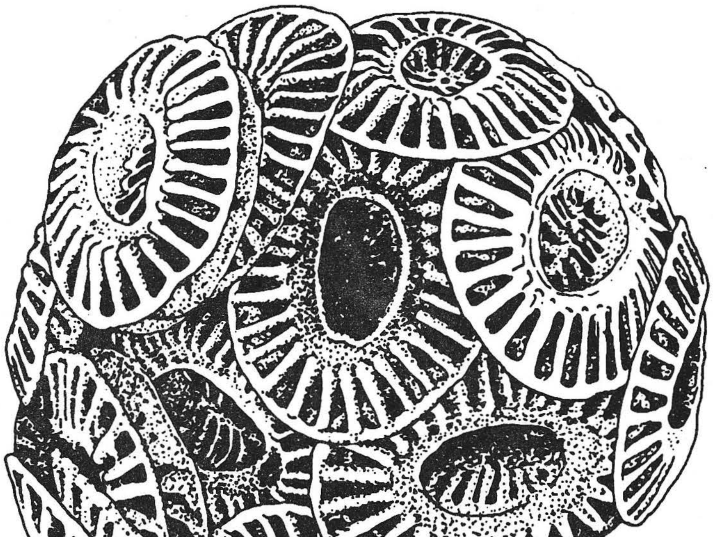
Journal of Nannoplankton Research



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CONTENTS

NEWS AND GOSSIP

Compiled by Jackie Burnett on behalf of the INA Committee

NEW POSITIONS

Harald Andruleit, formerly of Kiel, was successful in his bid for the nannopalaeontology position at the German Geological Survey.

FORTHCOMING EVENTS

7th International Nannoplankton Association Conference, Puerto Rico 1998

It seems like we just get over one when the next starts to loom on the horizon - yes, I'm talking about the next INA Conference! At Copenhagen it was decided that we would finally let Amos Winter drag us over to Puerto Rico for sun, sea and science. So, make space in your diaries for **February 1998** (hopefully outside of the wet and windy season). The meeting will be held 'most likely' at La Parguera, Puerto Rico. Amos needs 125 people to attend to make it economic. Airfares from Europe should be less than $1000 (Amos knows of someone who paid $600) but it may be worthwhile to check out fares to Miami, since this is a major holiday destination and it may be possible to get cheap flights through tour operators, and then get a flight from there (Miami-Puerto Rico around $200). From San Francisco, flights cost around $650. Very cheap! The hotel should cost around $40-50, shared occupancy. So, start saving and applying for conference funding!

on behalf of Amos Winter

Copenhagen Conference Proceedings Volume

Dave Jutson/the DGGU has finally produced author contribution guidelines for the conference volume. Contributions will appear in the *Geological Survey of Denmark and Greenland Bulletins*. Attendees of the conference should have received a letter containing the guidelines from Dave himself around October. If you presented a paper at the conference and wish to contribute to the volume but did **not** receive these guidelines, then you must inform either Dave or myself immediately. Dave looks forward to receiving your manuscripts and apologises for the delay.

Jackie Burnett

Recoveries '97
Final meeting of the UNESCO IGCP Project 335
'Biotic Recoveries from Mass Extinctions'
12th-14th September, 1997, Prague, Czech Republic
Call for participation - call for papers

About the project: In the history of the Earth (including the Recent), numerous events of ecosystem collapses occurred that were followed by recoveries and origination of new ecosystems. This significant transformation could be realised in numerous ways. The project aims to be a platform for the study of survival and recovery of the biosphere, and restructuring of global environments, following mass extinctions. This international project is headed by Douglas H. Erwin, Smithsonian Institution, Washington, DC, and Erle G. Kauffman, University of Colorado, Boulder. Over sixty countries are involved in the project. The meeting should bring together palaeobiologists, palaeontologists, biologists, ecologists, systems theorists, and other persons that are interested in the topic. The conference will be held under the auspices of the Geological Institute, Academy of Sciences, and is being organised by Petr Čejchan & Jindřich Hladil, Geological Institute, Academy of Sciences, Rozvojová 135, CZ 165 02, Praha 6 Lysolaje, Czech Republic.

Deadlines: Pre-registration by January 31st, 1997 (printed form, or **WWW: http://www.gli.cas.cz/conf/recovery/preform.htm**); abstracts by May 31st, 1997.

For further information: Please direct all your correspondence related to the conference to the Conference Manager: Petra Hovorková, Recoveries '97, Eurocongress Centre, Budějovická 15, CZ 140 00 Praha 4. For conference update and details on the programme please consult:
http://www.gli.cas.cz/conf/recovery/recovery.htm
or e-mail: **recovery@gli.cas.cz**

E-mail list

I would like to compile an up-to-date list of e-mail addresses for publication in the next issue. Although I know a few, I am sure there are many more which I am unaware of. So, could you please e-mail me and tell me you would like to be included on the list. Thank you.

j.burnett@ucl.ac.uk

PAST EVENTS

6th International Global *Emiliania* Modelling Initiative (GEM) Workshop
Château de Blagnac, Cabara, France
September 4th-8th, 1996,
Convenor: Patrizia Ziveri.
Hosts: Dorien and Jan van Hinte
'Global *Emiliania* Modelling Initiative: the geological aspects'

Seven years ago, in September 1989, an interdisciplinary meeting was held at the Château de Blagnac to discuss the impact on global climate of a single organism, the coccolithophorid alga, *Emiliania huxleyi*. This event marked the creation of the Global *Emiliania* Modelling Initiative, with the objective of developing *Emiliania* as a model organism for studying the general role of the marine pelagic biota in the climate system and in global dynamics. GEM integrates experimental, observational and modelling research on the *Emiliania* phenomenon, and is designed to produce a nested suite of models at the molecular, organismal, ecological and global level of organisation, ranging in time-scale between milliseconds and megayears.

This initial meeting triggered extensive collaborations, including more than 50 scientists from a wide range of institutions in many countries, with funding from both the EU and national research councils. The results of this work have been discussed at four subsequent meetings in Blagnac, and in international conferencesheld in Bergen (Norway), Plymouth and London (UK). In total, more than 100 papers have been published, many of which were collected together in the following volumes:

The Haptophyte Algae. 1994. J.C. Green & B.S.C. Leadbeater (Eds). The Systematics Association Spe cial Volume **51**, Oxford University Press.

The 1992 Norwegian Emiliania huxleyi experiment. 1994. B.R. Heimdal (Ed.). *Sarsia*, **79**(4).

EHUX (Emiliania huxleyi). 1996. J.C. Green & R. Harris (Eds). *Journal of Marine Systems*, **9**(1-2).

Now GEM, and particularly the geological branch of GEM, has moved from *E. huxleyi* as a target organism to include all coccolithophores.

This year's GEM meeting, the 6th International Global *Emiliania* Workshop, concentrated on coccolithophore dynamics at the geological scale. The major goals of this informal meeting were to establish working relationships concerning the following topics: (1) to quantify and map on a global scale the variety of the coccolithophore communities in the Recent ocean by season or month, and determine the coccolith-$CaCO_3$ export fluxes; (2) to quantify and map the coccolithophore-induced $CaCO_3$ transport and dissolution characteristics in the water-column and top sediments, and define thanatocoenosis composition in different climate regimes; (3) to develop and test models representing the regional distribution, sedimentation behaviour and archive preservation of coccolithophore-induced $CaCO_3$. In addition to providing an understanding of the Recent system, these models should serve as a key to interpret the deep-sea archive over geological time. The integration of these geologically oriented models with the biological GEM models is also to be implemented.

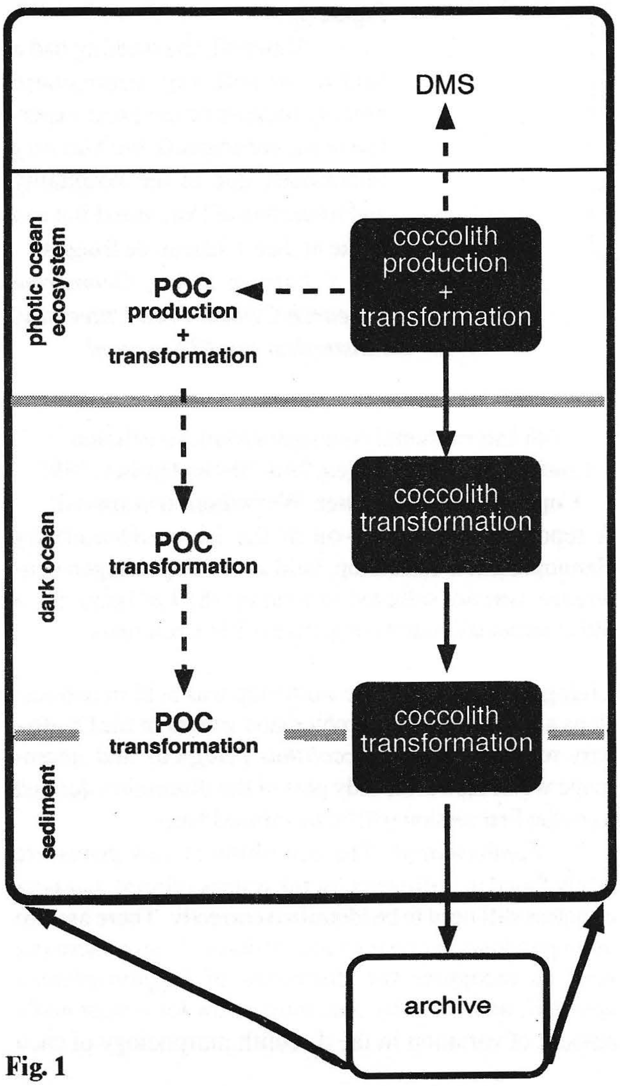

Fig. 1

Following the traditions of the previous GEM meetings, overview talks by Peter Westbroek (Leiden University, NL) and Patrizia Ziveri (Free University Amsterdam, NL) provided a general picture of the interactions between coccolithophores and climate, from the molecular biological to global geological levels. A range of more specialised topics were then reviewed: coccolithophore production, fluxes, sedimentation (**Michael Knappertsbusch**, Natural History Museum, Basel, SW); overview of work on coccolith fluxes in the Pacific Ocean (**Kozo Takahashi**, Hokkaido Tokai University, Sapporo, J); the practicalities of collecting coccolithophorids in sediment traps (**Geert-Jan Brummer**, NIOZ, NL); Saharan dust input and its impact on phytoplankton production (**Cemal Saydam**, Middle East Technical University, Turkey); prymnesiophyte molecular palaeontology (**Gerard J.M. Versteegh**, NIOZ, NL); modelling marine snow dynamics (**Gavin Ruddy**, PML, UK); coccolith carbonate mass estimation (**Jeremy R. Young**, Natural History Museum, London, UK); the contribution of *E. huxleyi* to mass fluxes (**Luc Beaufort**, LGQ-CNRS, FR). Great attention was given to the poster session, allowing us to focus on the results from different researches. The workshop was attended by 25 invited participants, including the majority of the specialists on sediment trapping of coccolithophores, and itgave us a unique opportunity to share experiences, suggestions and data with biologists and modellers. The 4-day workshop was very productive: open discussion, short- and long-term plans have been made.

