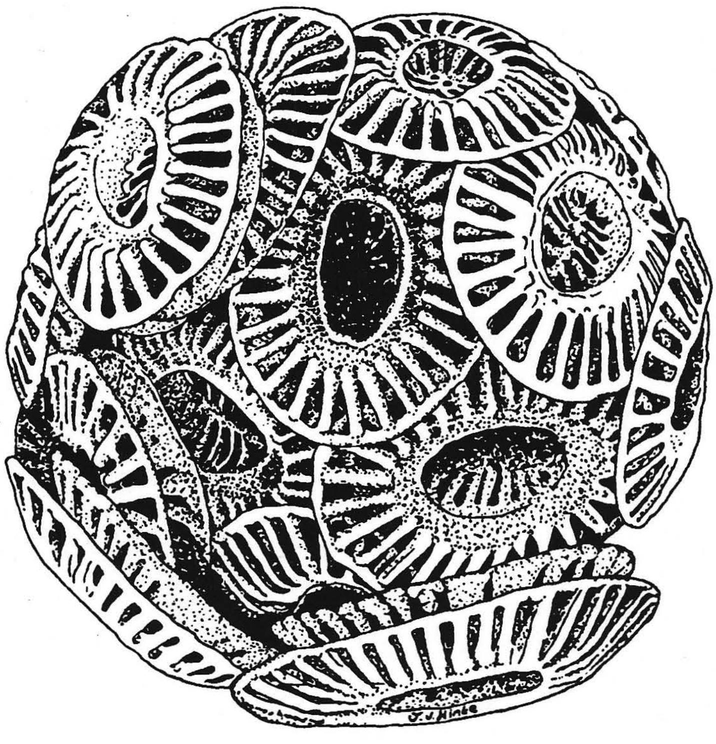
Journal of Nannoplankton Research



A Publication of the International Nannoplankton Association

JOURNAL OF NANNOPLANKTON RESEARCH

Published by the International Nannoplankton Association

Volume 18 **Number 1** **March 1996**

CONTENTS

NEWS AND GOSSIP

Compiled by Jackie Burnett on behalf of the INA Committee

LETTER FROM THE NEW EDITOR

Despite Jeremy's hope for a smooth transition between editors, a number of glitches occurred which caused the delay of this issue of the *Journal*, which should have appeared by December. For these, I apologise, since they were entirely my fault, however the transfer occurred at a time when I was experiencing an unusually heavy workload, combined with moving house, and planning and implementing a transfer to Arizona for a few months. It is from this haven (Northern Arizona University) that I eventually managed to pull this issue together! I'm sorry to keep you all waiting.

I am sure we all would like to extend our thanks to Jeremy for his hard work and dedication to editing the *Journal* over the past few years. However, he isn't leaving the job entirely - he will remain as a Deputy Editor, alongside Paul Bown. I hope *Marine Micropaleontology* appreciates his skills as much as we have. Thank you Jeremy! Strangely, enough, Jeremy has also just taken up a position which became vacant when I retired as Chairman, that of British Micropalaeontological Society Nannofossil Group Secretary...the nannoplankton world seems to be a small one, in more than one sense!

Taking on a job such as this one started me wondering about improvements or innovations that might enhance the *Journal*. However, Jeremy and Bohumil have done such a professional job on the editing and production that I feel loathe to alter anything. What I would like to do, though, is to remind you that this *Journal* is your *Journal*. It relies on *your* articles, *your* letters, *your* snippets of information. Its reputation is largely dependent upon the standard of the articles *you* submit for publication. It exists in order to inform fellow nannoplankton specialists of *your* research. This includes publicising your successful attainment of PhD status, or the start of your PhD research project, as well as the results of these and post-doctoral labours. If you're a research co-ordinator who has funding for a project, why not advertise this? If you have a project in mind, and think you can get funding for international collaboration, or for a foreign research assistant, why not advertise this? As palaeontologists, we are finding ourselves being undervalued and overlooked in an increasing number of countries (the UK now seems to be heading the same way as the US). Now, more than ever, we should be making a more concerted effort to win funding, carry out more research, and prove to those funding bodies, geological surveys and oil companies how spectacularly useful nannoplankton are!

Jackie Burnett

NEW PhDs

Dawn Windley, 1985. *Calcareous nannofossil applications in the study of cyclic sediments of the Cenomanian.* University College London.

FORTHCOMING EVENTS

Summer 1996 Fieldtrip

The Nannofossil Group of the British Micropalaeontological Society are contemplating organising a weekend fieldtrip to the Boulonnais area of northern France during the summer. This area is within easy reach of many other nanno workers and we would be very happy to have you join us. If you are interested in being kept informed of our plans, please contact one of us.

Dawn Windley , Chairman (edpdeaw@bath.ac.uk), Jeremy Young, Secretary (jy@nhm.ac.uk)

BOOKS & REVIEWS

International Code of Botanical Nomenclature (Tokyo Code)
Edited by W. Greuter *et al.* (1994)
Koeltz Scientific Books: 389pp.
ISBN 387429367X 1878762664 8090169910
Reviewed by Shirley E. van Heck, Sarawak Shell Berhad, Lutong, Sarawak, Malaysia

Compared to the previous (1988) version of the Botanical Code, also known as the Berlin Code, a major re-hash has taken place. Several articles have been deleted and others placed in a more logical sequence, such as articles 7-10. New articles have been added and quite a few articles have been split up. This has led to the renumbering of a lot of articles. Fortunately, a tabular key is provided in the front, listing old and new article numbers. This key alone takes up a whole page and is too long to reproduce here. Many of the articles have been revised or rephrased. On the whole, this is an improvement, although in a few cases (such as Art.7.5), I found the new phrasing more ambiguous than the previous. The general philosophy of the Code is more than ever aimed at achieving stability in nomenclature.

The preface suggests that extra effort has been made in the editing, although this is not noticeable, with the first errors occurring in the key that lists the differences between the Berlin Code and the Tokyo Code, and in references to other articles. To name a few examples: Art.6.4 refers to Art.19.5 instead of 19.6; in Art.6.8, the reference to Art.19.5 is omitted. More disturbing still is that whole lines are missing, such as the first two lines of Art.19.5!

Another issue addressed in the preface is the use of italics. I have always been under the impression that the rule was for names below the rank of family to be printed in italics, and names of family and above in normal script. Now I read that the use of italics is not covered in any rules, and that there are several habits around. In fact, the Code now recommends the writing of all Latin names in italics.

In this review, I will highlight only a few of the major changes made (in contents, not numbering) that affect us, as nannoplankton specialists, most. A more detailed account of the changes will be covered in the column "The ICBN: things you need to know - 13" (see elsewhere in this issue).

One interesting new article is the following: Art.9.7. *An epitype is a specimen or illustration selected to serve as an interpretive type when the holotype, lectotype or previously designated neotype, or all original material associated with a validly published name, is demonstrably ambiguous and cannot be critically identified for purposes of the precise application of the name of a taxon. When an epitype is designated, the holotype, lectotype or neotype that the epitype supports must be explicitly cited.* This article, therefore, offers the possibility to select a type for some of those species names which are really only based on a simple drawing that does not offer enough detail. I am thinking here of some of the species of Arkhangelskij and Górka, for example.

This next one could prove a source for trouble: the following has been added to Art.32.1: *...In addition, subject to the approval of the XVI International Botanical Congress, names (autonyms excepted) published on or after 1 January 2000 must be registered.* Art.32.2. *Registration is effected by sending the printed matter that includes the protologue(s), with the name(s) to be registered clearly identified, to any registering office designated by the International Association for Plant Taxonomy.* This new idea, although not approved yet, is going to trigger a lot of discussion. If we, as nannoplankton specialists, want to have any input into the validity of nannoplankton names, we have to be well-prepared. The discussion is hereby opened.

Another new, high-impact rule appears in Art.36: 36.3. *In order to be validly published, a name of a taxon of fossil plants published on or after 1January 1996 must be accompanied by a Latin or English description or diagnosis, or by a reference to a previously and effectively published Latin or English description or diagnosis.* Latin is still required for recent plants, but at least from now on any other language is invalid. To be fair, most taxa have been published in English lately, but it is now compulsory. The INA hereby officially recommends English, rather than Latin.

These are the changes with most impact. Because many, if not most, of the numbers of articles have changed, you should use this new code if you want to refer to any rules in taxonomic discussions.

THE 6TH INTERNATIONAL NANNOPLANKTON ASSOCIATION CONFERENCE, COPENHAGEN, 2ND-7TH SEPTEMBER 1995

Host: Geological Survey of Denmark and Greenland (DGGU). Convenor: Dave JUTSON

OVERVIEW

Organising an international scientific conference is a major task at any time, and for Dave Jutson a particularly exciting challenge since he was repeatedly posted offshore to North Sea drilling rigs during the run up to the conference. Nonetheless, this was a very smoothly-organised and successful meeting. Perhaps we had slightly fewer adventures than at some previous meetings (*perhaps the beer was too expensive? Ed.*) but all participants agreed that, scientifically, it was about the best nanno meeting they had attended (comparisons are of course invidious but, after ten years of biennial meetings, participants seemed to spend much of their time swapping stories about previous gatherings, so it is only fair to reflect this in a report).

There were some 71 registrants at this meeting, coming from 22 countries around the world. A few familiar faces were missing due to rival attractions, such as the Cretaceous Stage Boundaries meeting in Brussels (see reports below), although the most dedicated attended both. As in previous years, there were large contingents from the UK, Italy and USA but this time easily the best-represented nation was Germany, with 18 participants! This large contingent appeared to reflect the strength of microfossil research in Germany, and particularly the large calcisphere research group, as well as the geographical proximity of Denmark.

The meeting commenced with an excellent and very well-attended, one-day fieldtrip to Stevn's Klint and other Cretaceous/Tertiary boundary sections, led by Hans Jørgen Hansen. This was immediately followed by an ice-breaker party, which was even better attended.

There followed three days of scientific sessions, held in the smart, modern buildings of the Danish Geological Survey, which proved an excellent conference venue. Dave Jutson was assisted in running the conference by a host of colleagues to make us welcome, anticipate needs and help with problems - not least doing their best to insulate us from the shock of Danish prices by including as much as possible in the registration cost. Particularly appreciated was the very fine Celtic *Chiasmolithus* logo which featured on souvenir mugs and t-shirts, as well as the conference materials.

At the end, we enjoyed a wonderful end-of-conference dinner in a beautiful pavilion on one of the moatlakes that surround the centre of Copenhagen. In addition, of course, we spent many happy hours in the restaurants and bars of this enchanting, if expensive, city.

The post-conference fieldtrip, sadly, had to be cancelled owing to a shortage of well-funded participants but several of us stayed in Copenhagen for a few days more to enjoy the city atmosphere, visit the Little Mermaid, Tivoli Gardens, Hamlet's Castle in Helsingør (aka Elsinore), and even to do a little geology - with the help, once again, of Dave Jutson and a DGU car.

Jeremy Young

INA BUSINESS MEETING

We had, as usual, an INA business meeting at the conference. There were no major debates here but two important issues were formally decided:

Appointment of new editor

Jackie Burnett replaces Jeremy Young. Ric Jordan, the only other volunteer for the job, has no hard feelings about Jackie's appointment!

Decision of venue for the next meeting

Amos Winter was, in the end, the only candidate for hosting the next INA Conference, in Puerto Rico. After some discussion of arrangements and economics, his proposal was enthusiastically accepted.

Jeremy Young

SCIENTIFIC PRESENTATIONS

There were some 30 oral presentations. This is fewer than at previous conferences but, paradoxically, it seemed to lead to an improvement in the scientific value of the meeting; each speaker was able to have a 25 minute time-slot, which contributed to less-hurried presentations and a more attentive audience. Also, though, the standard of talks was generally very high. To balance the reduction in number of talks, there were more posters (about 40) presented at this meeting than at any previous INA Conference, and the general standard of posters seemed higher as well. The following notes are arranged by topic and I apologise for inaccuracies, which are inevitable since I was not very scrupulous about taking notes. I have tried to be comprehensive with the talks but coverage of posters is no more than random.

Recent and Living nannoplankton

Studies of modern nannoplankton appear to be flourishing at the moment, in part at least due to the stimulation of flux studies, and there were a number of presentations describing large projects looking at the distribution of coccolithophorids in various combinations of surface-water, sediment-trap and surface-sediment samples. These included talks by Lluisa Cros (NW Mediterranean), Harald Andruleit (N Atlantic), Jacques Giraudeau (Benguela System), and Amos Winter & Ric Jordan (Puerto Rico - a relatively informal presentation, including views of Ric's new base in Yamagata at various seasons). In addition, Helge Thomsen gave a beautifully-illustrated description of the polar coccolithophorids, of special interest to palaeontologists who had never encountered these extraordinary, weakly-calcified forms. Mario Cachão described the enigmatic distribution of *Coccolithus pelagicus* off Portugal, demonstrating once again that temperature alone cannot explain its biogeography, and suggesting that it might be adapted to a particular combination of turbulence and nutrient-concentration.

Tertiary and Quaternary nannofossils

Presentations on Cenozoic nannofossils concentrated on palaeoceanography. Talks on the Pliocene were given by Alex Chepstow-Lusty on discoasters and by Su Xin and Koji Kameo on total assemblages but particularly reticulofenestrids. These are now well-established lines of research but the presentations showed that accumulation of knowledge on the detailed stratigraphic record and environmental preferences of the groups, combined with integration of other, high-resolution data, are allowing ever more useful understanding. One result of this is that the type of high-resolution biostratigraphy established in the Quaternary is being gradually extended into the Neogene. Further back, Wuchang Wei used the record of nannofossils in high-latitude sites to date the initiation of the North Atlantic Deep Water (NADW). Viviana Reale departed from the oceanographic theme, describing variation in nannofossil assemblages in relation to sequence stratigraphy in Early Eocene deposits from the Pyrenées. Posters included several more palaeoceanographic and biostratigraphic studies, and also some taxonomic work - a superb review of Palaeocene lineages by Eric de Kaenel, and a detailed study of the *Coccolithus miopelagicus* lineage by Alysa Peleo-Alampay.

The Cretaceous/Tertiary boundary

There were actually only two talks on the K/T boundary, but being in Denmark our sessions were taking place only a few metres above the boundary and it reappeared frequently in discussions. These very much started on the pre-conference fieldtrip - a pleasant day's excursion to Stevn's Klint and other classic localities led by Hans Jørgen Hansen from the DGU. Hans carefully introduced us to the complex stratigraphy across the boundary, with many new observations and persuasively-marshalled evidence to support his strongly-held opinions - he is not a member of the pro-meteorite camp! In particular, he explained that there was very strong evidence from the palynomorphs of great ecological fluctuations across the boundary but that these fluctuations commenced *before* the boundary. He also described how micro-spherule layers are actually formed by Prasinophyte algae, and presented evidence for volcanic activity and for the boundary-clay being diachronous.

