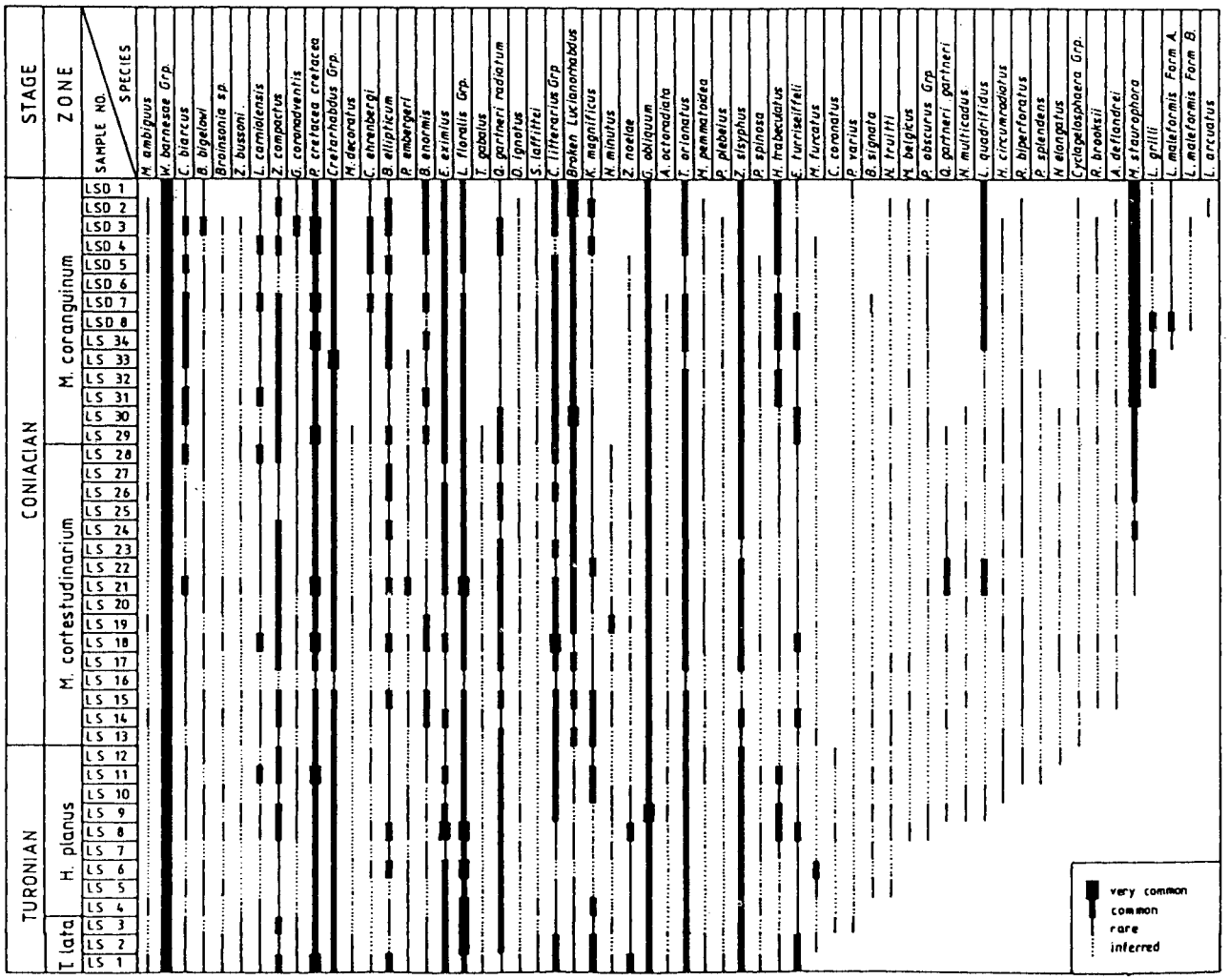
Fig. 4. Stratigraphy of the White Chalk (Turonian-Coniacian) at Langdon Stairs (locality 2). Only major marker beds are indicated on this diagram. Scale on left of column in 5m intervals.



during early diagenesis (Clayton 1986). Individual beds of flint are laterally extensive over 1000's of square kilometres. Many flints formed in burrows, as reflected by their complex shapes - particularly crustacean burrows called *Thalassinoides*. Beds of rough-weathered nodular chalk stained in yellow, brown and orange by iron oxides, are conspicuous in the St Margret's Member. Nodular chalks and hardgrounds were formed by early diagenetic cementation (Kennedy and Garrison 1975) In the lower part of the section, thin (< 20cm) beds of grey marl are present. Certain of these marls are laterally very widespread, and may be used to correlate throughout the Anglo-Paris Basin and into northern England. Their mode of formation is open to debate. Earlier authors have mostly ascribed their formation to pressure solution. Recently, Pacey (1984) has suggested that they are airborn ashfalls. Neither hypothesis is particularly satisfactory.