The main aim of the two workshops on 'Sediment trapping of coccolithophorids, collection and preparation procedures in the field and in the laboratory' and 'Coccolithophore counting and carbonate flux calculations' was to improve quantitative techniques and protocols to allow more-accurate and consistent estimation of the coccolith carbonate mass-fluxes per species. Numerous aspects where discussed: from the dispersion of the particles with chemical agents, through size fractionation due to sieving, and mechanical destruction of particles. Practical outcomes we hope to achieve include: (1) development of a document on standard preparation and counting methods, a first draft of which is in preparation by Patrizia Ziveri; (2) An intercalibration experiment will be carried out by

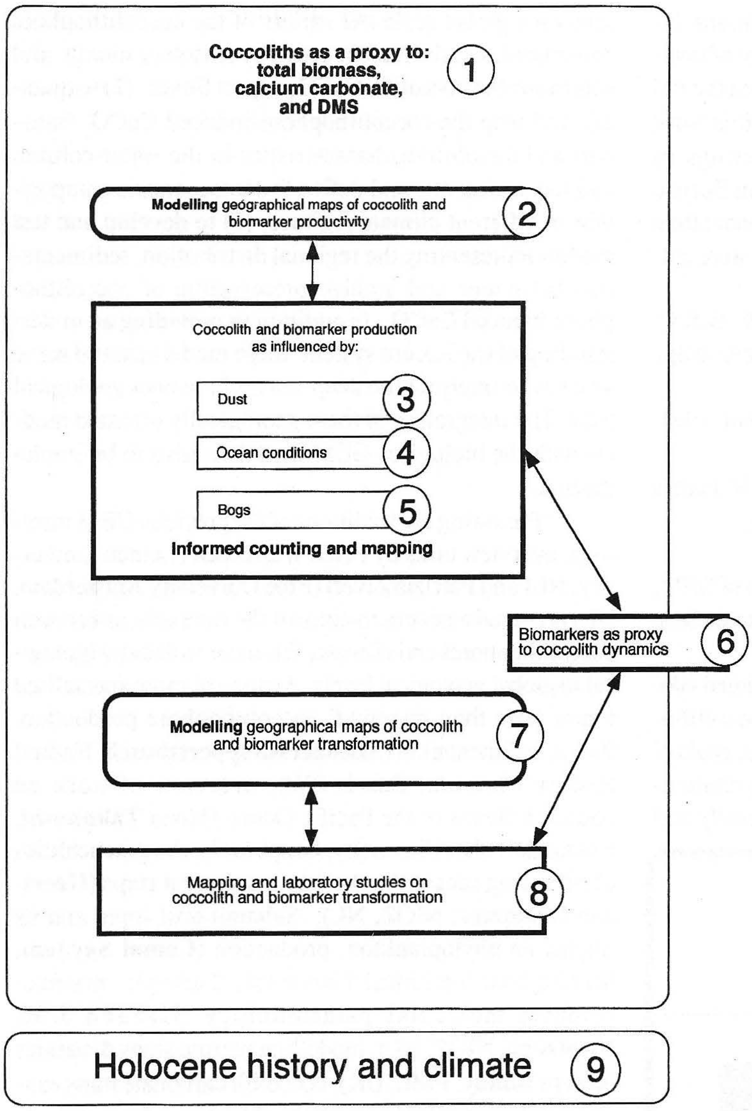

Fig. 2

around 20 specialists, in order to provide a practical test of the consistency of our results. Two samples have been selected, a sediment trap sample provided by Geert-Jan Brummer (NIOZ) and a Holocene sediment sample provided by Jacques Giraudeau (CNRS, Bordeaux, FR). Each of these has been distributed among interested participants and other relevant colleagues who are supposed to estimate individual species abundances per gram of sediment. Information on this intercalibration experiment will be posted on the **'coccoliths'** e-mail list. The comparison of these results should at the least allow an estimation of the error between different preparation and counting methods; (3) Within the organisation of the international program, a compilation of all available sediment trap data will be carried out.

An important issue for the international geological GEM network is that, in order to understand the impact of coccolithophores on the oceanic carbon cycle, it is necessary to understand, quantify, and predict the fate of coccoliths while they sink to the sea floor and settle on the ocean floor. Figure 1 (page 43) shows the approach of investigating the coccolith record in the sediment archive as a proxy for POC production and DMS emission over time-scales varying from seasons to geological time, and in different climate régimes. During the workshop, the practicalities of this approach were widely discussed. Different levels must be considered, including export of coccolith carbonate production recorded below the euphotic zone; the fate of this material whilst it sinks down through the dark ocean and settles on the ocean floor; transformation and dissolution at the sea floor.

During our final discussion in Blagnac, nine different major topics were defined for near-future collaboration and for discussion at the next Blagnac meeting (scheduled for September, 1997) - as outlined in Figure 2.

Above all, the meeting had a highly stimulating atmosphere notonly because of the great expertise of the participants, but also very importantly due to the hospitality and friendship of Dorien and Jan van Hinte at their Château de Blagnac.

Patrizia Ziveri, Geomarine Research Centre, Free University, Amsterdam, zivp@geo.vu.nl

6th International Nannoplankton Association Conference, Copenhagen, 2nd-7th September, 1995 Copenhagen Conference Workshops (continued)

A report on the goings-on at the Living/Quaternary Nannoplankton Workshop, held at the Copenhagen conference, was not solicited in time for the last issue. So, a little late but still interesting, here is Ric's summary:

Living/Quaternary: The workshop was held in two sessions and dealt with (1) problematic genera in the Quaternary record, and (2) *Coccolithus pelagicus* and microscope work. However, only part of the discussion derived from the first session will be mentioned here.

Pontosphaera: The coccoliths of this genus are rarely found in sediments (or the water-column), but nevertheless still need to be identified correctly. There are two main problems facing the nannoworker. Firstly, there is a need to recognise the discoliths of *Scyphosphaera apsteinii*, and secondly, one must allow for a reasonable amount of variation in the discolith morphology of each species. For instance, a few extra pores should not necessarily constitute a new species. A quick glance at the DSDP/ODP volumes shows that the problem of splitting has occurred within this genus - I have found at least 80 fossil 'species' from the literature (and there are probably more). This is an enormous number, considering that we have only five recognised extant species. As the genus originated in the Palaeogene, some of these species will be part of the evolutionary series, however, many are clearly from the Neogene/Quaternary and are possibly synonymous with other species.

Syracosphaera: The coccoliths of this genus are difficult to identify with the light-microscope, and are usually visible as just a dull ring (an exception to this is *S. pulchra*). At present, there are over 20 extant species of *Syracosphaera*, and in the Syracosphaeraceae there are several genera with caneolith-type coccoliths. From posters displayed at recent INA meetings, it is obvious that many of the extant species have records back into the Late Miocene. However, isolated caneoliths (and cyrtoliths) are relatively difficult to identify, even with the SEM, if one does not have knowledge of the coccospheres of extant species. For this reason, many taxa have been effectively redescribed. Once again, a recent review of *Syracosphaera* spp., this time from Loeblich & Tappan and INA bibliographies, came up with about 70 species (mostly living) which are not considered in recent check-lists of extant taxa. It is also a fact that many workers refer to these isolated coccoliths in the sediments as *Syracosphaera* sp. and so the DSDP/ODP volumes are probably littered with specimens which could have been identified.

The workshop members have decided within the next year to gather LM and SEM micrographs of *Pontosphaera* and *Syracosphaera* spp. from Quaternary sediments, with the aim of building up an atlas of the fossil species and comparing them with extant data. It is hoped that in this way we can progress in our understanding of how many species exist in the Quaternary and how far back certain families can be traced. If anyone is interested in joining this project then please contact me.

Ric Jordan
sh081@kdw.kj.yamagata-u.ac.jp

Palaeopelagos Meeting
Rome, June, 1996

At the beginning of June the Palaeopelagos (Group of Italian Palaeontologists) meeting was held in Rome. As usual, a meeting of the Italian nanno-workers was also organized. Our main purpose is to keep everybody updated on the ongoing research activities of all colleagues and to favour cooperation. As a general task we would like to collect, in an atlas, all the available data on Italian nannofossil stratigraphy. In order to do this, we are divided into working groups, subdivided for time periods. Each group meets periodically and will hopefully produce reports on the performed activity.

Andrea Fiorentino
otello@epidote.dmp.unipd.it

A REMINDER

The JNR bibliographers should be providing a comprehensive listing of all nannoplankton and silicoflagellate papers being published around the world (not everyone has the facility to scan the WWW databases). **They can only do this with your help - please send your reprints to the relevant bibliographer** so that they can broadcast your work. You might also check to see if all of your past references have appeared in the *JNR/INA Newsletter*. If you subscribe to the **'coccoliths'** mailing list, you will already be aware that Wuchang Wei has recently compiled a bibliography (nanno-related works since 1990) which you can find on his web site **(http://wwei.ucsd.edu)**.

Jackie Burnett

LETTERS

An open letter to all calcareous nannofossil specialists

The following letter was sent to the Editor and is here reproduced in its full and **unedited** form. Any comments may be directed either to Martin or Jeremy, or to the Editor if you wish them to be published (I think the contents should inspire some discussion in the *Journal*).

The Natural History Museum
Cromwell Road
London
SW7 5BD

October 1996

Martin Jakubowski has recently taken up the position of Head of Curation in the Department of Palaeontology at The Natural History Museum in London, England after spending almost 14 years working in the oil industry with The Robertson Group, Shell Exploration and Production (U.K.) and Shell International. As some of you will already know during that time Martin's responsibilities centred around the analysis and evaluation of calcareous nannofossil assemblages obtained from exploration and production well samples. They are now somewhat different, being concerned with the management of the curators at the Museum and it's fossil collections as well as carrying out research. In addition to the overall responsibility for curation in the Palaeontology Department, Martin specifically manages the micropalaeontological collections. It is concerning these collections and in particular the calcareous nannofossil collection, that we are writing to you.

In the Palaeontological Department the nannofossil activities have now been effectively doubled and together we would like to extend this activity further by establishing a collection of type species and/or sample material. This is in line with the Museum's mission statement; "to maintain and develop its collections and use them to promote the discovery, understanding, responsible use and enjoyment of the natural world". Already some authors have agreed to donate material to the museum. Remember that Article 37.5 of the I.C.B.N. states that "For the name of a new species or infraspecific taxon to be published on or after 1 January 1990 whose type is a specimen or unpublished illustration, the herbarium or institution in which the type is conserved must be specified." Everyone needs to consider a repository and so we are asking you to place The Natural History Museum high on your list. Our ultimate goal is to develop the museum as a major centre (at least in Europe) for calcareous nannofossil collections.

We are therefore making a request (plea, beg or whatever you wish to call it) for fellow nannofossil specialists to send material to the museum in order to enhance and further develop the collection. We would gladly accept original slides containing type species and/or type sample material together with, if possible, a copy of the paper documenting the supporting data. In those case where only sample material can be offered we will guarantee to prepare slides and place these within the collections. All donations will be suitably acknowledged and the information relevant to the donation recorded on the Palaeontology Department's digital database. In addition, we will provide regular updates on the state of the collection throughthe Journal of Nannoplankton Research and, in line with Museum policy, on the Internet.

In making your donation you will ensure that your work and collection are preserved and made available for future use by the next generation of nannofossil workers.

If you require any further information please do not hesitate to contact us.

Yours Faithfully

Mr. Martin Jakubowski
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Dr. Jeremy Young
Calcareous Nannofossil Research
Department of Palaeontology
E-mail: jy@nhm.ac.uk
Tel: +44-(0)171 938 8996

BOOKS & REVIEWS

Microfossils and Oceanic Environments
Edited by Alicia Moguilevsky & Robin Whatley (1996)
University of Wales, Aberystwyth-Press: 434pp.
ISBN 0 903 878 74 7
£25 Softback

Reviewed by Tim Bralower, University of North Carolina, USA

This volume serves as a Proceedings for the International Conference on "ODP and the Marine Biosphere" held in Aberystwyth on 19th-21st April, 1994. The volume contains 25 papers dealing with the application of benthic and planktonic microfossils in palaeoceanography, new microfossil techniques and applications, ecology, biostratigraphy and evolution, and includes studies of ostracods, planktonic and benthic foraminifera, radiolaria, diatoms and calcareous nannofossils.