A possibly similar story seems to be emerging from the calcisphere record, as presented by Helmut Willems & Ulrike Kienel (poster). They showed that, in addition to the well-known "*Thoracosphaera*" bloom, there is a complex ecological signal from calcispheres, including significant extinctions, but that the ecological excursions appear to start before the boundary, whilst the main extinctions post-date it.

Jim Pospichal presented his latest work on nannofossils across the K/T boundary, from Mexican sections near the putative Chicxulub impact site. He also described the extraordinarily passionate, and occasionally dogmatic, nature of the K/T controversy at present. Whilst carefully remaining neutral as to causes, he showed that his, extremely detailed, work still suggested a catastrophic and abrupt extinction.

Mesozoic nannofossils

As with the Tertiary, Mesozoic talks concentrated on the theme of palaeoceanography and palaeoecology, but covered a diverse range of topics. Yoram Eshet introduced a productivity index for Maastrichtian-Campanian nannofossils, and strongly argued that this type of index was a valuable way of synthesising palaeoecological data from the nannofossil record. He also introduced us to a novel technique for nannofossil preparations from organic-rich sediments (this article appears elsewhere in this issue). Andrea Fiorentino reviewed the biogeography of Tethyan Maastrichtian nannofossils. Jean Self-Trail traced the Late Cretaceous development of the proto-Gulf Stream, using in particular the distributions of *Nephrolithus* and *Quadrum* (*Uniplanarius*) which appear to be virtually confined to cold- and warm-water, respectively. Jorg Mutterlose described a detailed study of Early Cretaceous nannofossil palaeoceanography, comparing data from various time-scales. Bill Hay and Paul Bown both dealt with Early Cretaceous nannofossil provinciality and the question of whether the Austral and Boreal Realms had similar nannofloras; Bill Hay through a general overview with a stimulating discussion of palaeoceanography, and Paul Bown through a preliminary description of new studies of nannofloras from the Neuquen Basin in Argentina. By a happy coincidence, there were also posters presenting work by an Argentinian group on the Neuquen Basin, presented by Elena Mostajo. Marie-Christine Janin gave what was virtually the only Jurassic talk, describing fluctuations in Ellipsagelosphaeraceae assemblages in the Kimmeridgian in relation to other ecological indicators. This seemed to suggest that, as with the Tertiary reticulofenestrids, there is great potential for extracting information from the ellipsagelosphaerids.

Talks with a more biostratigraphic emphasis included Akmal Marzouk on the Egyptian Late Cretaceous and Early Tertiary, Francesca Lozar on dating and correlation of omission surfaces, and Fawzy Naji on the nannofossil record of a proposed Turonian/Coniacian stage-boundary stratotype section. Stage-boundary stratotype work for the entire Upper Cretaceous was also presented in a poster by Jackie Burnett (see article elsewhere in this issue).

Calcispheres

There were three talks and half a dozen posters dealing with calcispheres, which is probably some kind of record for any meeting, at least outside Germany. The presentations included a more or less continuous coverage from the living to the Early Cretaceous, and a similar breadth of topics reflecting the development of study of this group, from the initial descriptive phase toward ecological, biogeographic and stratigraphic applications. The wide diversity of the group, which nannofossil workers are still prone to lump together as *Thoracosphaera* spp., is particularly shown by the range of wall structures now known, as described in detail by Dorothea Janofske, and also illustrated in a number of other presentations.

New techniques and problems

A number of interesting and diverse presentations can be included in this category. On the computing front, Woody Wise and Jim Pospichal demonstrated "Nanno Notes" the Cenozoic nannofossil taxonomic database system they are developing for the Ocean Drilling Program. This is now at beta-testing, and it is hoped that it will be available to the general community of nanno workers in 1996. It includes illustrations and descriptions of >600 taxa, with rapid access to the data via an icon-based taxonomic key.

Jeremy Young described and demonstrated an image-analysis-based biometric system, developed to allow rapid measurement of size and shape variation in *Emiliania huxleyi*, using light microscopy.

Katharina von Salis gave an intriguing overview of collaborations of calcareous nannofossil workers with art historians and archaeologists. Although little has been published on this type of detective work, in the discussion afterwards many examples were described and it seemed that there was a real potential for more work of this kind, if the possibilities of nannofossils were better known outside the geological community.

Bob Young described the use of nannofossil biostratigraphy in biosteeering horizontal wells in the North Sea. For this kind of work, it is essential to keep the well within a very narrow lithological horizon. Nannofossils are ideal, firstly since they can provide very fine resolution, with the aid of slightly unconventional events, and secondly because results can be produced very fast. Liam Gallagher, who had just finished a stint offshore analysing 10-15 samples per hour for 12-hour shifts, was able to directly confirm this.

Dave Jutson followed this with a rather more sobering North Sea experience - "the case of the missing nannofossil". He explained how North Sea nannofossil assemblages often deteriorate with alarming rapidity: preparations made immediately on recovery of drilling-mud may be far richer than those prepared only a matter of hours later. He suggested that similar sample deterioration may seriously compromise assemblage analysis in many other contexts. This provoked some heated discussion, with strong arguments that it is not a universal problem (the culprit is liable to be a drilling-mud additive) but a clear implication is that nannofossil workers need to be much more aware of sample degradation as a factor in nannoplankton preservation.

Jeremy Young

COPENHAGEN CONFERENCE WORKSHOPS

Living

Ric Jordan will report on this workshop in the next issue.

Cretaceous

I've always been a little envious of the other conference workshops - they seem to have more of a cohesive approach to their get-togethers than the Cretaceous group. With this in mind, I tried to sort out a loose itinerary for the Cretaceous Workshop, particularly since I had a desire to air the subject of the Cretaceous Stage Boundaries Symposium, which was about to happen in Brussels the following week, and since a couple of colleagues had expressed a wish, well in advance of the conference, to show some microscope slides at the workshop. This, by the way, is an extremely useful form of communication which we don't make enough use of, and one which I hope we might exploit at the next conference, in light of some of the changes described by Shirley in her ICBN pieces in this issue; particularly, I'm thinking of the new rule allowing us to designate new types for old, line-drawn taxa. Wouldn't it be great to know that what you're calling *Staurolithites/ Chiastozygus/Zeugrhabdotus* species-whatever is the same as everyone else's? I know I'm getting well ahead of myself here, but if you think it'd be a good idea for us to maybe produce a joint work reillustrating and redescribing all of those annoying taxa, please get in touch with me and start collecting together your slides and photos (I'm assuming here that everyone's happy for me to act as coordinator for the next workshop, which I'm willing to do unless someone else has an urgent desire to do it - let me know your thoughts on this, too).

During the workshop, the subject of standardisation of species abundance was brought up. I felt that there might be some benefit to be gained from at least having standard estimated abundances (*e.g.* Abundant = >10 specimens per field of view; Common = 1-10 specimens per field of view; Few = 1 specimen per 2-10 fields of view; Rare = 1-2 specimens per traverse), simply because, at present, different workers' abundance rankings are at such variance, and in the past, if not so much now, certain workers have failed to include their abundance categories in their publications.This effectively makes their work impossible to evaluate. It was generally remarked that this idea was unworkable, although I am still of the opinion that it would be better if workers at least used abundance categories they've seen published elsewhere (I took mine from an ODP volume), rather than make up their own every time they plot a range-chart.

Another point raised was that of publishing complete range-charts. It has long been a gripe of mine, since I've been working on stage-boundary sequences around the globe, that the publication of comprehensive range-charts is still not universally viewed as entirely necessary, either by some workers or, more annoyingly, by certain journal editors. I consider it vital that we disseminate such data - how else will Cretaceous research progress and, again, how else is anyone supposed to evaluate or utilise your work? With this in mind, I'm wondering if it might be useful to dedicate a part of the *Journal* to publishing range-chart data that perhaps is too large to be published in full elsewhere. Let me know what you think. Would *you* use such a facility? I know I would, but I guess it wouldn't look right for the Editor to be the only one to do so!

The workshop attendees, most vociferously Katharina who has been involved in the subject for many years, then launched into a discussion of nannofossils and Cretaceous stage boundaries. Whilst involved in this, I forgot to take any notes, and can't remember any details! However, this isn't a problem, since the report on the Brussels conference appears below.

After the discussion had worn itself out, Yoram Eshet and Lilian Švábenická got out their slides, and everyone mingled to look at various workers' photomicrographs. I still think Cretaceous nannofossils are the prettiest!

Jackie Burnett

Jurassic Nannofossil Working Group

The Jurassic Working Group met briefly over lunch to discuss recent developments in Jurassic nannofossil research. Discussion mainly focused around the biozonation chart, Figure 1 (next page), which had been collated by myself for inclusion in a synthesis of recent Jurassic nannofossil research, presented at the 4th *International Congress On Jurassic Stratigraphy and Geology* meeting in Mendoza, Argentina, October 1994. The data presented in the paper (Bown, in press) and chart includes new and old data provided by members of the working group. The chart is based around the zonation of Bown *et al.* (1988), correlated with the boreal ammonite zonation. A number of secondary bioevents are included on the chart, and the uppermost Jurassic zones have been modified, based upon new data from the Kimmeridgian-Volgian Gorodische section in Russia - these modifications will be formally introduced in Bown and Cooper (in prep.). Also included, and tentatively correlated, are the tethyan zonation of Bralower *et al.* (1989), bioevents from the thesis research of Jim Bergen (in press, and hopefully out soon!!), and a brief synthesis of Italian nannofossil data provided by Emanuela Mattioli and others.

Paul Bown

REFERENCES

Bergen, J.A. In press.

Bown, P.R. In press. Recent advances in Jurassic calcareous nannofossil research. *Proceedings of the 4th International Congress On Jurassic Stratigraphy and Geology.*

Bown, P.R. & Cooper, M.K.E. In prep. Jurassic. *A New Stratigraphical Index of Calcareous Nannofossils.* British Micropalaeontology Society Series/Chapman & Hall, London.

Bown, P.R., Cooper, M.K.E. & Lord, A.R. 1988. A Calcareous Nannofossil Biozonation Scheme for the early to mid Mesozoic. *Newsletters on Stratigraphy,* **20**(2): 91-114.

Bralower, T.J., Monechi, S. & Thierstein, H.R. 1989. Calcareous nannofossil zonation of the Jurassic-Cretaceous boundary interval and correlation with the geomagnetic polarity timescale. *Marine Micropaleontology,* **14**: 153-235.

COPENHAGEN CONFERENCE PROCEEDINGS VOLUME

Author contribution guidelines for the conference volume are still unavailable. Dave Jutson was hoping to produce the proceedings as a special issue of the DGU journal but has experienced problems associated with the relaunch of a joint journal for the Danish and Greenland Geological Surveys, which merged last summer, just proior to the conference. We will keep you informed!

Jackie Burnett

A 'THANK YOU'

I wish to say a big 'thank you' to all the colleagues, both old and new ones, for having signed on the greeting card, which I received a couple of days ago (courtesy Shirley!). It really made me very happy. My best wishes and greetings to [the] nanno-family.

Syed A. Jafar, Birbal Sahni Institute of Palaeobotany, Lucknow, India

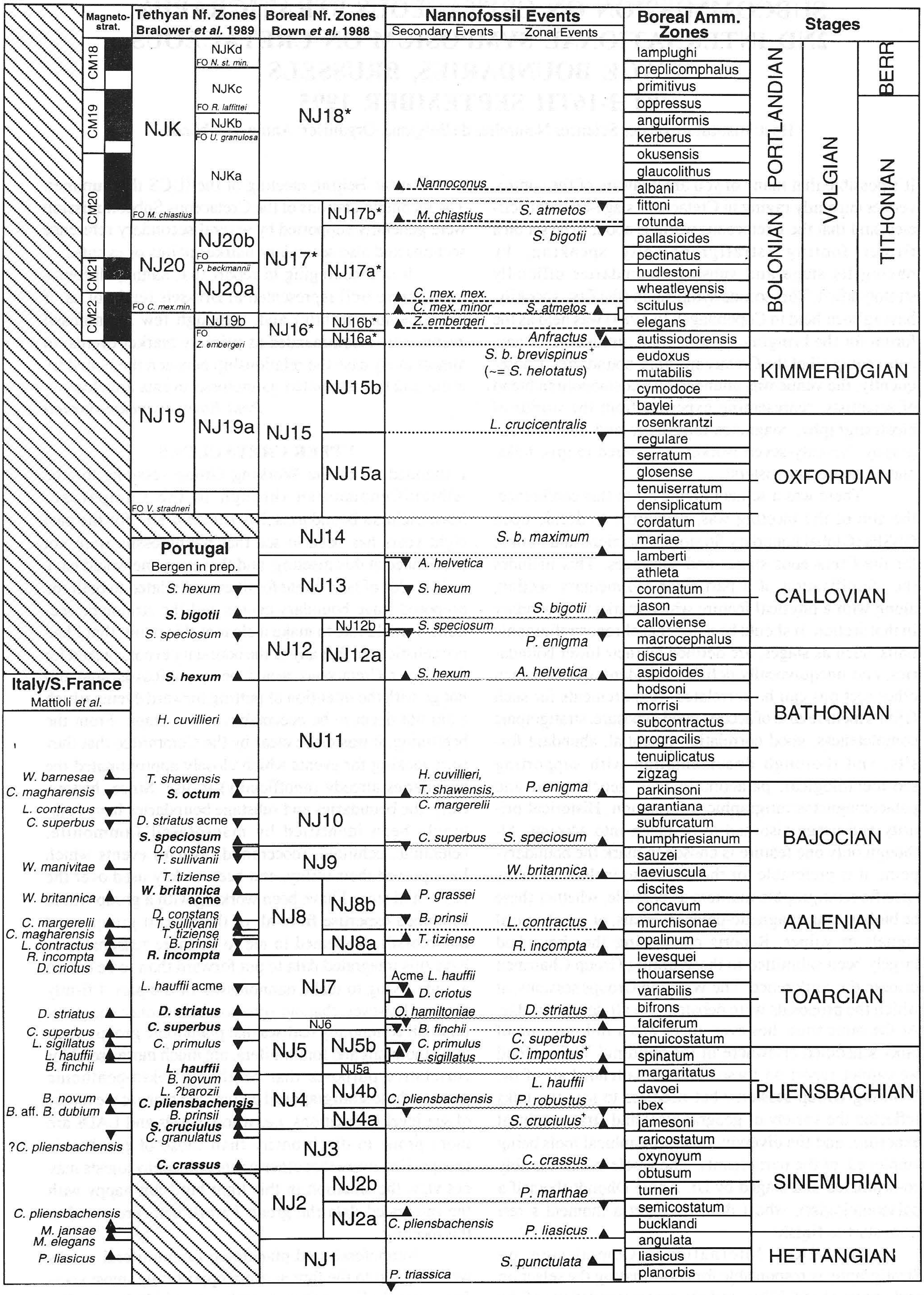


Figure 1: A biostratigraphic framework for the Jurassic based on calcareous nannofossils. * denotes modified zones (Bown & Cooper, in prep.), + denotes modified taxonomic nomenclature, dashed event line represent Tethyan taxa.