No bed by bed description of the nannofossils from Langdon Stairs has yet been published. The section was studied by Crux (1980, unpublished Ph.D. thesis), the range chart from his study is included here (fig. 5). Taxonomic concepts are those used in Crux (1982) (except *Q. gartneri* ssp.1 = *Q. gartneri radiatum* and *Q. gartneri* ssp.2 = *Q. gartneri gartneri*). Sample LS6 was collected from the Upper Bridgewick Marl, succeeding samples were colllected at 1.5m intervals with an approximate 2m gap between LS9 and LS10. Sample LS28 lies just below the East Cliff Marl.

FIG. 5. STRATIGRAPHICAL DISTRIBUTION OF CALCAREOUS NANNOFOSSILS LANGDON STAIRS, DOVER.



PEGWELL BAY, RAMSGATE-THANET FORMATION (LOCALITY 3)

The continuous cliff section which exposes the basal part of the Thanetian stratotype was split in the late 1960's by the construction of the sliproad to the Ramsgate International Hoverport, now disused. The stratigraphy has been reviewed by Ward (1977) and Siesser, Ward and Lord (in press). The foraminifera have been described by Haynes (1955, 1956-8) and Haynes and El-Naggar (1964) and the nannofossils by Hamilton in Hamilton and Hojjatzadeh (1982), Aubry (1983) and Siesser, Ward and Lord (in press).

To the north, lying unconformably on Santonian chalk in a low sea cliff, is a section with the three lowest members of the Thanet Formation (fig. 6). The Bullhead Bed, at the base of the Thanet, contains irregularly shaped, green solution-pitted flints in a fine glauconitic sand. Above this follows alternating silts and silty clays of the Stourmouth Clays Member. Close to the top of this member is a thin horizon that yields frequent specimens of *Heliolithus kleinpellii* but no *H. riedelii* or *Discoaster mohlerii (D. gemmeus)*, indicating a minimum age of NP6 (Siesser, Ward and Lord in press). At the base of the Pegwell Marls Member is a silty marl yielding abundant examples of the large foraminifera *Astacolus crepidula* (bed 10).