Seven separate papers address aspects of nannoplankton research. Most of these papers concern applications of nannofossils to palaeoceanography. **Ric Jordan and others** describe a combined study of coccolith and alkenone stratigraphy for the last 130,000 years of an ODP site off NW Africa. The authors recognize Heinrich and other cooling events in the alkenone record and postulate relationships between the relative abundance of major nannofossil species, temperature, depth and productivity. This is a superb paper for those interested in the application of nannofossils in high-resolution palaeoceanography. **Karl-Heinz Bauman** and **Helge Meggers** use nannofossil assemblages to shed light on the palaeoceanographic evolution of the Labrador Sea during the Plio-Pleistocene. These authors show conclusively that nannofossil assemblages respond dramatically to water-temperature changes during glacial and interglacial intervals and provide one of the clearest demonstrations of the effect of temperature on coccolith size. **Hisa Okada** and **Mariko Matsuoka** use the abundanceof nannofossils which inhabit the lower part of the photic zone to infer relative monsoonal wind-strength in the tropical Indian Ocean during the Late Quaternary. Using spectral analysis, they demonstrate that wind strength fluctuates cyclically in tune with the eccentricity of the Earth's orbit. An interesting twist to their research is the surprising result that glacial intervals show less intensified circulation than interglacials. **Alex Chepstow-Lusty** provides a useful summary of studies of *Discoaster* abundance, which has been previously been used by himself and other authors as an indicator of warm and oligotrophic watermasses. He shows high-resolution Late Pliocene data sets from 10 sites that support other evidence for major high-latitude cooling during this time interval with less dramatic temperature changes in lower latitude areas. **Jim Pospichal** provides yet another comprehensive paper on the nannofossil assemblage changes at the Cretaceous/Tertiary boundary. He shows conclusively that there was little precursor environmental pressure on the nannoplankton at a high-latitude site prior to the K/T event as has been postulated for the planktonic foraminifera, but that the surface-water productivity decreased substantially across the boundary. The paper serves as a excellent summary of Jim's long-term work on nannofossil assemblage changes across the K/T boundary in a host of different environments and ocean basins.

Jeremy Young describes in detail the study of the shape of *Emiliania huxleyi* using a light microscope-based image analysis system. He elegantly describes how the technique works and demonstrates that the LM-based system can provide high-precision measurements of a variety of morphocharacters. Jeremy convinced me that I have wasted thousands of dollars on scanning electron microscopy!

Finally **Dave Watkins and others** provide a state-of-the-art compilation of high southern latitude Upper Cretaceous nannofossil biostratigraphy. They demonstrate that it is possible to obtain relatively high stratigraphic resolution in this interval. The paper includes an updated list of species considered to be high-latitude in affinity and an analysis of how high southern latitude surface-water masses evolved both spatially and temporally in the latter stages of the Cretaceous.

In summary, the nannoplankton community did an excellent job providing a showcase of innovative and provocative papers for the rest of the micropalaeontological and palaeoceanographic community.

OCEAN DRILLING PROGRAM UPDATE

John Firth, ODP, Texas A&M University, College Station, TX 77840, USA

Leg 162 (July 9 - Sept. 3, 1995) was the second leg of the North Atlantic Arctic Gateways program (the first being Leg 151), and studied the gateway development between the Arctic Ocean, Norwegian-Greenland Sea, and Atlantic Ocean from the Palaeogene to Quaternary, as well as the palaeoceanographic and palaeoclimatic history of this region. Wuchang Wei was the nannofossil specialist for this leg.

Leg 163 (Sept. 7 - Oct. 28, 1995) drilled the SE Greenland margin in order to study the seaward-dipping basalt reflectors that formed massive flows along this margin during the early rifting of the Norwegian-Greenland Sea.

Leg 164 (Nov. 1 - Dec. 19, 1995) drilled the Blake Ridge and Carolina Rise in order to study gas-hydrate formation. Hisatake Okada was the nannofossil specialist on this leg.

Leg 165 (Dec. 24, 1995 - Feb. 18, 1996) was drilled in the Caribbean Sea and the Cariaco Basin in order to study Cretaceous, Palaeogene and Neogene ocean history, the K/T boundary event, and high-resolution Quaternary sedimentation in an anoxic basin. The K/T boundary was recovered in three holes, and a long history of Tertiary explosive volcanism in this region was documented by numerous volcanic ash layers. Tim Bralower and Koji Kameo were the nannofossil specialists for this leg.

Leg 166 (Feb. 23 - April 11, 1996) studied the sea-level and fluid-flow changes in the Bahamas carbonate platform, and the history of changes in oceanic circulation and climate from the mid-Cretaceous to Recent. Toki Sato was the nannofossil specialist for this leg.

Leg 167 (April 21 - June 16, 1996) studied the variability in strength and heat/salt transport capacity of the California Current due to climatic and tectonic changes in the Pacific Basin, and its relationship to fluctuations in upwelling and primary productivity, and CCD changes in the NE Pacific. Eliana Fornaciari was the nannofossil specialist for this leg.

Leg 168 (June 21 - Aug. 16, 1996) investigated the nature and consequences of hydrothermal circulation in oceanic crust, specifically to obtain information on lateral gradients in fluid composition, formation pressures and temperatures, formation-scale permeability, and circulation vigour. Xin Su was the nannofossil specialist for this leg.

Leg 169 (Aug. 22 - Oct. 17, 1996) drilled the Juan de Fuca-Gorda spreading system in order to ascertain the interrelationships between tectonic, igneous, and sedimentary processes in controlling fluid-flow, energy and mass flux, and formation ofhydrothermal deposits at sediment-dominated rift environments.

Leg 170 (Oct. 22 - Dec. 17, 1996) will drill the Costa Rica accretionary prism with the aim of studying the mass- and fluid-flow patterns through the prism in order to establish the mechanical and chemical behaviour of accretion and underplating, and tectonic erosion, and to determine how deformation and dewatering are distributed throughout an accretionary prism. Staffing is now confirmed for this leg.

Leg 171 (Dec. 30, 1996 - Feb. 16, 1997) is a two-part leg. The first part (Dec. 30 - Jan. 11) will be dedicated to using a Logging-while-Drilling tool to retrieve logs of the Barbados accretionary prism. The second part (Jan. 11 - Feb. 16) will drill the Blake Nose to recover Palaeogene and Cretaceous soft sediments with the APC/XCB, in order to study the older ocean history of the North Atlantic. Staffing is currently underway for this leg.

Leg 172 (Feb. 21 - April 18, 1997) will core a depth-transect down the Blake Bahama Outer Rise and the Bermuda Rise which will allow study of high sedimentation-rate drifts. This will elucidate the history of changes in bottom- and intermediate-waters on extremely high-resolution time-scales for the Late Neogene and Quaternary. Staffing is now underway for this leg.

Leg 173 (April 23 - June 18, 1997) will drill the Iberian margin to study the history of early rifting along this non-volcanic margin, and the ocean-continent basement transition. Staffing is now underway for this leg.

Leg 174 (June 23 - Aug. 18, 1997) is another two-part leg. The first part (June 23 - July 17) will core in shallow waters on the New Jersey Shelf to complete a transect of holes previously drilled on Leg 150. The second part (July 20 - Aug. 18) will place a CORK in DSDP Hole 395A for a long-term study on the nature of fluid-flow through the crust at this site. An engineering experiment will also be done to test a hammer drill-in casing system on bare, hard-rock outcrops on the Mid-Atlantic Ridge. Staffing is now underway for this leg.

Leg 175 (Aug. 23 - Oct. 18, 1997) will study the palaeoceanographic history of the Benguela Current, and the history of upwelling along the SW African margin. Staffing is now underway for this leg.

Leg 176 (Oct. 23 - Dec. 18, 1997) will re-enter Hole 735B to deepen the hole through the lower crustal gabbros. Staffing is now underway for this leg.

Scientific Prospectuses for upcoming ODP legs, beginning with Leg 171, and Preliminary Reports of past legs, beginning with Leg 159, are now available on the World Wide Web at **http://www-odp.tamu.edu**

For more information on ODP and other JOIDES activities, write to Joint Oceanographic Institutions, Inc., 1755 Massachusetts Ave., NW, Suite 800, Washington, DC, 20036-2102, USA. Phone: 202-232 3900 or e-mail: **joi@iris.edu** to request copies of the JOIDES Journal.

To apply for participation as a shipboard scientist on an ODP cruise, send a letter of request and a resumé to the Manager of Science Operations, Ocean Drilling Program, Texas A&M University Research Park, College Station, TX 77845, USA. You will receive an application form to fill in and return to ODP.

To request samples from DSDP/ODP cores, send a letter of request to Chris Mato, Assistant Curator, Ocean Drilling Program, Texas A&M University Research Park, College Station, TX 77845, USA. You will receive an application form to fill in and return to ODP.

THE ICBN: THINGS YOU NEED TO KNOW - 14

Shirley E. van Heck, Sarawak Shell Berhad, Lutong, Sarawak, Malaysia

The reorganisation of the new ICBN has slightly confused the sequence I was following, starting from Article 6 and following up on all references. However, since we have basically finished with the articles dealing with validity, we can return to Article 6, which has not changed much. One thing that always causes a tremendous amount of confusion is the difference between valid and legitimate, and this difference is addressed in Article 6. I shall repeat the rule on validity:

6.2. Valid publication of names is publication in accordance with Art.32 - 45 ...

(as usual, I omit items that are not very relevant to nannoplankton).

This rule is a bit misleading because references in Art.32 - 45 lead to a great many other articles, which therefore also have an impact on validity. These have been discussed in numbers 7 to 12 of this series of contributions.

6.3. A legitimate name is one that is in accordance with the rules.

That seems a simple statement, but the following article confuses the issue:

6.4. An illegitimate name is one that is designated as such in Art.18.3, 19.6, or 52 - 54 (see also Art.21 Note 1 and Art.24 Note 2). A name which according to this Code was illegitimate when published cannot become legitimate later unless it is conserved or sanctioned.

In the book, the reference is to Art.19.5 instead of 19.6, but this is clearly a printing error. The question arises: how about a name that does not comply with a rule not mentioned in Art.6.2 or Art.6.4? It is not legitimate, according to Art.6.3, but not illegitimate either. Actually, all the rules are referred to, one way or another, when following the references in the cited articles, so it is usually not a real problem. Another interesting feature is that an invalid name can be validated, but an illegitimate name cannot be made legitimate (except by conservation). Now, let's follow up on the references.

Art.18.3 has been discussed in van Heck (1991), so I shall merely quote it here:

18.3. A name of a family based on an illegitimate generic name is illegitimate unless conserved...

Art.19.6 is a new one, and basically says the same for a name of a subfamily:

19.6. A name of a subdivision of a family based on an illegitimate generic name that is not the base of a conserved family name is illegitimate...

Now to some more interesting rules. The article refers to Art.52 - 54, which are in Chapter V, but I shall discuss the rest of Chapter V as well, otherwise the other rules in that chapter might get left out altogether.

Chapter V: Rejection of names

ARTICLE 51

51.1. A legitimate name must not be rejected merely because it, or its epithet, is inappropriate or disagreeable, or because another is preferable or better known (but see Art.56.1), or because it has lost its original meaning, or...

Time and again people are tempted to do just that. Noellaerhabdaceae has been considered inappropriate, since the genus *Noellaerhabdus* is not a typical representative of the family (it also is a junior synonym, but that is another story). I know someone who used *Helicosphaera* not because it has priority, but because it was shorter than *Helicopontosphaera* (and how about *Pseudotriquetrorhabdulus*?). And of course, most people use *Discoaster* because it is better known/preferable/easier to use than *Eudiscoaster*.

ARTICLE 52

52.1. A name, unless conserved (Art.14) or sanctioned (Art.15), is illegitimate and is to be rejected if it was nomenclaturally superfluous when published, i.e. if the taxon to which it was applied, as circumscribed by its author, definitely included the type (as qualified in Art.52.2) of a name which ought to have been adopted, or whose epithet ought to have been adopted, under the rules (but see Art.52.3).