SUBCOMMISSION ON CRETACEOUS STRATIGRAPHY 2ND INTERNATIONAL SYMPOSIUM ON CRETACEOUS STAGE BOUNDARIES, BRUSSELS 8TH-16TH SEPTEMBER 1995

Host: Institut Royal des Sciences Naturelles de Belgique. Organiser: Annie V. Dhondt

It's possible that many of you are unaware of the controversies currently raging in Cretaceous stage-boundary circles, and that the Cretaceous world is about to be set on a firmer footing, stratigraphically speaking, by having its stage and substage boundaries officially stratotypified. This second symposium (the first, spookily, having been held in Copenhagen in 1983) was held as the forum for the bringing together, and discussion, of data concerning all of the Cretaceous stage boundaries. Consequently, the venue was attended by a cosmopolitan blend of scientists, representing expertise from the worlds of biostratigraphy, magnetostratigraphy and chemostratigraphy. Seventy-seven workers registered to give talks, and 75 to present posters!

There was a schizophrenic air to this conference: the aim of the meeting was, primarily, to decide upon GSSPs (Global boundary Stratotype Sections and Points) for the Cretaceous stages and substages. This includes the identification of a particular sedimentary section, along with a physical feature which marks the boundary in that section. It should be noted that chronostratigraphic units, such as stages, are defined by their lower boundaries, and unequivocally define a standard against which other sections can be correlated. Requirements for such GSSPs include ease of access, good exposure, stratigraphic completeness, good correlation potential, abundant fossils, and thorough documentation with supporting sedimentological, palaeontological, geochemical and palaeomagnetostratigraphic information. Historical priority and usage also had to be taken into account. Although only one feature is chosen to mark the boundary-point, it is preferable for the section to include as many specific stratigraphic markers as possible, whether these be biohorizons, magnetic-polar reversals, or geochemical signals or values. Reports comprising the above had largely been submitted to the Working Group Chairmen prior to the conference. The Working Groups sessions, at which the proposals were debated, ran all day, every day. At the same time, however, there was a full program of talks scheduled elsewhere in the building! We're afraid we cannot report on these, since we attended all of the Working Group sessions, but needless to say, the talks reflected the variety of geographical and stratigraphical expertise, and the diversity of stratigraphical tools being employed, of the participants. The whole event was ably co-ordinated and staged by Dr. Annie Dhondt (herself a palaeontologist), who I didn't see get a moment's rest from start to finish!

The IUGS International Commission on Stratigraphy is responsible for coordinating the selection and approval of GSSPs, and the recommendations of the Cretaceous Subcommission will go forward to this committee at the Beijing meeting of the IUGS this summer. The recommendations of the Cretaceous Subcommission were generally supported by several secondary reference sections and also secondary marker points or events.

It is encouraging to report that nannopalaeontologists were well represented at Brussels (eight of us, if we remember rightly) and, although few nannofossil events were recommended as primary marker events, in almost every case the relationship between the boundary event and the associated nannofossil events are clear.

Paul Bown & Jackie Burnett

UPPER CRETACEOUS

I attended all of the Working Group sessions for the Albian/Cenomanian through to the Campanian/Maastrichtian boundaries. My *raison d'être* for the past eight years has been to see that nannofossils were not overlooked at this meeting, and that everyone would have a clear idea of how nannofossil events related to both the proposed stage boundary events and the stratotype sections. I would like to make it clear at this point, that I had no realistic idea that any of the boundary events picked for the Upper Cretaceous would be nannofossils, and did not go with the intention of putting forward events which I did not deem to be acceptable at this stage. From the beginning, it was made clear by the Committee that they were looking for events which closely approximated the boundaries already (unofficially) in use. Since, historically, the boundaries and substage boundaries have commonly been identified by macrofossil (ammonite, belemnite, echinoid, inoceramid bivalve) events which have proved their utility, and been widely used over the years, and since I have been working with a group which combined expertise from all of these fossil groups, and microfossils, it seemed to me to be more reasonable to have this integrated data to put forward than to be out on a limb, trying to make nannofossils fit the part. I firmly believe, however, that our time will come, once the general fossil community realises that planktonic groups, such as nannofossils and foraminifera, are much more useful for correlative purposes that benthonic/nekto-benthonic groups whose stratigraphical datums are more at the mercy of sea-level fluctuations, *i.e.* whose FADs and LADs are more prone to diachroneity than those of planktonic groups. I'm aware that other nannopalaeonto-logists may not view the situation in this light but I am happy with the integrated data the group I work with presented at this meeting.

Nannofossil and planktonic foraminiferal events were brought to the fore at every opportunity, most vociferously in the Upper Cretaceous by myself, Katharina, Jim Bergen, Sylvia Gardin, and Isabella Premoli-Silva (who, I must say, it was a pleasure to meet at last!). The Upper Cretaceous Working Groups, although each having a designated Chairman, benefitted greatly from having Jim Kennedy in attendance, who at every opportunity (not being one to hide his considerable expertise concerning Upper Cretaceous stratigraphy under a bushel!) summarised each stage and substage boundary - both the potential stratotypes and events (obviously largely based on our groups' research but not exclusively so). His summaries were most useful because he did his home-work before arriving, and had data at his finger-tips, but also because he is an enlightened macropalaeontologist who is fully aware of the potential and utility of nannofossils in stratigraphy (it has taken years to train him, however!). His attitude, which was transmitted to the 'audience', was completely at variance to one particular Chairman, who shall remain nameless, but who obviously has no interest in nannofossils or planktonic foraminifera...

This was the most exhausting meeting I've ever attended. This is not a criticism, however: the Working Group sessions made full use of their scheduled times and more; every single point was debated; tempers were, at times, lost and soothed! At the end of each session, we took a vote (not the final vote - this was to have been carried out by post, to include all those members of the Working Groups who were unable to attend the conference), to determine the event and section we were most happy with, based on the preceeding discussions. As far as I can remember, there were no hung votes, and it seems likely that the recommendations of each Working Group will be carried. These recommendations will, hopefully, be approved in Beijing in August. And then, after publication of the relevent data, we will have precise boundaries (set in stone!) for us to work from and correlate with.

The details of the proposals put forward at the Upper Cretaceous Working Group sessions appear in conjunction with the work I presented at both the Copenhagen and Brussels Conferences, elsewhere in this issue.

Jackie Burnett

LOWER CRETACEOUS

The recommended GSSPs for the Lower Cretaceous are as follows:

Berriasian Stage

Chairman: Victor A. Zakharov, Institute of Geology, Siberian Branch of the Russian Academy of Sciences, University Avenue 3, 630090, Novosibirsk 90, Russia
Section: no decision. Suggestions included:
La Faure, Ravin de Deysniece, Alps de Provence, France
Section Z, Rio Argos, Caravaca, Murcia, Spain
Puerto Escano, Provincia de Cordoba, Spain
Point: no decision. Suggestions included:
base subalpina Ammonite Subzone, occitanica Ammonite Zone
base jacobi Ammonite Zone
Comments: not surprisingly, no firm decisions were reached on either the section or marker for this boundary stratotype. This boundary is certainly one of the most difficult to correlate on an inter-regional scale, with virtually no possibility of correlating boreal and tethyan sections. Further documentation was requested and a final decision has been delayed.

Valanginian Stage

Chairman: Luc Bulot, Institut Dolomieu, Université Fournier, F-38031 Grenoble Cedex, France
Section: probably Montbrun les Bain, France
Point: probably base Kilianella pertransiens Ammonite Zone, or FO *C. darderi* (calpionellid)

Hauterivian Stage

Chairman: Jörg Mutterlose, Intitut für Geologie, Ruhr Universität Bochum, Universitätsstraße 150, D-44801 Bochum, Germany
Section: La Charce
Point: FO *Acanthodiscus radiatus* (ammonite), *i.e.* base A. radiatus Ammonite Zone

Hauterivian Substage (Lower/Upper boundary)

Section: ?La Charce
Point: LAD *Cruciellipsis cuvillieri* (nannofossil)

Barremian Stage

Chairman: Pete F. Rawson, Dept. of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, UK
Section: Rio Argos, Caravaca, Murcia, Spain
Point: FO *Spitidiscus hugii* (ammonite), *i.e.* base S. hugii Ammonite Zone

Barremian Substage (Lower/Upper boundary)

Section: ?Section X.KV, Caravaca, Murcia, Spain
Point: FO *Ancyloceras vandenheckei*, *i.e.* base vandenheckei Ammonite Zone

Aptian Stage

Chairman: Elisabetta Erba, Dip. di Scienze della Terra, Universitá di Milano, via Mangiagalli 34, I-20133 Milano, Italy
Section: Gorgo a Cerbara, Umbria-Marche Basin, central Italy
Point: base M0 magnetic chron

Albian Stage

Chairman: Malcolm B. Hart, Dept. of Geological Sciences, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK
Section: ?Vocontian Trough
Point: ?FAD *Prediscosphaera columnata* (nannofossil)

Albian Substage (Lower/Middle boundary)

Section: ?Les Côtes Noires de Moeslain, St. Dizier, NE Reims, France
Point: ?FO *Lyelliceras lyelli* (ammonite)

Albian Substage (Middle/Upper boundary)

Section: ?Vocontian Trough or Texas
Point: FO *Diploceras cristatum* (ammonite) (=FO *Inoceramus sulcatus* (inoceramid))

THE ICBN: THINGS YOU NEED TO KNOW - 13

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

As discussed in the review elsewhere in this journal, a new issue of the Botanical Code has appeared, and it is significantly different from the previous Code. It would be too lengthy to list all of the changes and new numbers. Minor changes, such as in the references to other articles, are of course a logical consequence of the change in so many article numbers, and will not be mentioned either, but I would like to discuss the changes in articles covered previously in this column, in order to keep track of the route we were following. Therefore, on a chapter-by-chapter basis:

Preamble: One item was added, on cultivated plants.

Division I
Principles: No changes.

Division II
Chapter I: Ranks of taxa. Not much has changed, except that now the term 'phylum' is acceptable as a synonym for 'division'. Art.4 has been renumbered.

Chapter II: Names of taxa. Those of you who have followed this column may remember the rather convoluted route I took in discussing the typification of taxa (van Heck, 1994a, b), in an attempt to group the rules dealing with types in a more logical sequence. It appears that the botanical committee also recognised the illogical sequence of those rules in the 1988 Code, for they have changed the sequence of rules in section 2, on typification, completely. Virtually all of the rules in this section now have a different number, some have been omitted, some merged, and some new rules and recommendations have been added.

As mentioned in the review, one interesting new article is the following:

9.7. *An epitype is a specimen or illustration selected to serve as an interpretive type when the holotype, lectotype or previously designated neotype, or all original material associated with a validly published name, is demonstrably ambiguous and cannot be critically identified for purposes of the precise application of the name of a taxon. When an epitype is designated, the holotype, lectotype or neotype that the epitype supports must be explicitly cited.*

This article, therefore, offers the possibility to select a type for some of those species names which are based on simple drawings which do not offer enough detail, *e.g.* some of the species of Arkhangelskij and Górka.

The new code still offers no clarity on the acceptability of an illustration to serve as a type instead of a specimen: see discussion in issue 10 of this column (van Heck, 1994a) under the then Art.9.3 (now Art.8.3). One new recommendation creates some confusion in my mind:

8A.1. *When a holotype...is an illustration (see Art.8.3), the specimen or specimens upon which that illustration is based should be used to help determine the application of the name.*

Since Art.8.3 states that an illustration may be used (for non-fossil plants) if it is impossible to preserve a specimen as the type, and the recommendation specifically refers to that article, it is not quite clear to me how specimens that no longer exist can help to determine the application of a name. After all, only the original author would have access to the specimens and he would have no problems with the application of a name he created himself. This issue is clearly not yet resolved.

Section 3 deals with priority and consists of Art.11 and Art.12. Art.11 has been extended to include several articles of the previous Chapter V. In section 4, on the limitations of the principles of priority, the main changes occur in Art.14 and Art.15, which deal with conservation and sanctioning, and do not much concern us. The only relevant change is that conservation is now made easier.

Chapter III: Nomenclature of taxa according to their rank. This chapter comprises articles 16 to 28. No significant changes occur, except that some rules have been added and, consequently, some renumbering has taken place. In Art.23, which deals with the names of species, I found the new phrasing of some rules ambiguous (as in Art.23.6), but a new rule helps:

Art.23.8. *Where the status of a designation of a species is uncertain under Art.23.6, established custom is to be followed (Pre.10).*

Chapter IV: Effective and valid publication. Section 1, on effective publication, has been completely renumbered, but otherwise not changed. Some very substantial changes, however, occur in the section on validity. Several new rules have been added to Art.32, some of which affect us. The following has been added to Art.32.1:

32.1....*In addition, subject to the approval of the XVI International Botanical Congress, names (autonyms excepted) published on or after 1 January 2000 must be registered.*

32.2. *Registration is effected by sending the printed matter that includes the protologue(s),with the name(s) to be registered clearly identified, to any registering office designated by the International Association for Plant Taxonomy.*

This new idea, although not approved yet, is going to trigger a lot of discussion. If we, as nannoplankton specialists, want to have any input into the validity of nannoplankton names, we have to be well prepared with a functional database at the least.

Changes to articles 33 to 35 are limited to reshuffling of the numbers, but another new high-impact rule appears in Art.36:

36.3. *In order to be validly published, a name of a taxon of fossil plants published on or after 1 January 1996 must be accompanied by a Latin or English description or diagnosis or by a reference to a previously and effectively published Latin or English description or diagnosis.*

Latin is still required for recent plants, but at least from now on any other language is invalid. To be fair, most taxa of recent years have been published in English, but it is now compulsory. The INA hereby officially recommends English, rather than Latin.

No significant changes occur in the next few articles, but a rule has been added to Art.45:

45.2. *After 1 January 2000, when one or more of the other conditions for valid publication have not been met prior to registration, the name must be resubmitted for registration after these conditions have been met.*

Several new rules were added to Art.46, on citation, but I do not see any significant changes or deviations from common practise. The only change I can detect is that, whereas the previous Code stated (Art.46.2) that the word 'in' should be used when referring to a name by one author in the publication of another, the present Code recommends that only the author of the new name is quoted (Art.46.2, note 1).

No other significant changes occur in this chapter.