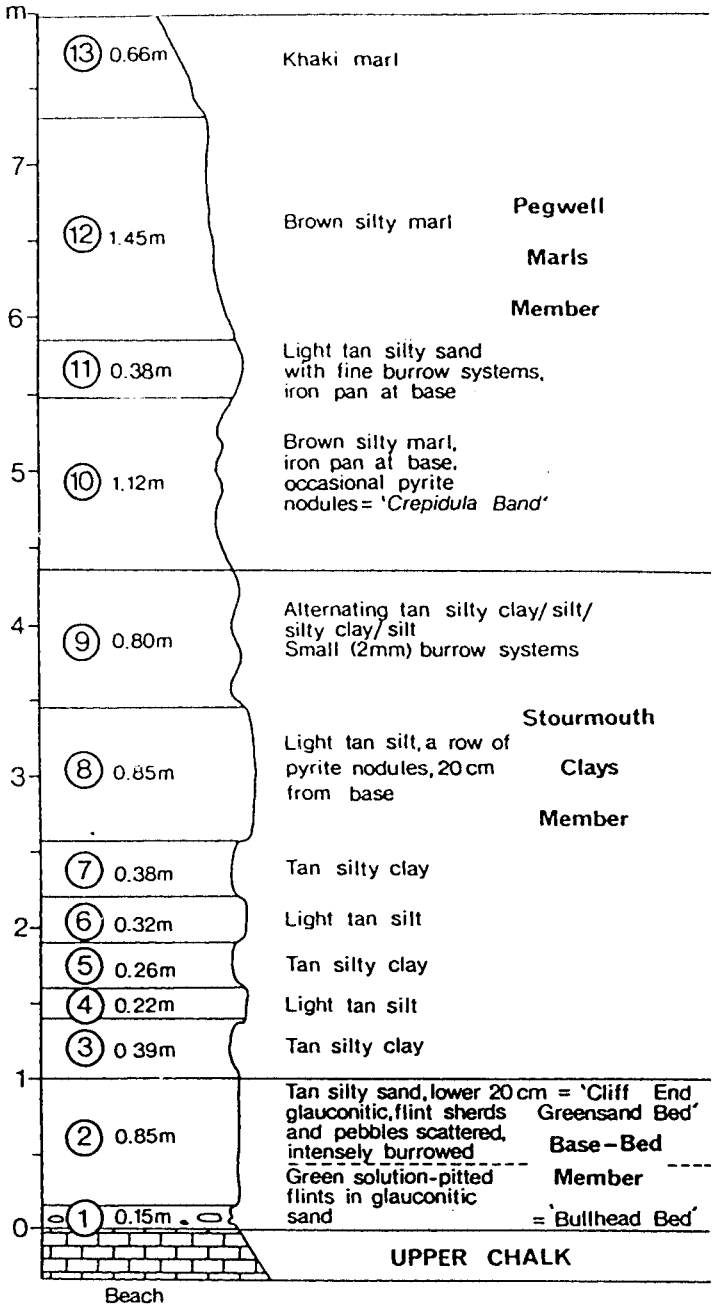
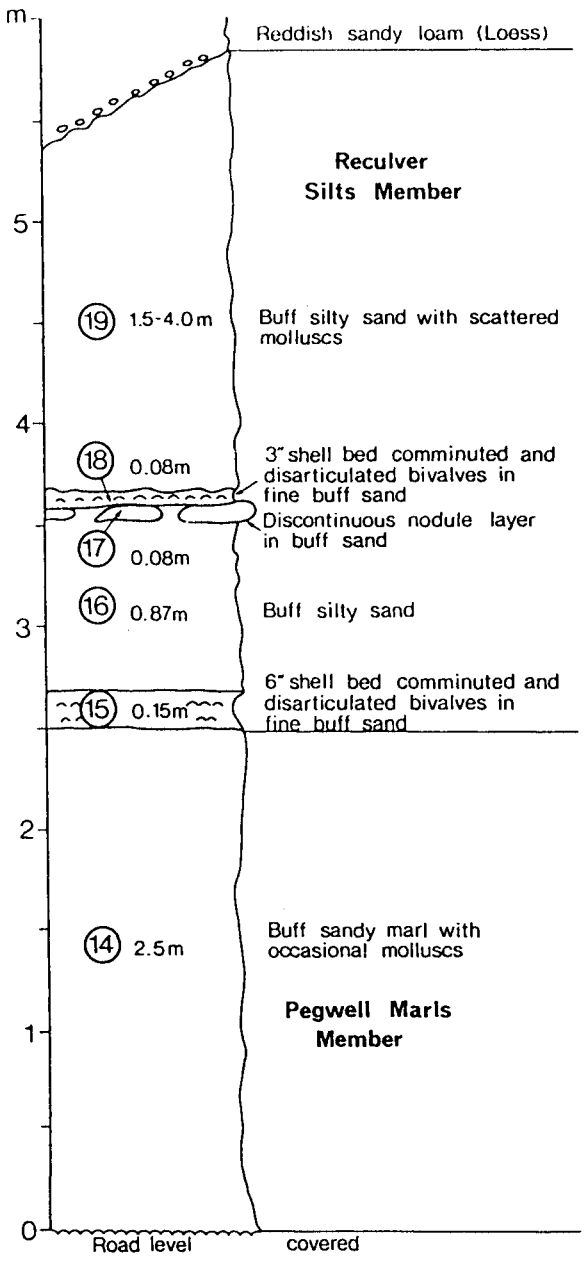


Fig. 6. The Thanet Formation section north of the Ramsgate International Hoverport (from Siesser, Ward & Lord in press).



The top of the Pegwell marls can be seen in a degraded cliff section to the rear of the Hoverport carpark (fig. 7). Immediately overlying is a shell bed in a coarse glauconite sand (bed 15). In this and the succeeding Reculver Silts Member *Heliolithus riedelii* is frequent, suggesting an age of NP8.

Fig. 7. The Thanet section west of the Ramsgate International Hoverport (from Siesser, Ward & Lord in press).

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