This is a lot of words to say that an objective junior synonym is illegitimate. It is further qualified in the next, although it does not add much:

52.2. For the purpose of Art.52.1, definite inclusion of the type of a name is effected by citation (a) of the holotype under Art.9.1 or the original type under Art.10 or all *syntypes under Art.9.4 or all elements eligible as types under Art.10.2; or (b) of the previously designated type under Art.9.9 or 10.2; or (c) of the illustrations of these. It is also effected (d) by citation of the name itself, unless the type is at the same time excluded either explicitly or by implication.*

Example: Schwartz (1894) proposes to introduce an official name for all coccoliths, and because he cannot distinguish different species 'since they are so minute' he proposes 'for all the forms hitherto described, recent and fossil, the one name *Coccolithus oceanicus*'. This makes it a junior synonym of *C. pelagicus* and *C. carteri* and hence illegitimate.

ARTICLE 53

53.1. A name of a family, genus or species, unless conserved or sanctioned, is illegitimate if it is a later homonym, that is, if it is spelled exactly like a name based on a different type that was previously and validly published for a taxon of the same rank.

Note 1: Even if the earlier homonym is illegitimate, or is generally treated as a synonym on taxonomic grounds, the later homonym must be rejected.

One of the earliest examples is the name *Coccosphaera* Wallich 1877, which is a homonym of *Coccosphaera* Perty 1852 (algae). Introducing a new combination might result in a homonym, which must be avoided by introducing a *nomen novum* instead (see Art.58).

53.3. When two or more generic, specific, or infraspecific names based on different types are so similar that they are likely to be confused (because they are applied to related taxa or for any other reason) they are to be treated as homonyms.

This rule is likely to cause problems, as it is very obviously subjective. The examples given in the ICBN are not all that illuminating either, because under the names they quote as not likely to be confused are several that I had to read twice to see the difference. This, however, may depend on the degree in which the taxa are related. However, I hereby propose to apply it to the following species: *Discoaster bergenii* Knüttel et al. 1989 as a homonym of *Discoaster berggrenii* Bukry 1971. Both species are rather similar, have similar ranges, and the names are similar enough to cause confusion to the uninitiated. I readily agree that *D. bergenii* is a useful species to have (stratigraphically), but I would suggest that the authors chose a different name. I further propose that anybody who wants to discuss homonymy under this rule do so in the *JNR*, so a wide nannoplankton readership is made aware of it and can react to it if people disagree.

53.4. When it is doubtful whether names are sufficiently alike to be confused, a request for a decision may be submitted to the General Committee (...) which will refer it for examination to the committee or committees for the appropriate taxonomic group or groups. A recommendation may then be put forward to an International Botanical Congress, and, if ratified, will become a binding decision.

This process, of course, takes several years, so it may be more efficient to decide amongst ourselves.

53.5. The names of two subdivisions of the same genus, or of two infraspecific taxa within the same species, even if they are of different rank, are treated as homonyms if they have the same epithet and are not based on the same type.

Compare this one carefully with Art.53.1, for this might cause confusion. A species and a subspecies of a different species may have the same name (see the discussion in van Heck, 1980, p.33 as an example) but, for example, a subspecies and a variety within the same species may not have the same name.

53.6. When two or more homonyms have equal priority, the first of them that is adopted in an effectively published text (Art.29-31) by an author who simultaneously rejects the other(s) is treated as having priority. Likewise, if an author in an effectively published text substitutes other names for all but one of thesehomonyms, the homonym for the taxon that is not renamed is treated as having priority.

I have no example for this happening in nannoplankton literature, but it is something to keep in mind for the future.

ARTICLE 54

54.1. Consideration of homonymy does not extend to the names of taxa not treated as plants, except as stated below:

(a) Later homonyms of the names of taxa once treated as plants are illegitimate, even though the taxa have been reassigned to a different group of organisms to which this Code does not apply.

(b) A name originally published for a taxon other than a plant, even if validly published under Art.32 - 45 of this Code, is illegitimate if it becomes a homonym of a plant name when the taxon to which it applies is first treated as a plant (see also Art. 45.5).

Finding out about the first, under (a), may be difficult, but not more so than finding out if, for instance, a generic name has already been used for another plant. However, a botanical institute may have the required records. More likely to apply though is (b), as many coccoliths were originally published under the zoological code. However, I cannot find an example where this rule would apply. The articles referred to have already been discussed in previous issues.

ARTICLE 55

55.1. A name of a species or subdivision of a genus, autonyms excepted (Art.22.1), may be legitimate even if its epithet was originally placed under an illegitimate name.

The 'may be' in this rule makes it rather difficult to understand, and the examples quoted do not help. The rest of the rules under Art.55 are as obscure, or do not apply.

ARTICLE 56

56.1. Any name that would cause a disadvantageous nomenclatural change (Art.14.1) may be proposed for rejection. A name thus rejected, or its basionym if it has *one, is placed on a list of* nomina utique rejicienda *(App.IV). Along with the listed names, all combinations based on them are similarly rejected, and none is to be used.*

I know of no nannoplankton names that have been officially rejected, for a good reason: it is a long legal battle to achieve rejection, and it is far easier to simply agree not to use a name. However, a time may come when we need to clean up our lists of taxa, and in that case this is the procedure to follow. Art.14.1 deals with conserved names, which equally does not apply. Only if you intend to offer names for rejecting need you bother with Art.56.2.

ARTICLE 58

58.1. A name rejected or otherwise unavailable for use under Art.52 - 54 or 56 - 57 is replaced by the name that has priority (Art.11) in the rank concerned. If none exists in any rank a new name must be chosen: (a) the taxon may be treated as new andanother name published for it, or (b) if the illegitimate name is a later homonym, an avowed substitute (nomen novum) based on the same type as the rejected name may be published for it. If a name is available in another rank, one of the above alternatives may be chosen, or (c) a new combination, based on the name in the other rank, may be published.

We have several examples in nannoplankton. The first I found serves as well as any other: *Crepidolithus pliensbachensis* was introduced as a *nomen novum* to replace *Crepidolithus ocellatus* Crux 1984 non *Crepidolithus ocellatus* (Bramlette & Sullivan 1961) Noël 1965.

58.2. Similar action is to be taken if transfer of an epithet of a legitimate name would result in a combination that cannot be validly published under Art.21.3, 22.4, 23.4 or 27, or in a later homonym.

The only two of interest to us here are the cases for Art.27 (a species name may not be the same as the genus name to which it is assigned) and the homonym. An example for the first is *Tribrachiatus orthostylus*, for which the type is *Discoaster tribrachiatus*. A well-known example for the second case, where a *nomen novum* was introduced to avoid homonymy, is *Coccolithus helis*. This has been discussed in detail in van Heck (1979, p.C-3).

This concludes the discussion of Chapter V. Also, this lengthy contribution covers the last of 'what you need to know' about the ICBN. I would encourage anyone to read through the volume to discover what more there is, and to see the rules in their proper sequence. If you have any questions, or want to discuss (or argue against) any points that I have made, please write to me or send an e-mail!

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TREATING STRONGLY - LITHIFIED ROCKS WITH ULTRASONIC WAVES

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A detailed calcareous nannofossil biostratigraphy has been established for the Cenomanian-Turonian of the Russian Craton Platform and the Crimean Peninsula, using the Cretaceous nannofossil zonation of Sissingh (1977) and modifications by Perch-Nielsen (1985). Quantitative and semiquantitative analyses of six sections created a biostratigraphical framework for palaeoenvironmental and palaeoceanographical interpretations. Results will be discussed in a separate paper, but we would like to make a short note on the methodology used during this study which might be useful to other nannofossil investigators who work with strongly-indurated rocks.

Strongly-lithified limestones from the Crimean sections proved to be barren of coccoliths after normal smear-slide preparation. Experiments were performed to obtain sufficient material from these limestones in a quick and easy way, as opposed to the laborious crushing and centrifuging technique, as described by Taylor & Hamilton (1982), or the crushing and decanting method described by Monechi & Thierstein (1985). It was found that treatment of rocks with convergent, high-frequency ultrasonic waves does not deleterously affect the small nannofossil fraction, and that sufficient nannofossiliferous material can be recovered by this method, if subsequently concentrated by centrifuging. So-called sonifiers are occasionally used in cleaning nannofossil material, but the frequency and strength of the ultrasonic waves is far less than used for this study.

Rock samples were placed into plastic bottles which were then filled with distilled, buffered water. The bottles were put under a Branson Sonifier 450. This machine, that can also be described as a ultrasonic 'disruptor', was operated for four minutes with the maximum output control (10) and a duty cycle of 70%. To check for the reliability of this method in keeping the small fraction intact, a comparison was made: smear-slides of a well-preserved, nannofossil-rich sample were prepared using both the 'normal' method (from a scratched rock-surface) and from an ultrasonic-waves preparation. No differences between the two preparations could be appreciated under the polarising light-microscope, and SEM images showed no differences in preservation, thus giving support for the non-destructive nature of this method. Under the SEM, samples treated with this method also showed intact coccospheres, giving additional support for the non-destructive character of the method with respect to the nannofossil fraction.

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NEW NAMES FOR OLD: TAXONOMIC CLARIFICATION OF SOME EARLY CRETACEOUS NANNOFOSSIL MARKER - SPECIES

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Abstract: Five new boreal Early Cretaceous calcareous nannofossil species are described and illustrated: *Clepsilithus maculosus, Nannoconus inornatus, Nannoconus pseudoseptentrionalis, Rhagodiscus gallagheri* and *Rucinolithus windleyae.* All five species have previously been misnamed or included within the concepts of other species. The more precise taxonomic concepts introduced here provide improved constraints for important marker-species events. One new combination, *Zeugrhabdotus scutula*, is introduced.

Introduction

A detailed study of calcareous nannofossils from the boreal area has shown that a number of biostratigraphically important taxa require more-precise definition. This paper describes five new species that previous workers have grouped with widely used marker-species, resulting in extended ranges and reduced biostratigraphical potential. Recognition of these new taxa enables clarification of a number of biostratigraphical ambiguities.

These observations are based on the detailed biostratigraphical study of nine sections of Ryazanian to Aptian age: three outcrop sections (two in England and a composite German section) and six cores (two from onshore England, one from the southern North Sea, one from offshore mid-Norway, and two from the Barents Sea). All of the outcrop material and some of the core material is accurately dated by means of cephalopods. The comprehensive results of this study will be presented in Rutledge & Bown (in prep.).

Systematic Palaeontology

Unless otherwise stated, all type-material is deposited in the Postgraduate Unit of Micropalaeontology, University College London.

Genus CLEPSILITHUS Crux, 1987
Type species: Clepsilithus polystreptus Crux, 1987

Clepsilithus maculosus sp. nov.
Plate 1, Figures 4-7

1982 *Stradnerlithus comptus* Black, 1971; Taylor, p.71, pl.4.6, figs 13-14 (EM).
1987 *Stradnerlithus comptus* Black, 1971; Jakubowski, p.117, pl.2, figs 23-24 (LM).
1988 *Thurmanolithion clatratum* Grün & Zweili, 1980; Applegate & Bergen, p.336, pl.17, fig.2 (EM).
1989 *Stradnerlithus comptus* Black, 1971; Crux, p.207, pl.8.13, figs 26-28 (LM).
1991 *Stradnerlithus comptus* Black, 1971; Mutterlose (not illustrated).
1991 *Stradnerlithus comptus* Black, 1971; Bralower, p.430, fig.6.41-42 (LM).

Diagnosis: Small (4.0-5.0μm), elliptical murolith with a bicyclic rim, the outer cycle of which is dextrally imbricate, and a central area occupied by about 14 short, radially-arranged bars which support a diamond-shaped central platform; in crossed-polars the bars appear as a cycle of regularly-spaced bright spots.

Description: The slightly flaring outer rim-cycle consists of about 25 dextrally-imbricate elements, and is only weakly birefringent (grey). The arrangement of elements in the inner rim-cycle is uncertain, but this cycle is highly birefringent (white) in crossed-polars. Each of the 12-16 regularly-arranged, radial bars consists of two laterally-fused elements, and exhibits white birefringence; these bars support a rather less-birefringent (grey-white), diamond-shaped platform that lies along the long axis of the central area. There is no distal process.