Chapter V: Rejection of names. This chapter used to be entitled, '*Retention, choice, and rejection of names and epithets*'. The change is a significant one, because originally the chapter comprised articles 51 to 72, and now contains only articles 51 to 58. Many of the original articles have been deleted, and others are included elsewhere in the Code. In what is left, not many changes occur, apart from the wording and numbers.

Chapter VI: Names of fungi with a pleomorphic life cycle. This chapter has only one article which, fortunately, does not concern us.

Chapter VII: Orthography of names and epithets and gender of generic names. After all of the deletions and changes in the previous chapters, the numbers have obviously been altered, but other than that I have been able to detect only one change, an addition:

60.10. *The use of an apostrophe in an epithet is treated as an error to be corrected by deletion of the apostrophe.*

The rest of the code contains procedures and appendices for special groups.

REFERENCES

Greuter, W. 1988. *International Code of Botanical Nomenclature (Berlin Code)*. Koeltz Scientific Books: 328 pp.
Greuter, W. *et al.* 1994. *International Code of Botanical Nomenclature (Tokyo Code)*. Koeltz Scientific Books: 389 pp.
Heck, S.E. van 1994a. The ICBN: things you need to know - 10. *Journal of Nannoplankton Research,* **16**(2): 55-58.
Heck, S.E. van 1994b. The ICBN: things you need to know - 11. *Journal of Nannoplankton Research,* **16**(3): 107-108.

NEW BOOKS

PROCEEDINGS OF THE 5 TH INTERNATIONAL NANNOPLANKTON ASSOCIATION CONFERENCE, SALAMANCA 1991

The Proceedings of the 5th INA Conference held in Salamanca in 1991 have already been printed. The volume will be sent free of charge to all Salamanca conference participants. However, about 100 issues are still available to all specialists interested in nannoplankton biostratigraphy, paleoecology, biogeography ....etc, that were not able to attend the conference. In this case, the volume price is 30 US dollars (3. 500 Spanish Pesettas), including the mailing costs. Please, send your orders to:

dr. José-Abel Flores
Departamento de Geologia
Universidad de Salamanca
Spain
fax: 34 - 23 - 294514
Email: flores@rs6000.usal.es

RESULTS OF THE SURVEY ON MOUNTING MEDIA

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

A fair number of reactions were received, concerning the different mounting media used in nannofossil slide preparation, in response to my request for information (*JNR*, **16**(3)). There is a wide range of products, and I have the impression that this survey includes most of them. As most of us know, there are basically two types of medium: those affixed by applying heat, and those by applying UV light (although only one example of the latter was reported). The various opinions on each product appear in the remarks: remarks from different individuals have only been slightly edited, and are prefixed by an asterisk.

(*Editor's note: xylene and toluene are carcinogens. The products containing these solvents should be used in a fume-cupboard.*)

Product name: Norland Optical Adhesive 61
Brand name: Norland Optical Adhesive
Supplier: Norland Products Inc., 695 Joyce Kilmer Avenue, New Brunswick, N.J. 08902, USA; Tech Optics, Unit 6 Cala Industrial Estate, Tannery Road, Tonbridge, Kent TN9 1RF, UK.
How to apply it: 2/3 drops applied to slide or coverslip, mount coverslip, expose slide to UV light (around 30 minutes).
Known durability: >10 years
Refractive index: 1.56
Remarks: *does not keep very long in its bottle, even with refrigeration, so you have to be prepared to order it every 6-12 months; *UV light for curing is not present at all remote sites (*sunlight is only unavailable at the North and South Poles during winter! - Ed.*), while hot-plates for curing other media can be found at almost any location; *we tried [Norland] a few years ago but we were not pleased with the way [the nannofossils] seemed to have a milky glow in phase. This gave me a headache after a few hours; *one of our contractors used [Norland] but I asked them to discontinue this because it caused milky haloes around the coccoliths, and appeared to have shrunk, pulling coccoliths apart (*it's possible these effects are caused by additives in the drilling-mud - Ed.*); *having used Canada balsam, a petroleum jelly recipe, Petropoxy and Lakeside 70 previously, we have found Norland to be the cleanest (droplets from the bottle do not need to touch anything but the slide, there is no excess to clean off), easiest (does not need to be mixed and can be cured in sunlight in the absence of a UV lamp; slides do not require sealing) and safest (no toxic fumes, no heat) medium to use. We have experienced no effects on the nannofloras mounted with it, for a range of sediment types and ages, including industrial samples.

Product name: Canada balsam
Supplier: Sigma Chemical Co., PO Box 14508, St. Louis MO, USA; Aristoforma-Interchemica, Kruisweg 405-411, 1437 CJ Rozenburgh, The Netherlands; Serva Feinbiochemica, Heidelberg/NewYork.
How to apply it: 1 drop on glass slide or coverslip (*N.B.* do not apply medium directly onto smear), heat to 70-80°C to let the solvent evaporate (test by scooping a little with a needle and letting it cool: if it becomes brittle all solvent has evaporated), apply coverslip. Excess Canada balsam can be removed, and the edges of the coverslip sealed with nail-polish. Alternatively, a cellulose acetate filter (millipore HAWP-filter) containing the plankton can be transferred onto the medium *upside down*. When the filter is soaked, the ensemble can be mounted on a slide with another (heated) drop of Canada balsam.
Known durability: >25 years
Refractive index: 1.52-1.54
Remarks: *we had some problems with coccoliths dissolving (on the slide) in the past, when we used the rapid, high-heat method. When we realised that fluid Canada balsam has a pH of 4, we switched to the slower, low-heat method to make sure all solvent had evaporated and the pH was neutral; *Canada balsam is in fluid form (*not necessarily - Ed.*), stored in a bottle. Use fume-cupboard when applying; *we ceased to use Canada balsam about 10 years ago for two reasons: (a) it became too expensive, compared to other media, and (b) the solvent was (is?) xylene, a carcinogen.

Product name: Synthetic Canada balsam
Brand name: Rhenohistol (no longer distributed)
Supplier: E. Merck, Darmstadt, Germany.
How to apply it: liquid medium, best results when cured rapidly with high heat; coverslip must be lightly tapped during heating to break seal on the edges of the coverslip to allow for out-gassing in order to obtain proper cure.
Known durability: >18 years, when properly cured
Refractive index: 1.52

Product name: Synthetic Canada balsam
Brand name: Caedax (no longer distributed)
Supplier: E. Merck, Darmstadt, Germany.
How to apply it: best results when cured rapidly with high heat.
Known durability: >28 years, when properly cured
Refractive index: 1.56
Remarks: *this liquid medium is still my first choice to ensure excellent slide preparations but supplies are very low. Its use is comparable to that of your grandmother's good china: "you bring it out only for special occasions"; *I first used Caedax, which was smelly but great otherwise. Those slides are still O.K. after 20 years, but it was taken off the market. Then I used Petropoxy, and all my slides that didn't have abundant calcite in them began to dissolve (*N.B. Petropoxy 154 should not be used as a mounting-medium under any circumstances, since many people discovered that it dissolves nannofossils on the slide! -Ed.*). I then switched to Norland Optical.

Product name: Thermoplastic resin
Brand name: Lakeside 70
Supplier: Production Techniques Limited, 13 Kings Road, Hampshire, UK; Production Techniques Limited, RFD5, Concord Ridge, New Town, CT-06470, USA; more practically, ask any friendly thin-section technician for a trial sample.
How to apply it: heat slide or coverslip to >70°C, and apply like lipstick.
Known durability: >10 years
Refractive index: similar to Canada balsam
Remarks: *solid, fume cupboard not needed. Soluble in white spirit (paintbrush cleaning-fluid). I apply Lakeside 70 to the coverslip then put it on the prepared slide; *my (admittedly small) experience of Lakeside is that it is messy to use (it takes a lot of practise to get the right amount on the coverslip and be able to get the coverslip of the stick before it cures!), easy to get contaminated (it comes in stick form, with no covering), and you have to be quick to get the bubbles out before it sets solid (it sets as soon as you take it off the hotplate).

Product name: Piccolite 60% in Xylene
Supplier: Ward's.
How to apply it: heat slide with smear on it to 350F (180°C). Apply 1 drop to coverslip, place on slide, 'cook' slide for about 10 minutes; most of the small bubbles will march to the edge of the slide while it is cooking, the rest will disappear when the slide cools (*N.B.* the bubbles remain in Piccolite in Toluene).

Known durability: >10 years
Refractive index: 1.52
Remarks: *we tried the UV-setting medium a few years ago but we were not pleased with the way [the nannofossils] seemed to have a milky glow in phase. We tested all the brands of mounting media we could find on the market and liked this one best.

Product name: Elvacite acrylic resin
How to apply it: attach nannofossils to coverslip with polyvinyl alcohol (solid). Make 1-5% water solution. Glue coverslip to slide with Elvacite acrylic acid. This is a solid and has to be dissolved in xylene: 32g resin to 60ml xylene.

Product name: Rapid mounting medium for microscopy
Brand name: Entellan Neu
Supplier: E. Merck, D-61 Darmstadt, Germany.
How to apply it: by heating.
Remarks: *personally, I prefer this medium to Canada balsam as I find it easier to handle: it is less viscous and emits less odour when heated, ...[and] its [curing] time is faster. Any excess amount that has dried up on the slide can easily be scraped off with a blade or paper cutter. There is no more need of acetone in cleaning the prepared slide, unlike when Canada balsam is used.

Many thanks to all contributors: Jackie Burnett, Laurel Bybell, Richard Constans, Helen Gillespie, Martin Jakubowski, Marietta De Leon, Musa bin Musbah, Mike Styzen, Paul van der Wal, and Jeremy Young.

OBTAINING RICH NANNOFOSSIL ASSEMBLAGES FROM 'BARREN' SAMPLES: PROCESSING ORGANIC- RICH ROCKS IN NANNOFOSSIL INVESTIGATIONS

Yoram Eshet, Geological Survey of Israel, 30 Malkhe Yisrael Street, Jerusalem 95501, Israel

Abstract: Campanian-Maastrichtian carbonate and marl successions in Israel are rich in organic matter (OM) of marine algal origin. Samples from these sections, which were originally processed for nannofossil study by standard techniques, were found to be almost completely devoid of nannofossils. However, removal of the OM by approximately 10 hours of controlled bleaching with sodium hypochlorite (household bleach) yielded extremely rich and diverse nannofossil assemblages. It is suggested that, by selectively bleaching the OM, calcareous nannofossils which were incorporated within the intricate organic debris were released. The fact that, after bleaching, both abundance and species diversity were clearly increased, and the preservation of the nannofossils had not changed significantly, suggests that the bleaching agent did not 'attack' the nannofloras and did not produce a biased assemblage. The proposed preparation method enables rich and diverse calcareous nannofossil assemblages to be recovered from samples which would have provided poor, or even barren, assemblages with the deployment of standard processing techniques.

Introduction

One of the commonly-employed procedures for preparing slides for calcareous nannofossil study involves crushing the rock into a powder, suspending the powder in distilled water, allowing the heavier fraction to sink, and preparing a slide from the remaining suspension (Moshkovitz & Erlich, 1976). For the study of Campanian-Maastrichtian nannofossils in organic-rich carbonates of ocean-phytoplanktonic origin (Bein *et al.*, 1990; Eshet *et al.*, 1994), this processing technique proved to be inadequate: since most calcareous nannofossils were encased within the dominant OM debris, few nannofossils were seen under the light-microscope, even after concentrating them, using the suspension method described above. Some of the samples were even considered to be barren. Herein, a new preparation method is described, which enables rich and diverse calcareous nannofossil slides to be obtained from organic-rich material.

Materials

Fifty-three organic-rich, Campanian-Maastrichtian core-samples from the M-8 core-hole (southern Israel) were processed and analysed in this study. The section belongs to the Campanian-Maastrichtian 'En Zetim Formation. It comprises bituminous marls and chalks, with phosphatic horizons in the lower part (Figure 1). Organic content is high, reaching upto 25% TOM, with an average of 10% TOM (Figure 1, Table 1). In order to examine and demonstrate the effect of the proposed preparation method on the recovered nannofossil assemblages, ten samples were analysed before and after processing (Table 1). The same samples were used previously in an experiment which tested the utility of bleaching in palynological sample-treatment (Eshet & Hoek, in prep.). Samples and slides are stored at the Geological Survey of Israel, Jerusalem.

SAMPLE		ABUNDANCE		SPECIES DIVERSITY		PRESERVATION	
NUMBER	TOM (%)	Before	After	Before	After	Before	After
1	16.5	10	39	18	25	65	71
13	17.0	9	35	11	26	59	54
15	11.0	13	41	12	30	76	75
25	18.8	6	37	8	22	58	64
33	11.5	12	33	9	20	61	60
34	8.5	15	48	12	25	71	70
37	6.7	13	50	10	16	45	48
38	3.8	16	51	11	18	51	49
46	2.0	10	49	13	23	60	62
47	2.0	15	54	14	20	49	53

Table 1: Results of ten hours of bleaching of selected samples. Abundance = number of nannofossils per visual field. Preservation = percentage of complete specimens in the assemblage. The increase in abundance and species diversity, and the small but inconsistent change in preservation, indicate the reliability of the bleaching technique.