Dimensions: Length 4.0-5.1μm, width 3.0-3.6μm.

Remarks: This Upper Hauterivian marker species has been previously misnamed *Stradnerlithus comptus* (e.g. Jakubowski, 1987; Crux, 1989). *S. comptus* was originally described from the Kimmeridgian by Black (1971, pl.31, fig.10) and has a similar number of radially-arranged bars, but these are more delicately constructed and support a slender longitudinal bar, not a diamond-shaped platform. However, the most significant difference between the two species is their rim structure: *S. comptus* has a narrow, monocyclic-appearing rim composed of non-imbricate elements. In the light-microscope, the two are easily distinguished, *S. comptus* being weakly birefringent and inconspicuous, while *C. maculosus* has a highly birefringent inner rim-cycle and central-area bars.

Clepsilithus polystreptus differs from *C. maculosus* in having a less-developed inner rim-cycle, and fewer central bars (that are differently constructed), but this small form has not yet been observed in the light-microscope. The only contemporary species with which *C. maculosus* might be confused is the similarly proportioned *Cretarhabdus inaequalis*, but the latter species has a less-regular central structure.

Derivation of name: Latin, *maculosus* meaning spotted, referring to the brightly-spotted appearance of the cycle of central-area bars in crossed-polars.

Holotype: Pl.1, fig.4 (EM).

Paratype: Pl.1, fig.6 (LM).

Type locality & level: BGS Borehole 81/43 (southern North Sea), 32.80m (Upper Hauterivian).

Occurrence: Hauterivian of the North Sea area, occurringconsistently within the uppermost Hauterivian (above the last occurrence of *Tegulalithus septentrionalis*). The last occurrence of this species (basal variabilis Amm. Zone) provides an excellent approximation of the Hauterivian-Barremian boundary, as currently defined at Speeton.

Genus NANNOCONUS Kamptner, 1931
Type species: Nannoconus steinmannii Kamptner, 1931

Nannoconus inornatus sp. nov.
Plate 1, Figures 8-12, 14-18

1982 *Nannoconus abundans* Stradner & Grün, 1973; Taylor pl.4.6, fig.19 (EM).
1987 *Nannoconus abundans* Stradner & Grün, 1973; Thomsen, pl.6, figs 10-11 (EM).

Diagnosis: A short, biconcave, pillar-like nannoconid constructed from thin plates arranged in a very low-angled spiral, with a narrow axial canal.

Description: The sides of this nannoconid are convex, and the ends unflared, slightly concave and identical, thus apical/basal ends cannot be distinguished. The height is generally less than the diameter, often considerably less. The axial canal is very much narrower than the wall of the nannoconid. The outer surface of the wall is smooth, giving a circular profile in end view. The thin plates composing the wall are arranged in a very low-angled spiral.

Dimensions: Diameter 5.0-9.0μm, height 2.5-6.0μm.

Remarks: Several previous authors (e.g. Taylor, 1982; Thomsen, 1987) have included *Nannoconus inornatus* within their concept of *Nannoconus abundans*, and consequently recorded an anomalously early first occurrence for this marker-species. *N. inornatus* is considered to be the ancestor of *N. abundans*, but it is important to differentiate between the two species clearly, in order to maintain the biostratigraphical integrity of *N. abundans*.

N. inornatus differs from *N. abundans* in lacking a ?basal flange, from *Nannoconus circularis*, *Nannoconus globulus* and *Nannoconus inconspicuus* in having a narrower central canal, and from *Nannoconus ligius* in its non-petalloid profile.

Two varieties of this species were recorded: a larger, highly birefringent form, and a smaller, shorter variety yielding only white birefringence in end view. *N. inornatus* developed vertical ribs in the Early Barremian (late fissicostatum Amm. Zone), giving it a regularly scalloped margin in end view. These ribbed forms probably gave rise to *Nannoconus pseudoseptentrionalis sp. nov.* in the late Early Barremian (elegans Amm. Zone).

Derivation of name: Latin, *inornatus* meaning unadorned, referring to the simple, unflanged form of this species.

Holotype: Pl.1, fig.8 (EM).

Paratype: Pl.1, fig.9 (EM); Pl.1, fig.16 (LM).

Type locality & level: BGS Borehole 81/43 (southern North Sea); 14.70m (Lower Barremian).

Occurrence: Upper Hauterivian-Barremian of the North Sea area; rare through the lower part of this range, but becoming common/abundant in the Lower Barremian, just prior to the inception of N. abundans.

Nannoconus pseudoseptentrionalis sp. nov.
Plate 1, Figures 20-22

?1987 *Nannoconus quadriangulus quadriangulus* Deflandre & Deflandre-Rigaud, 1967; Thomsen, pl.6, figs 6, 7, 9 (EM).
1989 *Tegulalithus septentrionalis* (Stradner, 1963) Crux, 1986; Crux, pl.8.9, figs 5, 6 (EM).

Diagnosis: A short, flangeless nannoconid with a very narrow axial canal, and an irregular, ragged margin, as seen in end/plan view.

Description: This species is so short that it has only been seen in end/plan view. The thin, shallowly-spiralling plates composing the test overlap irregularly to give a ragged margin. This form lacks regularly-spaced vertical ribs, and thus its margin is not regularly scalloped. The axial canal is much narrower than the width of the wall. It is highly birefringent in the light-microscope.

Dimensions: Diameter: 4.5-7.0μm.

Remarks: *N. pseudoseptentrionalis* is differentiated from other similar nannoconids by its irregular, ragged margin. This renders it similar to *Tegulalithus septentrionalis* in crossed-polars, and it has been identified as such in several previous studies (e.g. Crux, 1989). These optically-similar species are readily differentiated in phase-contrast (in which *T. septentrionalis* displays regularly-spaced wall elements) and in side view (*T. septentrionalis* is commonly encountered in highly-distinctive side view). In end view, *N. pseudoseptentrionalis* lacks the weakly birefringent flanges often (but not always) seen on *T. septentrionalis* (see Pl.1, fig.23).

Derivation of name: Greek, *pseudes* meaning false, i.e. false-*septentrionalis*.

Holotype: Pl.1, fig.20 (LM).

Paratypes: Crux (1989), p.199, pl.8.9, fig.5 (EM); Crux (1989), p.199, pl.8.9, fig.6 (EM) (Otto Gott, Germany, Bed 109, 'Middle' Barremian, Aulacoteuthis Belemnite Zone).

Type locality & level: Speeton, NE England, Speeton Clay Formation, Lower Cement Bed 49, Lower Barremian, elegans Amm. Zone.

Occurrence: 'Middle' Barremian of the North Sea area. This species is common in the Lower Cement Beds of

Speeton (elegans Amm. Zone) and at a corresponding level in Germany. It is associated with common/abundant *Zeugrhabdotus scutula* nov. comb. at both localities.

Genus RHAGODISCUS Reinhardt, 1967
Type species: Discolithus asper Stradner, 1963, designated by Reinhardt, 1967

Rhagodiscus gallagheri sp. nov.
Plate 1, Figures 1-3

1987 *Rhagodiscus angustus* (Stradner, 1963) Reinhardt, 1971; Thomsen, p.77, pl.16, figs 6-8 (EM).

Diagnosis: Small (<5.0μm long), elliptical *Rhagodiscus* with a length/width ratio of <2.5, and straight or slightly convex longer sides. The central area is filled with a proximally-situated granular plate and spanned by short, transverse struts which support a relatively large, hollow spine-base.

Dimensions: Length 3.5-4.5μm.

Remarks: Previously included within the species concept of *Rhagodiscus angustus* by several authors (Thomsen, 1987; Mutterlose, 1991), *Rhagodiscus gallagheri* occurs earlier than *Rhagodiscus angustus* and is distinguished by its smaller size and more-elliptical outline. Morphologies transitional between these two species have been observed, confirming the difficulty in using *R. angustus* as a zonal marker. Note that Stradner's (1963) holotype drawing of *Rhagodiscus angustus* is parallel-sided with dimensions 5.0μm x 2.0μm. The oldest forms with these dimensions were recorded, in our study, from the Chale Clay, Isle of Wight, from the lower forbesi Amm. Zone (intra-Lower Aptian), although *R. gallagheri* is still the dominant form at this level. This first occurrence for *R. angustus* is still very much earlier than the basal Upper Aptian event recorded by previous authors, perhaps reflecting application of an even narrower species concept, i.e. very elongate forms with a length/width ratio of >3.

Derivation of name: Named in honour of Dr. Liam Gallagher, nannopalaeontologist.

Holotype: Pl.1, fig.1 (LM).

Paratype: Thomsen (1987), p.77, pl.16, fig.6 (EM) (Well E-1, Danish Sector of the North Sea, 8193', basal Aptian). Reproduced here as Pl.1, fig.3.

Type locality & level: Atherfield Point (Isle of Wight), Atherfield Clay Formation (Sample AC 13), Lower Aptian, forbesi Amm. Zone.

Occurrence: Common throughout the Aptian of the North Sea area; particularly abundant in nannofossiliferous samples from the Atherfield Clay, Isle of Wight, southern England (fissicostatus-forbesi Amm. Zones).

Genus RUCINOLITHUS Stover, 1966
Type species: Rucinolithus hayi Stover, 1966

Rucinolithus windleyae sp. nov.
Plate 1, Figures 24-29

?1987 *Lithastrinus* sp. Bralower, p.298 (not illustrated).

Diagnosis: Nannolith consisting of two inclined cycles of broad, petal-like elements: a wider ?proximal cycle of about nine regularly-imbricate elements, and a ?distal cycle formed from a lesser number of irregularly-overlapping elements.

Description: Two inclined cycles of broad, petal-like elements join at the solid centre of the nannolith; there is no central-area diaphragm structure. The wider ?proximal cycle consists of about nine sinistrally-imbricate, broadly-petalloid elements. The ?distal cycle consists of a lesser number of irregularly-arranged elements, at least one of which projects distally, overlapping the other elements of this cycle. In proximal view in the light-microscope, this form appears as a large (7.0-11.0μm), highly- birefringent rosette, with imbricating, petalloid elements; distal focusing reveals the irregular distal cycle. In side view, it exhibits a typical polycyclolith construction (*sensu* Varol, 1992), with two cycles of inclined elements. The fairly high and irregular form of this species ensure that it is often encountered in oblique view in the light-microscope, where it appears as an irregular, radiating birefringent body.

Dimensions: Diameter 7.8-11.0μm.

Remarks: This species is only tentatively assigned to *Rucinolithus*, due to its bicyclic construction. It would seem to be intermediate between previously described species of *Rucinolithus* (mostly older) and fully formed polycyclolithaceans, in which the two cycles of the nannolith are equally developed.

Differentiation: *R. windleyae* differs from *Lithastrinus* (as emended by Varol, 1992) in lacking a small central diaphragm. It is similar and possibly related to *Rucinolithus pinnatus* Bergen, 1994, but this older species (middle Tithonian to latest Berriasian) has only eight imbricate elements and lacks a well-developed, irregular ?distal cycle, having instead, a small-element cycle surrounding a central perforation. R. *windleyae* is differentiated from the light-microscopically similar *Assipetra terebrodentarius* (Pl.1, figs 30, 31) by its larger size, and petalloid, rather than globular, habit. It is important to make this distinction in order to retain the biostratigraphical integrity of the latter species, which has a first occurrence in the uppermost Hauterivian.

Derivation of name: Named in honour of Dr. Dawn E. Windley, erstwhile nannopalaeontologist.

Holotype: Pl.1, fig.25 (EM).

Paratype: Pl.1, fig.27 (EM); Pl.1, fig.28 (LM).

Type locality & level: BGS Borehole 81/43 (southern North Sea), 41.16m (Upper Hauterivian).