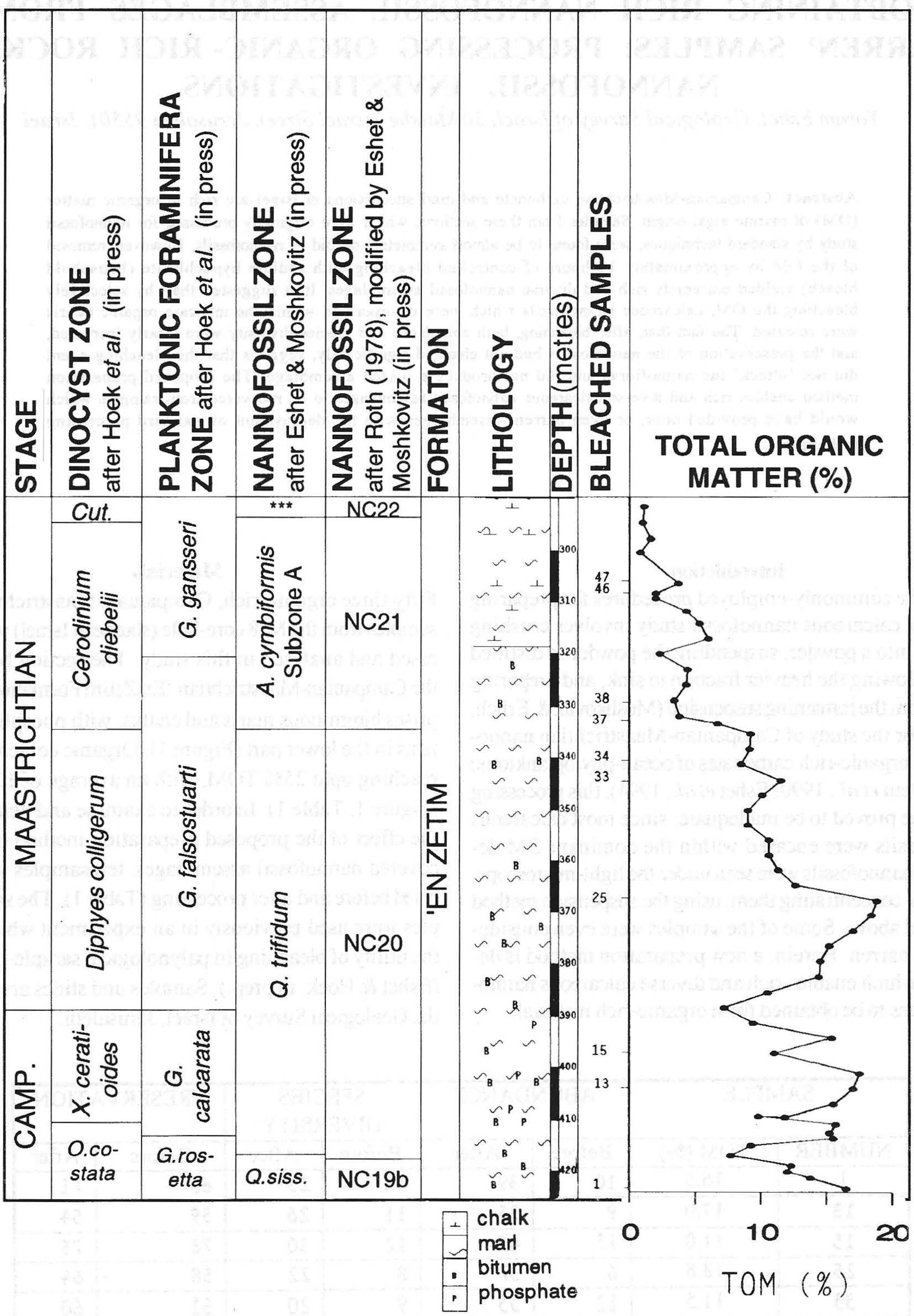


Figure 1: The M-8 sequence: litho- and biostratigraphy, and Total Organic Matter.

Sample processing

All organic-rich samples were treated according to the following procedure:

(1) 2g of rock were crushed to a powder, added to 50ml of distilled water, and stirred thoroughly.

(2) This supension was then subjected to ultrasonic treatment for 1 minute. The suspension was again stirred thoroughly, and allowed to stand for 1 minute so that some settling could take place. Moshkovitz & Ehrlich (1976) suggested that, after 1 minute, most of the settled fraction does not contain nannofossils, thus the suspended fraction was decanted into another beaker and the settled fraction was discarded. This suspension was allowed to stand for 10 minutes. Observation has shown that, after this period, most of the nannofossils have settled out of suspension, and the remaining supernatent liquid contains only very fine, mainly non-coccolithic particles (Eshet *et al.*, 1992).

(3) Bleaching: The amorphous nature of the organic residue, and the high organic-content of the samples, made

it impossible to observe nannofossils which were incorporated into the thick OM debris. Therefore, it was necessary to remove as much of the OM as possible, without affecting the nannofossils. For palaeontological preparations, oxidation of OM is usually performed using either 'Schulz Solution' (a solution of potassium chlorate ($KClO_3$ in nitric acid (HNO_3)) or hydrogen peroxide (H_2O_2). These methods have been described by Brown (1960), Faegri & Iversen (1964) and Doher (1980), among others. In the present study, the use of Schulz Solution produced a harsh chemical reaction which required the use of a fume-cupboard and other safety measures. In addition, in some samples, the nannofossils were either etched or destroyed by the reaction. H_2O_2, on the other hand, was completely ineffective, having no apparent effect on the OM, even after a 12-hour oxidation period. This was probably due to the high organic-content of the samples.

Thus, the suspension obtained in step (2) was mixed with 250ml of a 10% solution of sodium hypochlorite (NaClO). In this case, a commercial brand of household bleach called 'Economica' was used to oxidise the excess OM. Economica was used by Almogi-Labin *et al.* (1993) to remove excess OM in a foraminiferal study of similar Campanian-Maastrichtian sections in Israel. NaClO creates a basic chemical environment (A. Bein, pers. comm., 1995) and therefore does not dissolve calcite. It is thus safe to use for nannofossil preparation, and does not require a fume-cupboard or special safety measures.

For most samples, a period of 10 hours was sufficient to remove most of the OM, and to obtain a rich and diverse assemblage, with no apparent damage to the nannofossils (Table 1, Figure 2). For samples with a particularly high OM-content, a slightly longer oxidation period was required. In order to examine the effect of OM digestion by NaClO, and the process of liberation of nannofossils from the OM, a controlled experiment was conducted on ten samples of different OM-content (Table 1): 5g of each sample were soaked in NaClO for 10 hours. A comparison was then made between the pre- and post-oxidation assemblage, including the abundance (number of observed nannofossils per visual field, NVF), species diversity, and preservation (percentage of complete nannofossils in the assemblage). The results suggest the following: (a) ten hours are enough to oxidise most of the OM, and to expose calcareous nannofossils for microscopic study; (b) nannofossil assemblage 'richness' was increased dramatically: the average abundance increased from 11.9 to 43.7 NVF, and the observed average species diversity increased from 11.8 to 22.5 species per sample; (c) there was no significant change in preservation, thus the bleaching process did not destroy the nannofossils nor considerably alter the assemblage composition.

(4) Because NaClO tends to crystallise on the slide during slide-preparation, it must be removed: after bleaching, the suspension was transferred to a centrifuge-tube, and centrifuged at 2000rpm for 5 minutes. The supernatent liquid was decanted, distilled water added, and the suspension centrifuged a second time. The supernatent liquid was again decanted.

(5) The white, OM-free sediment was diluted with distilled water until the suspension became pale milky-white. One drop was mounted on a slide with Canada Balsam.

Calcareous nannofossil assemblages

The procedure utilised in the present study led to the recovery of well-preserved, rich and diverse assemblages of calcareous nannofossils from most of the samples (Plate 1). The most common fossils were: *Watznaueria barnesae*, *Micula decussata*, *Prediscosphaera* spp., *Thoracosphaera* spp., *Eiffellithus* spp., *Ahmuellerella* spp., *Cribrosphaerella ehrenbergii*, *Glaukolithus* spp., *Quadrum sissinghii*, *Q. trifidum*, *Tranolithus* spp., *Lithraphidites* spp., *Vagalapilla* spp., and *Vekshinella* spp.. A complete taxonomic list and a distribution chart for the M-8 sequence are given in Eshet & Moshkovitz (in press).

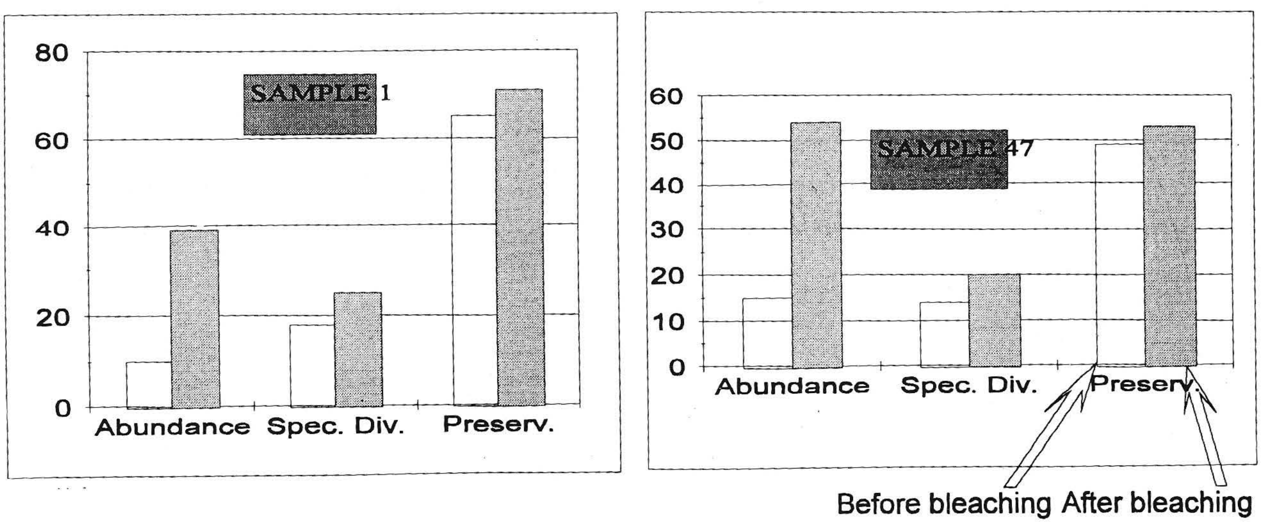


Figure 2: Bar graphs showing changes in abundance, species diversity and preservation after ten hours of bleaching. Note the drastic increase in abundance and species diversity, with no apparent decrease in preservation, suggesting that this method does not damage the nannofloras.

Summary

Bleaching the amorphous organic debris in organic-rich carbonates using NaClO has been found useful in obtaining nannofossil-rich slides. Other preparation techniques were found to be inadequate for processing this type of material. The proposed method is simple, rapid and inexpensive. A bleaching period of ten hours was found to be most effective, although a shorter period will probably be required for samples with a lower OM-content. Bleaching of the OM led to a considerable rise in observed abundance and species diversity, without affecting the preservation of the nannofossils.

Acknowledgements

I thank T. Minster (GSI) and Helena Thomassen (LPP, Utrecht) for assisting in sampling and selecting materials from the M-8 section. A. Almogi-Labin (GSI), A. Bein (GSI) and E. Sass (Hebrew University) are thanked for providing bleached samples from the Zin and Shefela sections, which were used as comparative materials in the present study.

REFERENCES

Almogi-Labin, A., Bein, A. & Sass, E. 1993. Late Cretaceous upwelling system along the southern Tethys margin (Israel): interrelationship between productivity, bottom water environments and organic matter preservation.*Palaeoceanography*, **8**: 671-690.

Bein, A., Almogi-Labin, A. & Saas, E. 1990. Sulphur sinks and organic carbon relationships in Cretaceous organic-rich carbonates: implications for evaluation of oxygen-poor depositional environments. *American Journal of Science*, **290**: 882-911.

Brown, C.A. 1960. *Palynological Techniques.* Louisiana State University Press: 188pp.

Doher, I. 1980. Palynomorph separation procedures currently used in the paleontology and stratigraphy laboratories. *U.S. Geological Survey, Circular* **830**: 29pp.

Eshet, Y., Almogi-Labin, A. & Bein, A. 1994. Dinoflagellate cysts, paleoproductivity and upwelling systems: a Late Cretaceous example from Israel. *Marine Micropaleontology*, **23**: 231-240.

Eshet, Y. & Hoek, R. In prep. Palynological processing of organic-rich rocks, or: How many times have you called a palyniferous sample 'barren'? (Submitted to *Review of Palaeobotany and Palynology.*)

Eshet, Y. & Moshkovitz, S. In press. New nannofossil biostratigraphy for Late Cretaceous organic-rich carbonates in Israel. *Micropaleontology.*

Eshet, Y., Moshkovitz, S., Habib, D., Benjamini, C. & Magaritz, M. 1992. Calcareous nannofossils and dinoflagellate stratigraphy across the Cretaceous/Tertiary boundary at Hor Hahar, Israel. *Marine Micropaleontology*, **18**: 199-228.

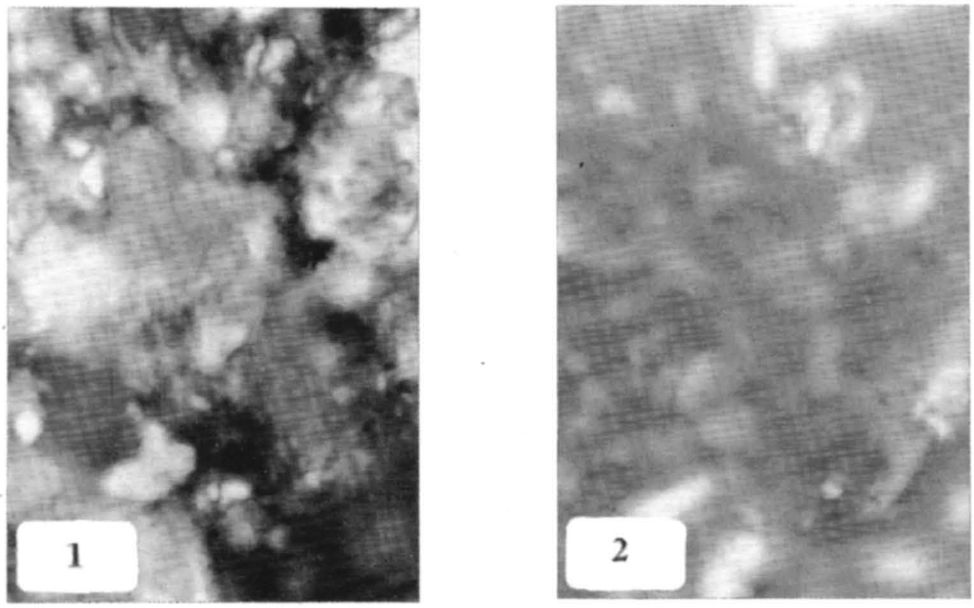
Faegri, K. & Iversen, J. 1964. *Textbook of Pollen Analysis.* Hafner Publishing Company, New York: 237pp.

Hoek, R. *et al.* In press.

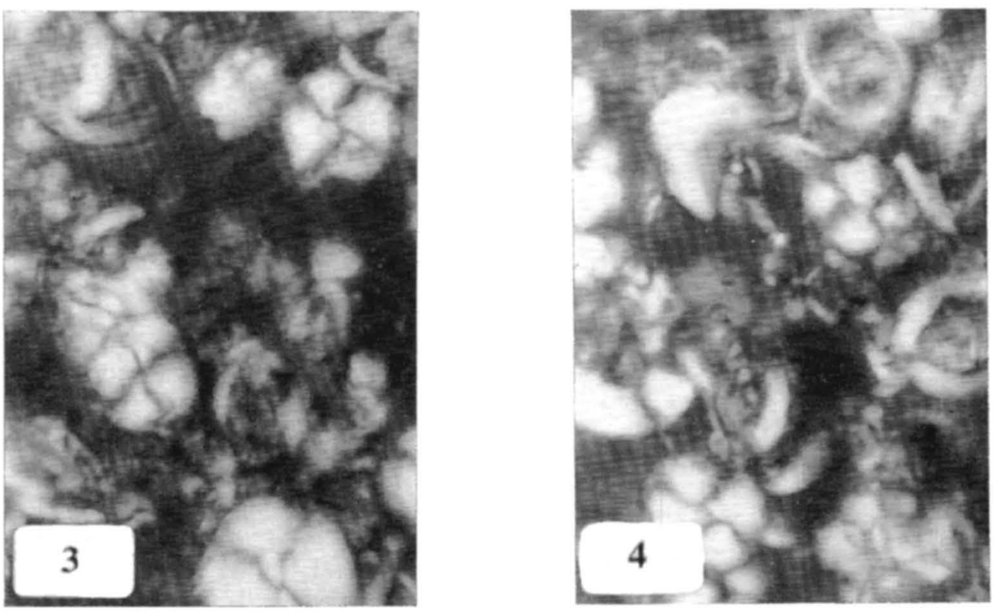
Moshkovitz, S. & Erlich, A. 1976. Distribution of Middle and Upper Jurassic calcareous nannofossils in the northern Negev, Israel and in Gebel Maghara, northern Sinai. *Bulletin of the Geological Survey of Israel*, **69**: 49pp.