Occurrence: Lower/Upper Hauterivian boundary to Lower Barremian of BGS Borehole 81/43 and the Speeton section; rare through most of this range, but occasionally common in the Upper Hauterivian to basal Barremian. Bralower (1987) recorded the first occurrence of '*Lithastrinus* sp.' (which included the later-appearing *Assipetra terebrodentarius*) in the Upper Hauterivian of a number of tethyan sites.

Genus ZEUGRHABDOTUS Reinhardt, 1965
Type species: Zygolithus erectus Deflandre in Deflandre & Fert, 1954, designated by Reinhardt, 1965

Zeugrhabdotus scutula (Bergen, 1994) *comb. nov.*

Basionym: *Reinhardites scutula* Bergen, 1994 (*Journal of Nannoplankton Research*, **16**(2): 59-69, p.64, pl.1, figs 24a-c (holotype), 25a-b).

1989 *Zeugrhabdotus sisyphus* (Gartner, 1968) Crux, p.198, pl.8.7, fig.1 (EM); pl.8.12, fig.30 (LM).
1994 *Reinhardites scutula* Bergen, 1994, p.64, pl.1, figs 24a-c (holotype), 25a-b (EM and LM; same specimen).

Remarks: Previous authors have assigned this species to *Zeugrhabdotus sisyphus*, but included several other species (e.g. *Z. trivectis*) in this category, giving a much longer, composite range. We believe that this species is best classified within the genus *Zeugrhabdotus* although it may well be the ancestral species to the *Reinhardtites* lineage of the Late Cretaceous, as suggested by Bergen (1994).

Acknowledgements

We would like to thank DENI for funding of this research project, IKU and BGS for the provision of sample material and stratigraphic information, and Tim Bralower, Jim Bergen, Osman Varol and Peter Rawson for advice, discussion and help along the way.

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Assipetra terebrodentarius (Applegate *et al.*, 1987 in Covington& Wise, 1987) Rutledge & Bergen in Bergen, 1994
Clepsilithus maculosus sp. nov.
Clepsilithus polystreptus Crux, 1987
Cretarhabdus inaequalis Crux, 1987
Nannoconus abundans Stradner & Grün, 1973
Nannoconus circularis Deres and Achéritéguy, 1980
Nannoconus globulus Brönnimann, 1955
Nannoconus inconspicuus Deflandre *in* Deflandre & Deflandre-Rigaud, 1962
Nannoconus inornatus sp. nov.
Nannoconus pseudoseptentrionalis sp. nov.
Nannoconus ligius Applegate & Bergen, 1988
Rhagodiscus angustus (Stradner, 1963) Reinhardt, 1971
Rhagodiscus gallagheri sp. nov.
Rucinolithus windleyae sp. nov.
Stradnerlithus comptus Black, 1971
Tegulalithus septentrionalis (Stradner, 1963) Crux, 1986
Zeugrhabdotus scutula nov. comb. (= *Zeugrhabdotus sisyphus* Burnett *in* Gale *et al.* in press)

PLATE 1

Light micrographs x2112 magnification; electron micrographs, magnification as stated. Negatives are stored in the Postgraduate Unit of Micropalaeontology, University College London. Neg. - negative number; LM - light-micrograph; SEM - scanning electron micrograph; xp - crossed-polars; pc - phase-contrast.

Figs 1-3: *Rhagodiscus gallagheri sp. nov.*
Figs 1, 2: Atherfield Clay Formation (Isle of Wight), AC 13, Lower Aptian, forbesi Amm. Zone.
Fig.1: Holotype, LM-xp, Neg.5051-9.
Fig.2: LM-xp, Neg.5051-8.
Fig.3: Paratype, from Thomsen, 1987, p.77, pl.16, fig.6; Well E1, 8193', Lower Aptian.

Figs 4-7: *Clepsilithus maculosus sp. nov.*
BGS Borehole 81/43 (southern North Sea), 32.80m, Upper Hauterivian.
Fig.4: Holotype, SEM, distal view, x9180, Neg.4061-11.
Fig.5: SEM, distal oblique view, x8500, SEM, Neg.4061-12, same specimen as Fig.4.
Fig.6: Paratype, LM-xp, Neg.4071-19.
Fig.7: LM-pc, Neg.4071-21, same specimen as Fig.6.

Figs 8-12, 14-18: *Nannoconus inornatus sp. nov.*
Figs 8-12: BGS Borehole 81/43 (southern North Sea), 14.70m, Lower Barremian.
Fig.8: Holotype, SEM, oblique view, x5000, Neg.4079-17.
Fig.9: Paratype, SEM, oblique view, x5250, Neg.4079-16.
Fig.10: SEM, oblique view, x4875, Neg.4079-24.
Fig.11: SEM, oblique view, x5000, Neg.4079-22.
Fig.12: SEM, end view of Fig.11, x5000, Neg.4079-21.
Fig.14: LM-xp, side and end views, Neg.4099-6, Speeton, Bed LB5C.III, Lower Barremian, rarocinctum Amm. Zone.
Fig.15: LM-pc, Neg.4099-7, same specimens as Fig.14.
Fig.16: Paratype, LM-xp, Neg.4099-4, side view, Speeton, Bed LB5C.III, Lower Barremian, rarocinctum Amm. Zone.
Fig.17: LM-xp, Neg.3545-28, end view, Speeton, Bed LB1F (10), Lower Barremian, fissicostatum Amm. Zone.
Fig.18: LM-pc, Neg.3723-11, end view, Speeton, Bed LB5C.III, Lower Barremian, rarocinctum Amm. Zone.

Figs 13, 19: *Nannoconus abundans* Stradner & Grün, 1973.
Speeton, Bed LB1F (13), Lower Barremian, fissicostatum Amm. Zone.
Fig.13: SEM, oblique view, x4000, Neg.4069-29.
Fig.19: LM-xp, side view, Neg.3545-4.

Figs 20-22: *Nannoconus pseudoseptentrionalis sp. nov.*
Speeton, Lower Cement Bed 49, Lower Barremian, elegans Amm. Zone.
Fig.20: Holotype, LM-xp, end view, Neg.4094-20.
Fig.21: LM-pc, Neg.4094-21, same specimen as Fig.20.
Fig.22: LM-xp, end view, Neg.4065-32.

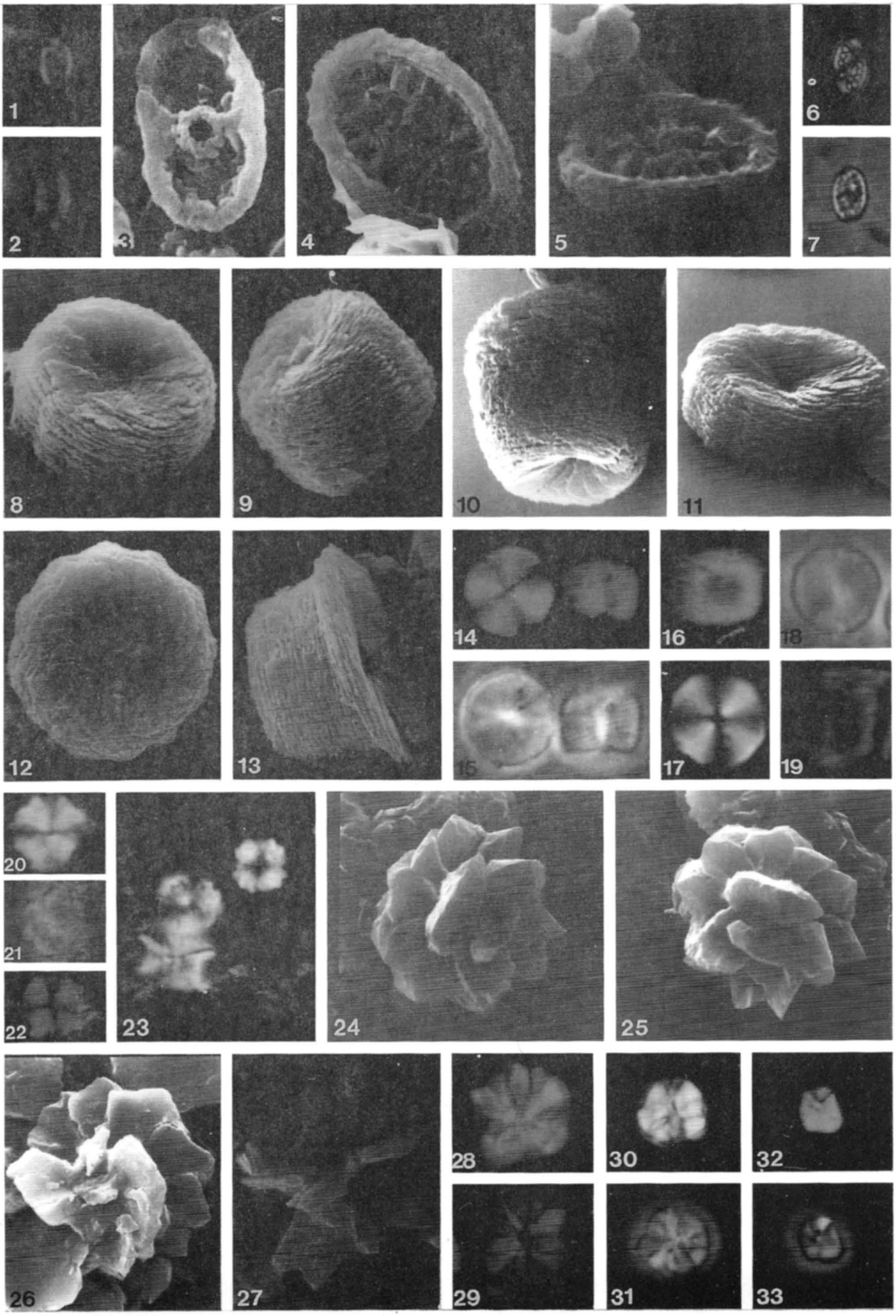
Fig.23: *Tegulalithus septentrionalis* (Stradner, 1963) Crux, 1986.
LM-xp, Neg.4023-27, side and end views, BGS Borehole 81/43 (southern North Sea), 41.16m, Upper Hauterivian.

Figs 24-29: *Rucinolithus windleyae sp. nov.*
BGS Borehole 81/43 (southern North Sea), 41.16m, Upper Hauterivian.
Fig.24: SEM, oblique view, x3875, Neg.4063-28.
Fig.25: Holotype, SEM, same specimen as Fig.24, x4000, Neg.4063-29.
Fig.26: SEM, ?distal view, x4000, Neg.4063-31.
Fig.27: Paratype, SEM, side view, x4500, Neg.4060-30.
Fig.28: Paratype, LM-xp, Neg.4023-32.
Fig.29: LM-xp, Neg.4023-24.

Figs 30, 31: *Assipetra terebrodentarius* (Applegate *et al.*, 1987 *in* Covington & Wise, 1987) Rutledge & Bergen *in* Bergen, 1994
Fig.30: LM-xp, Neg.4071-17, BGS Borehole 81/43 (southern North Sea), 11.92m, Lower Barrremian.
Fig.31: LM-pc, Neg.4071-18, same specimen as Fig.30.

Figs 32, 33: *Assipetra infracretacea* (Thierstein, 1973) Roth, 1973.
Fig.32: LM-xp, Neg.4071-2, BGS Borehole 81/43 (southern North Sea), 62.38m, Lower Hauterivian.
Fig.33: LM-pc, Neg.4071-3, same specimen as Fig.32.