PLATE 1

Nannofossil assemblages before and after bleaching
Example from Sample #47
All magnifications x3750



1, 2: Microscope view before bleaching. Note outline of nannofossils obscured by the thick covering of organic matter.



3, 4: Microscope view after 10 hours of bleaching, which has removed most of the organic matter. Note rich and diverse nannofossil assemblages which were revealed.

NANNOFOSSILS AND UPPER CRETACEOUS (SUB-)STAGE BOUNDARIES - STATE OF THE ART

Jackie A. Burnett, Research School of Geological & Geophysical Sciences, Birkbeck College & University College London, Gower Street, London, WC1E 6BT, UK

Abstract: An integrated study of primarily nannofossil and macrofossil biostratigraphies (with some planktonic foraminifera biostratigraphy, chemostratigraphy and magnetostratigraphy) around numerous potential Upper Cretaceous stage and substage boundary sections, from a variety of geographical locations, has been in train since 1988. This project was devised in response to the discussions held at the original *Symposium on Cretaceous Stage Boundaries*, held in Copenhagen in 1983 by the Subcommission on Cretaceous Stratigraphy, and a subsequent 'call for help' by Dr. K. (von Salis) Perch-Nielsen (1986), in both of which some potential boundary-stratotypes were identified. Most of these sections have been examined in detail, in addition to numerous others. The work has been, and still is being, carried out in collaboration with Dr. W.J. Kennedy (Oxford), Prof. A.S. Gale (Greenwich/NHM), Prof. J.M. Hancock (ICL), and others.

An integrated approach was applied to these studies in order to overcome correlation problems at stage boundaries. Although there was a strong historical precedent for macrofossil events to be used to officially define the Upper Cretaceous stage and substage boundaries, macrofossils cannot be used to *directly* date the majority of boreholes, nor any of the cores drilled by the Deep Sea Drilling Project nor the Ocean Drilling Program. In the oceans, nannofossils and planktonic microfossils are, and have been, extensively used for dating and correlation due to their small size, high abundance and wide geographical coverage. Complications have arisen in the past, with respect to correlation and boundary definitions in shelf and oceanic sediments, because of this situation: unfortunately, it is already the case that we have an unofficial system of stage boundaries defined on macrofossils for onshore sequences, and ones based on nannofossils and microfossils for the oceans.Thus, in order to precisely define a stage boundary, and, importantly, to be able to correlate it, it was viewed as imperative that the stratigraphies of a number of important fossil groups were precisely *integrated.*

These studies have integrated the biostratigraphies of nannofossils and macrofossils across potential stage and substage boundary stratotypes (Albian/Cenomanian to Maastrichtian/Palaeocene) around the world. The chosen sequences represented all palaeobiogeographical regions. Thus, the discrepancies between macrofossil and nannofossil approximations for potential stage boundaries has been largely overcome. The nannofossil results are presented here in summary and in the context of the provisional proposals for stage and substage boundaries determined by the various Working Groups at the second *Symposium on Cretaceous Stage Boundaries*, held in Brussels, in September, 1995. More detailed works, which will incorporate nannofossil range-charts for all of the Upper Cretaceous stage and substage boundary stratotypes in relation to the other stratigraphical events, are in preparation (Gale, Kennedy, Hancock & Burnett, and combinations thereof). Proposals and data based on the results of many of these studies were presented, both at the Working Group sessions and as a poster, at the second *Symposium on Cretaceous Stage Boundaries* and at the sixth *International Nannoplankton Association Conference* (Copenhagen, September 1995)

Introduction

In response to the discussions held at the original *Symposium on Cretaceous Stage Boundaries* (Copenhagen, 1983) and comments made by Perch-Nielsen (1986), the British Natural Environment Research Council (NERC) funded an extensive research program which would provide integrated macrofossil, microfossil and nannofossil biostratigraphical, and Sr-, O- and C-isotope chemostratigraphical event sequences across Upper Cretaceous stage and substage boundaries (Albian/Cenomanian to Maastrichtian/Palaeocene) for a variety of geographical locations. The aims of these studies were to (i) provide an integration of stratigraphic scales for the Upper Cretaceous, (ii) provide more-accurate and higher-resolution biostratigraphic scales for the Upper Cretaceous, (iii) improve and/or effect correlations between onshore and oceanic sequences, and thus (iv) propose the most useful stage boundary events and stratotypes for the Upper Cretaceous. By using an integrated approach, the research team was able to overcome certain problems associated with simple, second-order correlation studies, which necessarily incorporate a degree of error (sadly, some of which the author has seen reproduced in Working Group discussion documents). In examining a number of sections per stage boundary, the team was able to first evaluate the correlatability of events over wide geographical areas before proposing the best candidates for Global Stratotype Sections and Points (GSSPs), as per the requirements of the Subcommission on Cretaceous Stratigraphy.

Although a number of publications have already resulted from this program, further manuscripts are in preparation which particularly document the nannofossil data from the studied sections. Many of our data, therefore, have not yet been published, and none of it has been combined to provide a complete view. One aim of the present document is to provide a summary overview of both the published, in press and in preparation nannofossil work, the details of which will be used to formulate a new, high-resolution nannofossil zonation for the Upper Cretaceous which will incorporate the flexibility of being applicable to high- and low-latitude sediments (Burnett in prep., a).

Nannofossils and stratigraphic utility

Nannofossil events do not appear to have been regarded as very useful at the 1983 Symposium, ammonites and foraminifera being to the fore, and no chapter dedicated to nannofossils appeared in the conference volume (*Bulletin of the Geological Society of Denmark*, **33**(1/2), 1984), although Perch-Nielsen (1983) contributed to the abstracts volume. One aim of this paper is to provide an overview for nannopalaeontologists *and others* on the status of nannofossil events at Upper Cretaceous (sub-)stage boundaries, in order to redress the balance of the earlier meeting and to provide a firm basis for future biostratigraphical and correlative work.

As nannopalaeontologists know, nannoplankton are, and have been since the Late Triassic, planktonic and geographically widespread. Their planktonic habit has made them less susceptible to sea-level fluctuations than most macrofossil groups. Their cosmopolitan distribution, and their high diversity even in sub-polar regions, has provided them with great correlation potential, some of which persisted even at times of heightened provincialism (*e.g.* Burnett, 1990; Watkins *et al.*, in press; Burnett, in prep. b, c). Their abundance in sediments, and the closely-spaced sampling approach adopted by most nannopalaeontologists, means that first appearance datums (FADs) and last appearance datums (LADs) can be fairly accurately determined, as opposed to macropalaeontologists, who deal with far fewer specimens and lower sample frequencies and who, therefore, cannot be certain of detecting true FADs or LADs. (*N.B.* The FAD and LAD are distinct from the first and last *occurrence* of a taxon (FO, LO), which may be specific to a particular section, and may thus have no global relevence.) During the research program, it was continually underlined that there were major problems associated with correlating between disparate macrofossil zones, and particularly between the Boreal and Tethyan Realms (*i.e.* between belemnites and ammonites). In such cases, nannofossils proved their efficacy as correlative tools.

Nannofossils are generally 1-30μm in length/diameter, which makes them ideal for dating borehole sequences, *e.g.* for the oil industry and the Ocean Drilling Program (ODP), situations in which macrofossils are mostly lacking. In order to provide a truly global relevence for any designated GSSP, the GSSP should be correlatable with oceanic sequences. Thus, there is a very real need for such GSSPs to incorportate some definition in terms of nannofossils. It is unfortunate that, at present, even though the majority of ODP authors use the 'cosmopolitan' nannofossil biozonation scheme originally devised from stage-stratotype (and other) material by Sissingh (1977) and supplemented by Perch-Nielsen (1979, 1983, 1985), and even though the biozones have consequently been directly correlated with stages and the majority of nannofossil events shown not to fall exactly at the commonly-used, but unofficial, (macrofossil-defined) stage boundaries, in oceanic material the nannofossil events are often taken to define, rather than approximate, stage boundaries. This introduces a primary correlation error between the oceans and shelves, and between nannofossil biozones and other fossil biozones. Workers using other fossil groups, or other dating methods, tend to understand the concept of the stage rather than the specifics of the nannofossil biozone (*i.e.* one tends not to be *au fait* with other biozonation schemes). Thus, they use the stage interpretion for correlating their own results with, or discussing their results in relation to. On the surface this may seem trivial but, as an example, the author has been involved in some heated discussion concerning the dating of industrial borehole sequences, wherein the stage indicated by nannofossils was not the stage indicated by another microfossil group. The problem was not due to inaccurate biozonation by either party, but simply that the biozonation for one fossil group had not been directly correlated with the stage stratotype, such that the stages assigned to the zones could be described as arbitrary. When you consider that such apparent discrepancies are then passed on to people with little or no biostratigraphical background (this happens in academia, too), who have no idea how to interpret such apparent errors, it does become important. Is it any wonder that second-order correlation-of-everything charts, with such inaccuracies built in, tend not to work? Even worse, such charts portray a confidence in correlation which any expert will admit is, as yet, unfounded.

So, although not *necessarily* advocating the use of any particular nannofossil event as a boundary marker, it was seen as absolutely vital that GSSPs were defined with a clear knowledge of the associated nannofossil events. The success/failure of transmission of this point of view to other members of the Stage Boundary Working Groups at Brussels will eventually become apparent!

Upper Cretaceous nannofossil biozonation and stage boundaries - a historical perspective

In 1977, Sissingh published the second nannofossil zonation scheme for the entire Cretaceous (Thierstein published a more rudimentary one in 1976), introducing 26 numerical zones based on observations made from stage-stratotype material and sequences elsewhere in France, and also from Denmark (sidewall cores?), western Germany, The Netherlands, Oman (sidewall cores), western Tunisia (Dyr el Kef), Turkey (sidewall cores), the UK and North Sea, and the eastern USA. He also correlated the Upper Cretaceous portion with planktonic foraminifera zones (Sissingh, 1978). Previous schemes existed for parts of the column, based on geographically-limited observations: Sissingh (1977) and Perch-Nielsen (1979, 1985) have provided overviews of these. The events used by Sissingh (1977) mirrored these earlier observations to an extent, but some of the earlier observations are now known to be either erroneous or ephemeral. Thus, Sissingh's scheme stands as a commonly-used framework, although it is not without its problems, either. Certain of these are discussed below but basically stem from his use of many low-latitude taxon events (derived from the Tunisian sequence), and possibly his apparently erratic sampling methods (he examined mainly spot-samples from the type sequences). Perch-Nielsen (1979, 1983, 1985) supplemented Sissingh's (1977) biozones with her own (from the North Sea to the Mediterranean) and a variety of others' observations, and highlighted the fact that certain of Sissingh's biozones were not applicable in Boreal areas.

Surprisingly few nannopalaeontologists have worked on material from the Upper Cretaceous type areas (the published work is summarised below), or have integrated nannofossil events with other fossil events. Data from those that have has mostly been published in a summarised format, rather than as detailed stratigraphical distribution charts. Consequently, it is virtually impossible to glean enough information from published sources to facilitate further resolution of the Sissingh/Perch-Nielsen biozonation, nor to check the validity of potential new nannofossil events for a global zonation scheme. Perch-Nielsen (1985) commented that Upper Cretaceous coccolith zones have repeatedly been correlated with the classic stages but that the preservation of coccoliths in the stage-stratotypes is variable and that "correlations have had to be made via other fossils with the evident possibilities of shifting boundaries higher or lower depending on one's own preferences, tradition or wishful thinking" (p.340)! This has demonstrably been the case, such that there is still no consensus between current workers. It is hoped that the proposals put forward by the Brussels Working Groups, and acceptance of these at the Beijing *International Geological Congress* in August, 1996, will filter through our science rapidly and change this situation for the better.

The **Cenomanian** type section is represented in and around Le Mans, Sarthe (NW France). The nannofloras of the Marnes de Ballon ('Lower' Cenomanian) and the Craie de Théligny ('Middle' Cenomanian), both close to Le Mans, were described by Verbeek (1976). He used the FADs of *Eiffellithus turriseiffelii, Lithraphidites alatus* and *Gartnerago obliquum* to subdivide the stage. The Cenomanian nannoplankton of Ballon and Ste. Ulphace-Théligny-Moulin de l'Aunay were investigated by Sissingh (1977). He was able to assign one nannofossil zone to the sections (CC9), based on the FAD of *Eiffellithus turriseiffelii*, but his other Cenomanian marker event, the FAD of *Microrhabdulus decoratus*, was absent from these sections (the reference section for the zone is in Tunisia). This latter event has been found to be highly diachronous by the author. Sissingh (1977) noticed that predominantly Tethyan, *e.g.* Tunisian, Late Cretaceous nannoplankton assemblages were generally more diverse than more northerly, European (*e.g.* northern France) assemblages, the latter being characteristically dominated by solution-resistant forms, a point also noted by Verbeek (1977). Verbeek (1977) proposed the utilisation of the FAD of *Lithraphidites acutus* between the FADs of *Eiffellithus turriseiffelii* and *Microrhabdulus decoratus* in the 'Middle' Cenomanian. Manivit *et al.* (1977) used the LAD of *Hayesites albiensis* and the FAD of *Lithraphidites acutus* as as datums in the 'Middle' Cenomanian of the Théligny section. The *Lithraphidites acutus* event is commonly substituted for the FAD of *Microrhabdulus decoratus*, and this is followed by the author. Manivit *et al.* (1977) also utilised the LAD of *Microstaurus chiastius* to subdivide CC10 (from the FAD of *Lithraphidites acutus*), and this event has been found to be widely applicable.