PLATE 1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UPPER ZANCLEAN SILICOFLAGELLATES FROM MILOS ISLAND (CYCLADES, GREECE)

Dimitris Frydas, Department of Geology, University of Patras, GR-26110 Patras/Rion, Greece

Abstract: A calcareous and siliceous assemblage of phytoplankton from diatomaceous, laminated marls of the Frago section, at the southern part of Milos Island, was studied. It contains principally calcareous nannofossils and silicoflagellates. The calcareous nannofossil association belongs to subzone CN11b (*Discoaster assymetricus*) from the Upper Zanclean (*sensu* Okada & Bukry, 1980), whereas the silicoflagellates correspond, more or less, to the upper part of the *Dictyocha extensa* Interval Zone (*sensu* McCartney et al., 1995). *Dictyocha arbutusensis* (Bukry, 1982) *cycladica* n. subsp. and *Dictyocha*(?) sp. were found and are described from the silicoflagellates of the Frago section. The percentage variation of the silicoflagellate species reflects the deposition of the sequence in subtropical to tropical conditions.

Introduction

The island of Milos belongs to the southern part of the active Cyclades volcanic arc (Figure 1A), which extends from Soussaki (adjacent to the Isthmus of Corinth) up to Nissyros and Giali, through Aegina, Methana, Poros, Milos and Santorini islands (Fytikas *et al.*, 1976). Numerous scientists have studied the geology of Milos since the last century. Sauvage (1846) compiled a geological map of the island. Philippson (1897) published the first synthetic work on the geology of the Cyclades. The significant work of Sonder (1925) relates to the volcanic rocks. Liatsikas (1949) studied the important minerals and rocks of the island. Angelier *et al.* (1977), Fytikas (1977a), Jacobshagen (1986) and Pe-Piper & Piper (1989) studied the geology of Milos with respect to the evolution of the Hellenides. A detailed geological map of the island (at 1:25 000 scale) was compiled by Fytikas (1977b). Neogene carbonate deposits transgressively overlie the Upper Cretaceous-Palaeogene metamorphic basement. Volcanic deposits are the dominant lithology of the island. This volcanic activity has lead to the development of hydrothermal fields and fumeroles at Chora and Adamas (Fytikas, 1977a), related to the increased geothermal gradients. Frydas (1994a) studied the stratigraphy and palaeoecology of Lower Pleistocene silicoflagellate and diatom assemblages near Adamas. Bellas & Frydas (1994), in a preliminary report, described the Neogene deposits of the Tsouvala and Frago sections in southern Milos. They assigned to the calcareous nannofossil assemblage of the former section a Messinian age.

The subject of this paper is a stratigraphical study of Neogene deposits from the Frago section, using calcareous nannofossils in conjuction with silicoflagellates.

Lithostratigraphy

The sequence outcrops along the southern coast of Milos Island. It comprises approximately 8m of sediment above present sea-level and is located on the Frago Peninsula, between the cape Mesa Akrotiraki and the Pounta Peninsula (Figure 1B). Three coarsening-upwards sedimentation cycles can be distinguished in the section (Figure 2). The beds of the section dip S-SE at an angle of 5-15°. The basal

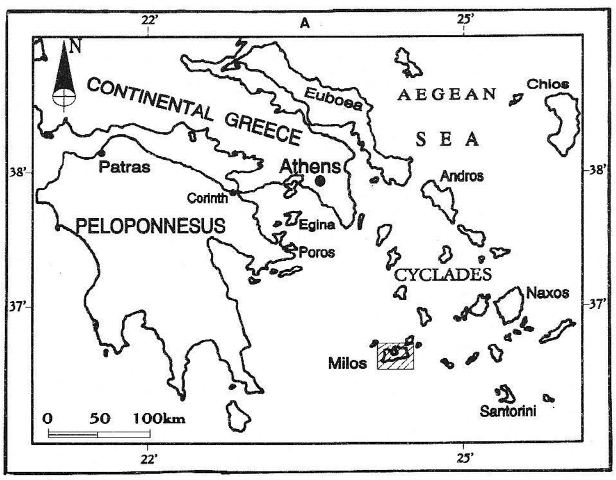

Fig. 1A: Map showing the island of Milos among the Cyclades group in the southern part of the volcanic arc of the Aegean Sea.

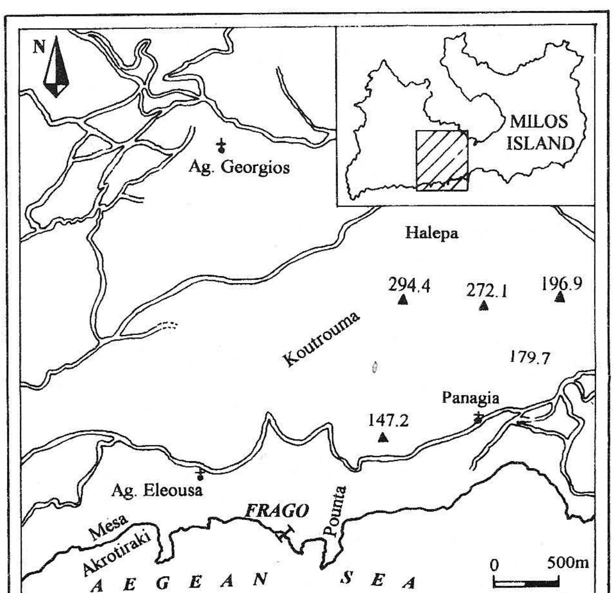

Fig. 1B: Location of the Frago section on the island of Milos, Greece.

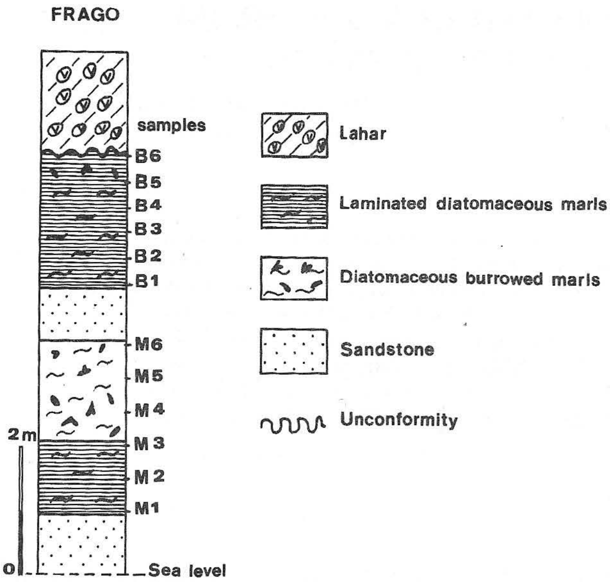

Fig. 2: Lithostratigraphy of the Frago section.

part consists of a sandstone bank which probably represents the uppermost part of an incomplete sedimentation cycle. This is overlain by light green to yellowish, medium-cemented, laminated marls which pass upwards through yellowish, sandy marls with burrows and iron oxides, to medium-grained, light green, slightly cemented sandstone. White in colour, stratigraphically important diatomaceous layers are also interbedded in the second complete sedimentation cycle. Moderately laminated, white to yellowish diatomaceous marls overlay the complete cycle. The upwardly-increasing percentage of sand, heavily burrowed traces, and an internally, almost-destroyed structure due to the bioturbation, are indications of water shallowing during the deposition of these diatomites. The sandstone, which probably covered them as part of a third sedimentation cycle, has been removed by erosional processes which followed another regressional event.

Finally, at the top of the section, an approximately 1.5m thick, green-coloured volcanic deposit ('lahar' after Fytikas, 1977b) unconformably overlies the older sequence. Recent studies consider lahar to be the result of one or more discrete processes, rather than a single depositional product (Fisher & Smith, 1991).

Biostratigraphy

The studies of Deflandre (1950), Stradner (1961), Stradner & Bachmann (1978), Bukry (1981, 1982), Bukry & Foster (1973), Dumitrica (1973), Perch-Nielsen (1985a, b) and Frydas (1990, 1991, 1993) were used for the identification of the various calcareous and siliceous phytoplankton species. The most characteristic species are shown in Plate 1. Table 1 shows the stratigraphical distribution of the calcareous and siliceous nannofloras along the studied section.

Calcareous nannofossils, as well as some silicoflagellate species (samples M1 to M6), were recovered from the laminated, marly diatomites of the lower part of the Frago section. According to the common presence of *Discoaster asymmetricus, Discoaster tamalis* and *Reticulofenestra pseudoumbilica*, the rich calcareous nannoplankton association (Table 1) is assigned to NN14-15B (Lower Pliocene) *sensu* Driever (1988), which corresponds to CN11b of Okada & Bukry (1980) and to the upper part of NN15 (Martini, 1971).

The diatomites of the upper part of the Frago section (samples B1-B6) yielded silicoflagellates and diatoms of higher abundance compared to the underlying, lower part, while the occurrence of calcareous nannoplankton decreased towards the top. In this upper part, *Reticulofenestra pseudoumbilica* is absent, whereas *Discoaster*

Frago-section, Milos Island												Table 1
M						B						Sample number / Nannofossils are indicated as percents (%)
1	2	3	4	5	6	1	2	3	4	5	6	
Uppermost Zanclean												Age
Discoaster asymmetricus Subzone												Calcareous nannofossils
	6			3								*Calcidiscus leptoporus* (MURRAY & BLACKMAN)
11	9	4	8	5	7				4	6		*C. macintyrei* (BUKRY & BRAMLETTE)
3		1										*Coccolithus pelagicus* (WALLICH)
14	5	9	2	6	7							*Discoaster asymmetricus* GARTNER
9	7	10	12	9	6				3	2		*D. brouweri* TAN SIN HOK
7	10	12	9		3							*D. pentaradiatus* TAN SIN HOK
	9	8	4		5							*D. surculus* MARTINI & BRAMLETTE
17	7	6	10	6	8				2			*D. tamalis* KAMPTNER
				6	4							*D. triradiatus* TAN SIN HOK
4	3											*D. variabilis* MARTINI & BRAMLETTE
6	4	7	10	7	5							*Helicosphaera carteri* (WALLICH)
12	11	12	10	7	5							*Pseudoemiliania lacunosa* (KAMPTNER)
4	6		4		3							*Reticulofenestra pseudoumbilicus* (GARTNER)
1			2									*Scyphosphaera* sp.
												Silicoflagellates
						11			16			*Dictyocha* (?) sp.
				12	14							*D. arbutusensis* (BUKRY) *cycladica* n. subsp.
					4			8	5		9	*D. brevispina brevispina* (LEMMERMANN)
7	8	12	10	12	13	34	48	39	22	48	46	*D. extensa extensa* (LOCKER)
	5				4	7	8		5			*D. messanensis aspinosa* (BUKRY) LOCKER & MARTINI
									4	7		*D.* cf. *perlaevis perlaevis* (FRENGUELLI)
						4			6			*Distephanus boliviensis boliviensis* (FRENGUELLI)
					2	5	4	8		2		*Ds. speculum minutus* (BACHMANN)
	4	8	5	7		16	21	23	13	25	28	*Ds. speculum speculum* (EHRENBERG)
5	6	11	14	20	10	23	19	22	20	10	17	*Mesocena circulus* (EHRENBERG)
100	100	100	100	100	100	100	100	100	100	100	100	

tamalis is scarcely present. In our material, the silicoflagellate association corresponds to the upper part of the *Dictyocha fibula* Zone (Bukry, 1981) and, more or less, to the upper part of the *Dictyocha extensa* Interval Zone of the eastern equatorial Pacific (McCartney *et al.*, 1995).

The above-mentioned *Dichtyocha extensa* Interval Zone is not congruent to the *Mesocena circulus* Zone of Martini & Müller (1976, DSDP Leg 38) and Perch-Nielsen (1985b), which really represents the *Paramesocena apiculata/Paramesocena circulus apiculata* Zone. Locker & Martini (1986, DSDP Leg 90) have introduced a *Paramesocena circulus* Zone for Lower to Upper Pliocene sediments of the southwestern Pacific Ocean. This zone lies above the uppermost Miocene-Lower Pliocene *Neonaviculopsis neonautica neonautica* Zone (Locker & Martini, 1986).

Common to abundant silicoflagellates are: *Dictyocha extensa extensa, Distephanus speculum speculum* and *Mesocena circulus*, the latter constituting more than 20% in the studied samples. In smaller amounts are also to be found: *Dictyocha* (?) sp., *Dictyocha arbutusensis cycladica* n. subsp., *Dictyocha brevispina brevispina, Dictyocha* cf. *D. perlaevis perlaevis* and *Dichtyocha messanensis* aspinosa, while *Distephanus boliviensis boliviensis* and *Distephanus speculum minutus* are rare. Most of the silicoflagellate species encountered in the present study have been reviewed in detail (Frydas, 1990, 1991, 1993). Silicoflagellate taxonomy is fully given in these works. Therefore, full synonymies are not presented here. One new subspecies of the genus *Dictyocha*, as well as a *Dictyocha*(?) species of late Early Pliocene samples from the Frago section, were determined and are described here.

Systematic descriptions

Order Silicoflagellata Borgert, 1891
Family Dictyochaceae Lemmermann, 1901
Genus DICTYOCHA Ehrenberg, 1840

Dictyocha arbutusensis (Bukry, 1982) *cycladica* n. subsp.
Plate 1, Figures 1, 2

Derivation of name: 'Cyclades' = group of islands in the Aegean Sea to which the island of Milos belongs.

Holotype: Plate 1, Fig. 1; sample M5.

Paratype: Plate 1; Fig.2, sample M6, from type locality.

Type locality: Frago section, samples M5, M6 (290-340cm above sea-level), Milos Island, central Aegean Sea.

Type horizon: Lower Pliocene (Zanclean), Subzone CN11b (*Discoaster asymmetricus*) (or upper NN15).

Diagnosis: Elongated basal ring with two short radial spines and a very short apical bar.

Description: *Dictyocha arbutusensis cycladica* n.subsp. has an elongated to elliptical ring lacking minor-axis spines, and a very short apical bar. Two short, radial spines are aligned atthe major axis of the elongated basal ring. The basal-ring bars show a distinctly rounded to half-circular form in the part on the ring where the lateral bars instate. The maximum from inner diameter ranges from 39 to 52μm (holotype = 49.3μm). The length/width (L/W) ratio from inner diameter ranges from 1.7 to 2.5.

Discussion: *Dictyocha arbutusensis cycladica* n.subsp. is distinguished from *Dictyocha arbutusensis* (Bukry, 1982) by the distinctly more semi-circular, rounded basal bars in the part of the ring where these are joined with the oblique lateral bars; by the obliquely-oriented apical bars; by the very short, radial spines; and by its generally smaller size and less broad outline. *Dictyocha arbutusensis* (Bukry, 1982) has a maximum inner diameter from 45 to 65μm, and a L/W ratio from 2.8 to 3.4.

Age: *Dictyocha arbutusensis cycladica* n.subsp. first appears in the Frago section at the stratigraphical level of Subzone CN11b (*Discoaster asymmetricus*) in the Lower Pliocene (Zanclean). *Dictyocha arbutusensis* (Bukry, 1982) occurs in low frequencies in the Upper Pliocene in the eastern equatorial Pacific. Its stratigraphical range is not yet exactly established.

Occurrence: *Dictyocha arbutusensis cycladica* n.subsp. is a common species in Zanclean samples M5 and M6 (290-340cm above sea-level) in the Frago section. Other common species in these samples are: *Dictyocha extensa extensa, Dictyocha messanensis aspinosa, Distephanus speculum minutus, Distephanus speculum speculum* and *Mesocena circulus.*

Dictyocha(?) sp.
Plate 1, Figures 3, 4

Holotype: Plate 1, Fig.3; sample B1.

Paratype: Plate 1, Fig.4; sample B4, from type locality.

Type locality: Frago section, samples B1 and B4 (470cm and 570cm above sea-level, respectively).

Type horizon: Lower Pliocene (Zanclean), Subzone CN11b (*Discoaster asymmetricus*) (or upper NN15).

Diagnosis: Subparallel basal ring with two short spines and a convex apical bar.

Description: *Dictyocha*(?) sp. has a subparallel to slightly oblong basal ring with only two short spines aligned at the major axis of the elongated ring. A slightly convex apical bar connects the subparallel sides of the ring along the minor axis. The maximum from inner diameter ranges from 42 to 62μm (holotype = 51.3μm). The L/W (length/width) ratio from the inner diameter ranges from 2.1 to 2.6.

Discussion: *Dictyocha*(?) sp. is distinguished from *Dictyocha neonautica* (Bukry, 1981), from the Upper

Miocene of the Carnegie Ridge, Pacific Ocean, DSDP 157-38-CC (343m) and the Panama Basin, by its essentially smaller size. *Dictyocha neonautica* (Bukry, 1981) has a maximum inner diameter of 70-90μm.

Age: *Dictyocha neonautica* defines the homonymous subzone (Bukry, 1981) which is equivalent to the lower part of the silicoflagellate *Dictyocha fibula* Zone (Upper Miocene). On the island of Crete, *Dictyocha* cf. *D. neonautica* (*sensu* Bukry, 1981)has been established as the marker for an acme-subzone in the Lower Piacentian in the Marathiti, Aghios Vlassios (Frydas, 1990, 1996) and Gournes (Frydas, 1994b) sections of the Heraklion Province, and also in the Stavromenos section (Frydas & Keupp, 1992) of the Rethymnon Province.

Occurrence: *Dictyocha*(?) sp. is a common species in Upper Zanclean samples B1 and B4 in the Frago section. Its stratigraphical range is not yet exactly known. Other common species in these samples are: *Dictyocha extensa extensa, Dictyocha brevispina brevispina, Dictyocha* cf. *D. perlaevis perlaevis, Dictyocha messanensis aspinosa, Distephanus boliviensis boliviensis, Distephanus speculum minutus, Distephanus speculum speculum* and *Mesocena circulus.*

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PLATE 1

Figs 1-17: Silicoflagellates. Figs 1-6, 12, 14 and 15-17 magnified x850 approximately; Figs 7-11 and 13 magnified x950 approximately. Figs 18-24: Calcareous nannofossils. All specimens magnified 1400x approximately. Holotypes are stored in the Dept. of Geology, University of Patras.

Figs 1, 2: *Dictyocha arbutusensis* (Bukry) *cycladica* n.subsp..
Fig.1: Holotype, sample M5.
Fig.2: Paratype, sample M6.

Figs 3, 4: *Dictyocha*(?) sp..
Fig.3: Holotype, sample B1.
Fig.4: Paratype, sample B4.

Figs 5, 6: *Dictyocha brevispina brevispina* (Lemmermann).
Fig.5: Sample M6.
Fig.6: Sample B4.

Figs 7-9: *Dictyocha extensa extensa* (Locker) Locker & Martini.
Figs 7, 9: Sample B4.
Fig.8: Sample M6.

Figs 10, 11: *Dictyocha messanensis aspinosa* (Bukry) Locker & Martini.
Fig.10: Sample M6.
Fig.11: Sample B4.

Fig.12: *Distephanus boliviensis boliviensis* (Frenguelli). Sample B4.

Fig.13: *Distephanus speculum minutus* (Bachmann). Sample M6.

Fig.14: *Distephanus speculum speculum* (Ehrenberg). Sample B4.

Figs 15-17: *Mesocena circulus* (Ehrenberg) [syn: *Paradictyocha circulus* (Ehrenberg) Dumitrica].
Fig.15: Sample B4.
Fig.16: Sample M5.
Fig.17: Sample M6.

Figs 18-19: *Discoaster asymmetricus* Gartner.
Fig.18: Sample M1.
Fig.19: Sample M6.

Fig.20: *Discoaster brouweri* Tan Sin Hok. Sample M6.

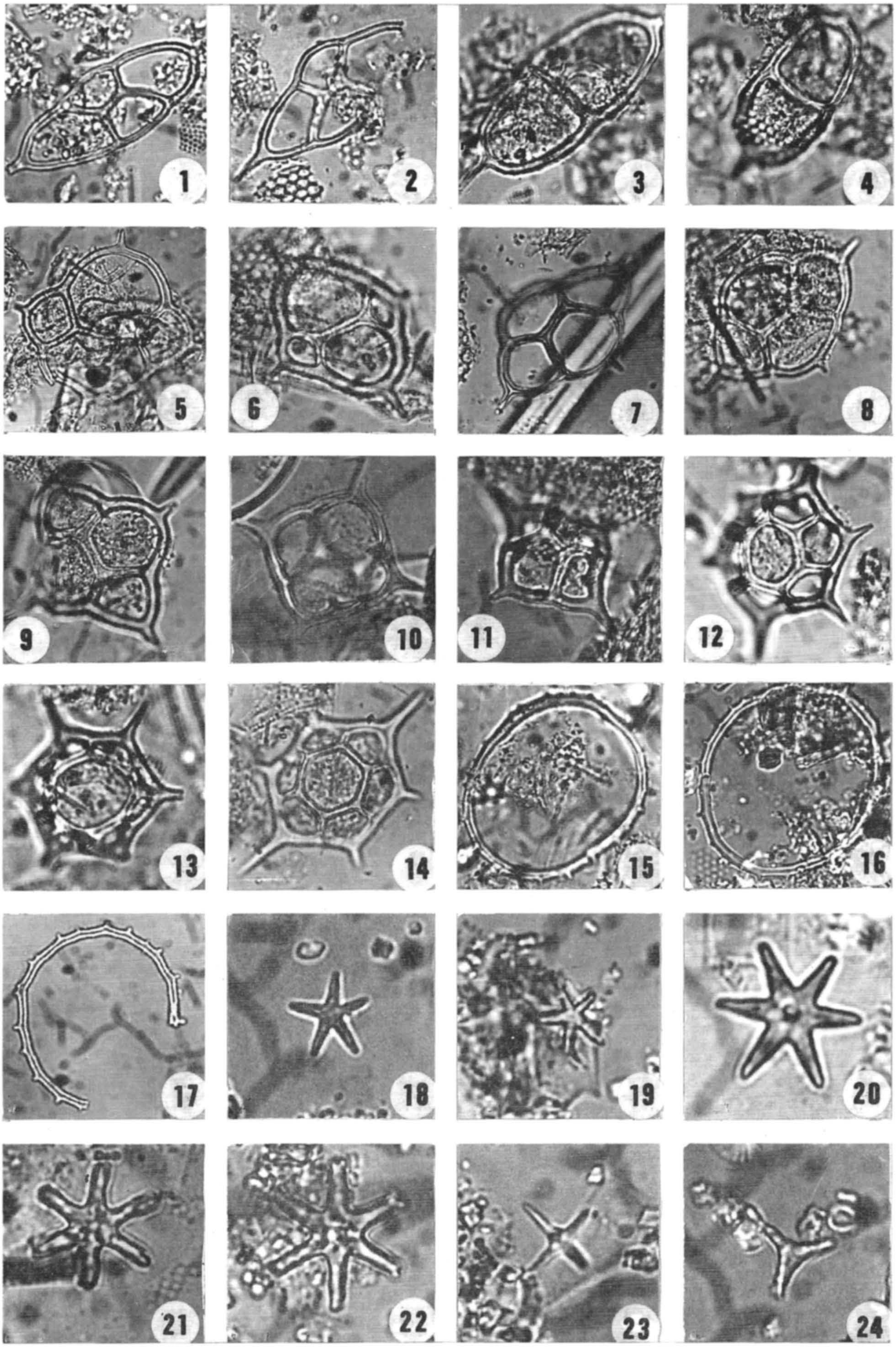
Fig.21: *Discoaster surculus* Martini & Bramlette. Sample M6.

Fig.22: *Discoaster variabilis* Martini & Bramlette. Sample M6.

Fig.23: *Discoaster tamalis* Kamptner. Sample M6.

Fig.24: *Discoaster triradiatus* Tan Sin Hok. Sample M6.

PLATE 1



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B184

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NEW CALCISPHERE TAXA

Genera
Amphora

Species
aequilamellata, Orthopithonella
coronata, Amphora
pyramidalis, Pithonella
ramonii, Scrippsiella
tumulosum, Bicarinellum

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