Perch-Nielsen (1979, 1983, 1985) placed the LAD of *Crucicribrum anglicum* at the same level as the LAD of *Hayesites albiensis,* at the base of CC9B. At the proposed boundary stratotype, Mont Risou, *Crucicribrum anglicum* was found to range from near the base of the uppermost MF subzone of the Albian in CC9B to at least the Lower Cenomanian (CC9C). She also used the FAD of *Corollithion kennedyi* to further subdivide CC9, but placed this event at the same level as the LADs of *Watznaueria britannica* and *Braarudosphaera africana*. These events occur above the *Corollithion kennedyi* FAD at Mont Risou.

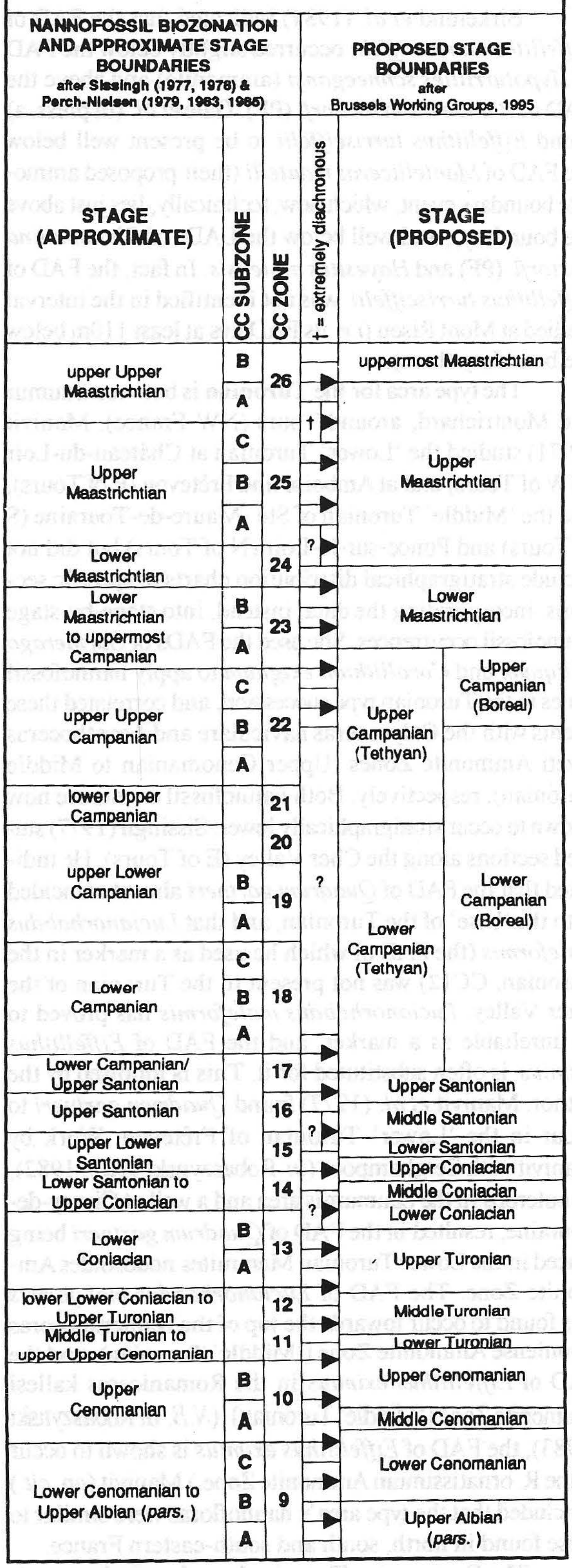
Birkelund *et al.* (1984) indicated that the FAD of *Eiffellithus turriseiffelii* occurred slightly below the FAD of *Hypoturrilites schneegansi* (ammonite) and above the LAD of *Planomalina buxtorfi* (PF). Gale *et al.* (in press, a) found *Eiffellithus turriseiffelii* to be present well below the FAD of *Mantelliceras mantelli* (their proposed ammonite boundary event, which now, technically, lies just above the boundary), and well below the LADs of *Planomalina buxtorfi* (PF) and *Hayesites albiensis*. In fact, the FAD of *Eiffellithus turriseiffelii* was not identified in the interval studied at Mont Risou (*i.e.* its FAD lies at least 110m below the boundary there).

The type area for the **Turonian** is between Saumur and Montrichard, around Tours (NW France). Manivit (1971) studied the 'Lower' Turonian at Château-du-Loir (NW of Tours) and at Amboise and Frêtevou (E of Tours), and the 'Middle' Turonian of Ste.-Maure-de-Touraine (S of Tours) and Ponce-sur-le-Loir (N of Tours) but did not include stratigraphical distribution charts of specific sections, incorporating the data, instead, into stage-by-stage nannofossil occurrences. She used the FADs of *Gartnerago obliquum* and *Corollithion exiguum* to apply nannofossil zones to the Turonian type succession, and correlated these events with the Calycoceras naviculare and Acanthoceras bizeti Ammonite Zones (Upper Cenomanian to Middle Turonian), respectively. Both nannofossil events are now known to occur stratigraphically lower. Sissingh (1977) studied sections along the Cher Valley (E of Tours). He indicated that the FAD of *Quadrum gartneri* almost coincided with the 'base' of the Turonian, and that *Lucianorhabdus maleformis* (the FAD of which he used as a marker in the Turonian, CC12) was not present in the Turonian of the Cher Valley. *Lucianorhabdus maleformis* has proved to be unreliable as a marker, and the FAD of *Eiffellithus eximius* is often substituted for it. This is followed by the author. Manivit *et al.* (1977) found *Quadrum gartneri* to occur in the 'Lower' Turonian of Frêtevou. Work by Manivit with Zeighampour (*in* Robaszynski *et al.*, 1982), on outcrops in the Saumurois area and a well at Civray-de-Touraine, resulted in the FAD of *Quadrum gartneri* being placed in the Lower Turonian Mammites nodosoides Ammonite Zone. The FAD of *Lucianorhabdus maleformis* was found to occur towards the top of the Kamerunoceras turoniense Ammonite Zone ('Middle' Turonian), and the FAD of *Eiffellithus eximius* in the Romaniceras kallesi Ammonite Zone ('Middle' Turonian). (*N.B.* In Robaszynski (1983), the FAD of *Eiffellithus eximius* is shown to occur in the R. ornatissimum Ammonite Zone.) Manivit (*op. cit.*) concluded that the type area's nannofloras were similar to those found in north, south and south-eastern France.

The Cenomanian/Turonian boundary is characterised in many locations (shelf and oceanic, Boreal to Austral regions) by hiati, condensation and black shales, the result of an extensive oceanic anoxic event. This event is explored in biostratigraphical detail by Bralower (1988) and Jarvis *et al.* (1988).

Birkelund *et al.* (1984) indicated that the FAD of *Quadrum gartneri* was "widely recognisable" (p.12) and

FIGURE 1: COMPARISON OF STAGE- BOUNDARY DEFINITIONS AND NANNOFOSSIL ZONES



lay within the Neocardioceras juddii Ammonite Biozone (Upper Cenomanian). The author found the event in the Plenus Marls/Metoicoceras geslinianum Ammonite Zone (Upper Cenomanian) in S and NE England. At Rock Canyon, near Pueblo, Colorado (the proposed boundary stratotype), Watkins (1985) apparently identified its FAD in the Watinoceras devonense Ammonite Biozone (Lower Turonian), whilst Bralower (1988, Figure 16) found it in the Metoicoceras mosbyense Ammonite Biozone which lies below the Sciponoceras gracile Ammonite Biozone (Upper Cenomanian) (Cobban *et al.*, 1995). Therefore, the FAD is placed in the Upper Cenomanian.

The area around Cognac, Charente (W France) represents the **Coniacian** type area. Manivit (1971) studied the type Coniacian at Cognac, and utilised the FADs of *Marthasterites furcatus* (CC13) and *Kamptnerius magnificus* to identify the stage here. Both species are now known to occur stratigraphically below the base of this stage. The *Marthasterites furcatus* event was found in the top of the Coniacian Micraster cortestudinarium Echinoid Zone, according to Manivit (1971). Sissingh (1977) also examined the Coniacian of Cognac but did not find *Marthasterites furcatus*, whilst Robaszynski (1983) indicated that *Marthasterites furcatus* was found in the Peroniceras tricarinatum Ammonite Zone of the Turonian type area. Sissingh (1977) used the FAD of *Micula staurophora* to define the Upper Coniacian (CC14).

Birkelund *et al.* (1984) stated that the FAD of *Marthasterites furcatus* was a "world-wide marker...which is generally used by nannofossil specialists as the basal...[event]...of the Coniacian" (p.13-14), although Bailey *et al.* (1984), in the same volume, indicated that the event lay in the Subprionocyclus neptuni Ammonite Biozone (Upper Turonian) in the UK and Germany. The author has found *Marthasterites furcatus* to be virtually useless as a biostratigraphic indicator in many geographical areas: its geographical and stratigraphical distributions are patchy at best outside of the Tethyan Realm, such that one can never be sure of identifying its true FAD. In S England, the author found *Marthasterites furcatus* in the Sternotaxis planus Echinoid Biozone ('Upper' Turonian), whilst Crux (1982) found it below this in the Terebratulina lata Brachiopod Biozone ('Mid' or 'Upper' Turonian). In the Salzgitter-Salder section (the proposed boundary stratotype), *Marthasterites furcatus* is present at least from below *Didymotis* Event I (Bed 38b, Upper Turonian; Burnett in prep., d); the FAD of *Lithastrinus septenarius* was found from Bed 42a, below the proposed boundary. This latter event was used by Perch-Nielsen (1979, *etc.*) to subdivide CC13.

The **Santonian** type area is around Saintes, Charente (W France). The nannofloras of Cognac and Chateaubernard (SE of Saintes) were studied by Manivit (1971). She assigned one zone to the stage, using the FADs of *Kamptnerius magnificus* and *Broinsonia parca parca* to define it. The former event is in the Turonian, the latter in the Campanian. Sissingh (1977) investigated the Santonian of Saintes and of Javresac and Ste. Laurent-Louzac (SE of Saintes). *Micula staurophora* (CC14) was present, and he also used the FADs of *Reinhardtites anthophorus* (CC15) and *Lucianorhabdus cayeuxii* (CC16) to define two nannofossil zones within the stage, although there appeared to be a reversed succession in the type area (rare *Lucianorhabdus cayeuxii* were believed to occur below the stated FAD datum, although these could possibly be ascribed to either *Lucianorhabdus quadrifidus* or *Acuturris scotus*). Verbeek (1977) produced a nannofloral distribution chart from the type section, which included

Micula staurophora. He used the FADs of *Placozygus fibuliformis* and *Broinsonia parca parca* to characterise the 'Middle? to Upper' Santonian in the type area.

Reinhardtites anthophorus appears to evolve from *Zeugrhabdotus sisyphus* (= *Z. scutula*), or similar forms, and thus its FAD may vary between authors with differing concepts of the taxon. It may, therefore, seem to first occur before the FAD of *Micula staurophora* due to this reason, or one (both?) of these markers may be diachronous. However, *Reinhardtites anthophorus* often first occurs in association with *Lithastrinus grillii*, as noted by Perch-Nielsen (1979), an event which can be used as confirmation of, or possibly a substitute for, the datum. She also reported the coincident FAD of *Lucianorhabdus cayeuxii* with the LAD of *Lithastrinus septenarius*. However, the latter event has been found to predate the FAD of *Lucianorhabdus cayeuxii* in many locations.

Birkelund *et al.* (1984) made no mention of nannofossils in relation to the Santonian/Campanian boundary.

The **Campanian** type area lies around the Grande and Petite Champagne, northern Aquitaine (SW France). Manivit (1971) investigated sections at Ste.-L'Heurine, Gente and Archiac (S of Cognac), Talmont (on the north bank of the Gironde) and Aubeterre (S of Angoulême). She used the FADs of *Arkhangelskiella specillata, Ceratolithoides aculeus* (CC20) and *Lithraphidites quadratus* (CC25B, Maastrichtian) to subdivide the stage. She correlated the former two events with the Actinocamax quadratus/Placenticeras bidorsatum and Hoplitoplacenticeras vari/Belemnitella mucronata Macrofossil Zones, respectively.

Sissingh (1977) originally placed the Santonian/ Campanian boundary at the first regular occurrence of *Calculites obscurus* (at the base of CC17) but revised this (Sissingh, 1978), placing the base of CC17 in the 'Upper' Santonian based on PF associations, remarking, however, that the Santonian/Campanian boundary still lay *within* CC17. He examined material from Gimeux (SW of Cognac), Gente, along the north bank of the Gironde from Royan to Ste.-Seurin-d'Uzet, Montmoreau (S of Angoulême) and Brossac (SW of Angoulême). Of the seven zones he erected for the Campanian, six were recognised in the type area. These were based on the FADs of regular *Calculites obscurus, Broinsonia parca parca* (CC18), *Ceratolithoides aculeus* (CC20), *Uniplanarius sissinghii* (CC21), *Uniplanarius trifidus* (CC22A-CC23B; the occurrence of which was sporadic, a finding duplicated by Verbeek's (1977) study of a section at Aubeterre, S of Angoulême), and the LADs of *Reinhardtites anthophorus* (CC22C) and *Tranolithus orionatus* (CC23B). The majority of these events are Tethyan and cannot be recognised in high-latitude areas. A large number of sections in the type area were sampled by Lambert (1980), including those between Royan and Beaumont (on the north bank of the Gironde) and between Saintes (to the NW) and Aubeterre (to the SE). He used the FADs of *B. parca parca, C. aculeus, Prediscosphaera stoveri, Lithraphidites praequadratus* and *"Tetralithus* sp." to divide the stage.

The FAD of *Broinsonia parca parca*, a virtually cosmopolitan event, was noted by Birkelund *et al.* (1984) to be "used by coccolith specialists for definition of the [Santonian/ Campanian] boundary" (p.16), although the taxon's FAD is actually well within the traditionally defined Campanian (Bailey *et al.*, 1984; Gale *et al.*, in press, b). Birkelund *et al.* (1984) also made comment that "this species is known to be diachronous" (p.16). This, however, is relative to macrofossil datums which themselves may be diachronous! One problem noted at various locations by the author, however, and forming the crux of a brief presentation by Sylvia Gardin at the Working Group session, was the problem of correct identification of *B. parca parca* within the *B. parca* plexus. *Broinsonia parca parca* belongs to an evolutionary lineage (*Broinsonia parca expansa-Broinsonia parca parca-Broinsonia parca constricta*) which involves the gradual reduction in dimensions of the central area plate of the coccolith. In order to use this event correctly, a precise definition of the central area dimensions of the taxon must be determined in order to obtain the correct FAD. A biometric study on numerous sections containing the plexus is currently being carried out at UCL, which will form a basis for comparison with other studies.

The Campanian stage contains the endemic acme for Mesozoic nannofossils, at which time widespread correlation potential was reduced but diversity reached a peak (Bown *et al.*, 1991, 1992). Recent works have begun to overcome the intercorrelative problems associated with this interval (*e.g.* Burnett, 1990; Watkins *et al.*, in press; Burnett, in prep., b: the latter work in particular has managed to identify tie-lines between Indian Ocean sites at palaeolatitudes ranging from 18.9°S to 62.9°S for this interval).

Sissingh (1977) introduced the FAD of *Reinhardtites levis* as a subzonal marker event in the uppermost Campanian. This taxon evolved from *Reinhardtites anthophorus* by gradual closing of the central area, such that *Reinhardtites levis* possesses "very small or completely sealed openings" (p.47), transitional morphologies being represented through the Campanian. Unfortunately, these openings can also be closed by calcitic overgrowth. Additionally, *Reinhardtites levis* has been found to have diachronous FADs and LADs (Burnett, in prep., a), its FAD apparently trangressing from the Lower to the Upper Campanian, from certain low to high latitudes.

The type section for the **Maastrichtian** is in the ENCI Quarry, near Maastricht, Limburg (SE Netherlands). The lithostratigraphy of both this quarry and the Halembaye Quarry (near Visé, Liége, E Belgium) has been published by various authors (*e.g.* Felder *et al.*, 1980; Bless *et al.*, 1987). Sedimentation in this area was repeatedly interrupted, giving rise to numerous hardgrounds which facilitated lithological subdivision.

Bramlette & Martini (1964) examined three samples from the 'Upper' Maastrichtian of the ENCI Quarry but did not attempt to identify zonal indicators. Manivit (1971) was the first to apply nannofossil zones to this section, using the FADs of *Lithraphidites quadratus* (CC25B) and *Nephrolithus frequens* (CC26). She then attempted a correlation of these zones with ammonite zones, resulting in the emplacement of the Lithraphidites quadratus NF Zone in the Bostrychoceras polyplocum Ammonite Zone (Up-

FIGURE 2: SUMMARY OF WORKING-GROUP PROPOSALS FOR UPPER CRETACEOUS STAGE AND SUBSTAGE BOUNDARY EVENTS AND STRATOTYPES

arrows refer to (sub-)stage boundaries

ABSOLUTE AGE after Gradstein *et al.* (1994)	ABSOLUTE $(^{40}Ar/^{39}Ar)$ AGE after Obradovich (1993)	STAGE	SUBSTAGE	BOUNDARY EVENT AMM = ammonite BEL = belemnite CRIN = crinoid INOC = inoceramid bivalve NF = nannofossil PF = planktonic foraminifer	AUXILLIARY EVENT(S)	BOUNDARY STRATOTYPE AG = Andy Gale JH = Jake Hancock EK = Erle Kauffmann ML = Marcos Lamolda RM = Rory Mortimore FR = Francis Robaszynski IP-S = Isabella Premoli-Silva K-AT = Karl-Armin Tröger CW = Chris Wood	COMMENTS & REFERENCES CONTAINING NANNOFOSSIL DATA	WORKING-GROUP CHAIRMAN full reports by the chairmen on the Brussels Working Group decisions will appear in the conference volume by summer, 1996
		PAL.	LR.				poor preservation of NFs & PFs makes this a poor stratotype choice, however, correlations can be made via Zumaya (NE Spain) & Bidart (SW France). Burnett in prep., e; Burnett *et al.* , 1992a, 1992b, 1992c; Hancock *et al.* , 1993; Jagt *et al.* , 1992; Kennedy *et al.*, 1995; McArthur *et al.* , 1992; Robaszynski *et al.* , 1985; Schönfeld & Burnett, 1991.	
65.0±0.1Ma	65.4±0.1Ma	MAAST-RICHTIAN	UP.					Dr. Gilles S. Odin, Dépt. Géologie Sédimentaire, Université Pierre et Marie Curie, 4 place Jussieu, Case 119A, F-75252, Paris Cedex 05, France
			LR.	no decision, probably AMM event		no decision, probably Zumaya, NE Spain		
71.3±0.5Ma	71.3±0.5Ma	CAMPANIAN	UP.	FAD *Pachydiscus neubergicus* (AMM)	corresponds to FAD *Belemnella lanceolata* (BEL)	Tercis Quarry, SE France, @117m (in Bed N)		
			?MID.	no formal proposals, investigation underway into possibility of equal-duration, 3-fold subdivision	compatible with FAD *Placenticeras bidorsatum* (AMM). Links with PF (*Dicarinella asymetrica*), NF (*Broinsonia parca* lineage), & 34N/33R magnetostratigraphic boundary under investigation		insertion of 7th stage (?Dordognian) contemplated at top of Camp. due to long duration of Camp. & apparently complete Camp. stratotype. Burnett, 1990; Burnett in prep., e; Jagt *et al.* in press; Kennedy *et al.* , 1992; Kennedy & Hancock, 1995; Schönfeld & Schulz (Co-ords) *et al.* in press.	Prof. Jake M. Hancock, Dept. of Geology, Imperial College of Science & Technology, Prince Consort Road, London SW7 2BP, UK
			LR.					
83.5±0.5Ma	83.5±0.5Ma	SANTONIAN	UP.	LAD *Marsupites testudinarius* (CRIN)		no decision, either Waxahachie, Texas (AG/JH) or Seaford Head, Sussex, UK (RM/CW), IP-S co-ord.	Gale *et al.* in press, b; Gale *et al.* in prep., b.	
			MID.	no decision, probably FAD *Uintacrinus socialis* (CRIN)		no decision (AG)	Kennedy *et al.* in press.	Dr. Marcos A. Lamolda, Universidad del Pais Vasco, Facultad de Ciencias, Estratigrafía y Paleontología, Apartado 644, E-48080, Bilbao, Spain
			LR.	no decision, either FAD *Cordiceramus cordiformis* (INOC) or LAD *Cordiceramus undulatus* (INOC)		no decision (AG)		
85.8±0.5Ma	86.3±0.5Ma	CONIACIAN	UP.	FAD *Cladoceramus undulatoplicatus* (INOC)	approximates FAD *Sigalia carpathica* (PF)	no decision, either 10 Mile Creek, Texas (AG/EK) or Olazagutía Quarry, Navarra, Spain (ML)	Gale *et al.* in prep., a; Kennedy, 1995c.	
			MID.	FAD *Inoceramus (Magdaceramus) subquadratus* group (INOC)	?corresponds to FAD *Gonioteuthis praewestfalica* (BEL)	no decision, either 10 Mile Creek, Texas (AG) or Seaford Head, Sussex, UK (CW)	expanded sequence, no ammonites but abundant other fossils, easy access to vertically-bedded strata: Wood *et al.* , 1984; Burnett in prep., d; Burnett *et al.* in prep., a; Kennedy, 1995b; Naji (in press).	Dr. Erle G. Kauffmann, Dept. of Geological Sciences, University of Colorado, Boulder, Colorado 80309-0250, USA
			LR.	FAD *Volviceramus koeneni* (INOC)	corresponds to FAD *Stensoina granulatagranulata* (ECH)	no decision, either Dallas, Texas (AG) or S England (CW)		
89.0±0.5Ma	88.7±0.5Ma	TURONIAN	UP.	FAD *Cremnoceramus rotundatus* (INOC) of authors	corresponds to flood of *Inoceramus waltersdorfensis hannovrensis* of authors (INOC) & *Didymotis* Flood Event II (INOC)	Salzgitter-Salder Quarry, Lower Saxony, N Germany, within base of Bed 45c		
			MID.	no decision, probably INOC event (WG of INOC workers to recommend datum)		no decision, INOC WG to recommend stratotype (K-AT)	no condensation, lies in Milankovitch cycles correlatable over Western Interior, radiometrically-dated via associated bentonites: Bralower, 1988; Jarvis *et al.* , 1988; Robaszynski, 1983; Robaszynski *et al.* , 1982; Watkins, 1985.	Prof. Peter Bengtson, Geologisch-Paläontologisches Institut, Im Neuenheimer Feld 234, D-69120 Heidelberg, Germany
			LR.	FAD *Collignoniceras woollgari* (AMM)		Rock Canyon Anticline section, W of Pueblo, Colorado, base of Bed 120 in Bridge Creek Member, Greenhorn Limestone Formation		
93.5±0.2Ma	93.3±0.2Ma	CENOMANIAN	UP.	FAD *Watinoceras devonense* (AMM)	corresponds to FAD *Helvetoglobotruncana helvetica* (PF) & base of Bed 86, 50cm above FAD of *Mytiloides hattini* (INOC)	Rock Canyon Anticline section, W of Pueblo, Colorado, base of Bed 86 in BCM, GLF		
			MID.	no decision, either FAD *Calycoceras gueranger*i (AMM) or FAD/LAD *Acanthoceras jukesbrownei* (AMM) or FAD *Inoceramus pictus* group (INOC) (FR)		no decision, probably S France (FR)	expanded sequence containing well-preserved fossils, & NFs with both Boreal & Tethyan elements. A secondary reference section in the Tethyan Realm was proposed at Kalaat Senan, N of El Kef, Tunisia by Robaszynski and his group but it is likely that this sequence is condensed in part. Gale *et al.* in press, a; Kennedy, 1995a; Robaszynski *et al.* , 1993, 1994.	Prof. Dr. Karl-Armin Tröger, Bergakademie Freiberg, Institut für Geologie, Fakultät 3, Bernhard-von-Cotta Straße 2, 09596 Freiberg, Sachs., Germany
			LR.	FAD *Cunningtoniceras inerme* (AMM)	corresponds to FAD *Inoceramus schloendorfi* (INOC) & FAD *Rotalipora reicheli* (PF)	no decision, either Southerham Grey Quarry, Lewes, Sussex, UK or ?Folkestone-Dover, Kent, UK or ?Boulonnais, N France (AG)		
98.9±0.6Ma	98.5±0.5Ma	ALB.	UP.	FAD *Rotalipora globotruncanoides* (PF)		Mont Risou, near Rosans, Hautes-Alpes, SE France		

per Campanian) and the Nephrolithus frequens NF Zone in the Pachydiscus neubergicus/Cidaris faujasi Macrofossil Zone (Lower Maastrichtian). Sissingh (1977) also studied material from the type section. He utilised the LADs of *Tranolithus orionatus* (CC23B) and *Reinhardtites levis* (CC24), and the FAD of *Nephrolithus frequens* (CC26) to define his zones for the Maastrichtian. The poor preservation of the type material was commented on by Verbeek (1977), who used the FADs of *Lithraphidites quadratus* and *Micula murus* (CC25C) to define zones in this interval. Sissingh's (1977) material was reinvestigated by van Heck (1979), who did not attempt to reapply a nannofossil zonation. Čepek & Moorkens (1979) also studied the ENCI Quarry stratotype, using *Lithraphidites quadratus* and *Nephrolithus frequens* as marker events. It is now known that the FAD of *Nephrolithus frequens* is highly diachronous and should be used with caution.

Verbeek (1983) restudied material from the ENCI Quarry, this time using *Nephrolithus frequens* as a zonal marker. A multidisciplinary study, undertaken by Robaszynski *et al.* (1985), included investigation of material from the Halembaye Quarry, in the type area. Manivit (*in* Robaszynski *et al.*, 1985) noted the largely Boreal influence on the nannofloras, and the good preservation, with only weak diagenetic effects on the specimens, of the material. She believed that the LADs of *Broinsona parca constricta, Eiffellithus eximius* and *Reinhardtites anthophorus* (used to indicate an approximation to the Campanian/Maastrichtian stage boundary in Tethyan areas), rather than being represented due to reworking, could here be of Upper Maastrichtian age, *i.e.* their LADs were diachronous. However, in the presence of so many hardgrounds, reworking of these events into younger sediments cannot be ruled out. Manivit (*op. cit.*) used the FADs of *Lithraphidites praequadratus* and *Lithraphidites quadratus* to subdivide the interval.

Birkelund *et al.* (1984) commented that the LAD of the "widespread" (p.17) *Uniplanarius trifidus* "had been used to define the base of the Maastrichtian" but that the event was actually well within the Lower Maastrichtian. This event (and nannofossil) is Tethyan-restricted.

In summary, Figure 1 shows the most commonly-used biozonation scheme (after Sissingh and Perch-Nielsen, *op. cit.*) with Sissingh's stage approximations redefined according to the proposals put forward by the Brussels Working Groups and the author's data.

Nannofossil biozones are generally supposed to have been devised utilising easily-recognisable, frequently-occurring members of evolutionary lineages, with subzones supposedly based on taxa which do not necessarily fulfill these requirements. In these respects, the Sissingh/Perch-Nielsen scheme has been generally acceptable and useful. It seems, however, that the only way forward in nannofossil biozonation and correlation, as we learn more about palaeobiogeographical and palaeoecological constraints on spatial distributions and abundances of taxa, and as we become more aware of stage boundaries, is by ongoing refinement of their subzones. In order to achieve this, we must be prepared to start to utilise and incorporate anything that appears to have a reliable FAD or LAD, whether it is abundant or not, or biogeographically restricted or not, but which can be correlated elsewhere, either directly or via sequences which contain mixed (*e.g.* high- and low-latitude) nannofloral elements derived from adjacent palaeobiogeographical provinces. This approach has been adopted by the author, and the proposed new zonation scheme (Burnett in prep., a) will incorporate this feature.

Upper Cretaceous (Sub-)Stage boundary proposals and nannofossils

The definition of Cretaceous stage boundaries is a momentous event! So far, all definitions have been unofficial. Once the proposals for GSSPs have been ratified, we will be obliged to redefine our nannofossil zonations with respect to these boundaries, since the GSSP "must be used without modification...[although an author may]...express his personal opinion, but the author will be obliged to make clear what is the general consensus compared to his personal views" (Remane *et al.*, 1995, p.6).

Figure 2 contains a summary of the proposals for Upper Cretaceous stage-boundary stratotypes and marker events put forward by the Brussels Working Groups. The formal proposals will be published by summer 1996 in the conference volume of the Brussels meeting. The candidates for event and stratotype had to fill certain requirements in order to qualify: the correlation potential of the GSSP had to be demonstrated; the event and stratotype had to respect historical precedents where possible; the boundary event had to lie within a "bundle of successive events" (Remane *et al.*, 1995, p.5); the boundary sections had to be well-exposed, easily accessible, unaltered, complete, expanded, with one facies crossing the boundary, and not tectonically disturbed; they had to contain a variety of well-preserved fossil groups, which showed no ecologically-related FADs or LADs across the boundary; the boundary event had to preferably be a FAD; data concerning magnetostratigraphy, chemostratigraphy and radiometric dates were expected to be available also. Despite the requirements, it was realistically observed that 'the perfect stratotype' was unlikely to exist for every boundary, and that it may not have been possible to fulfill every criterion.

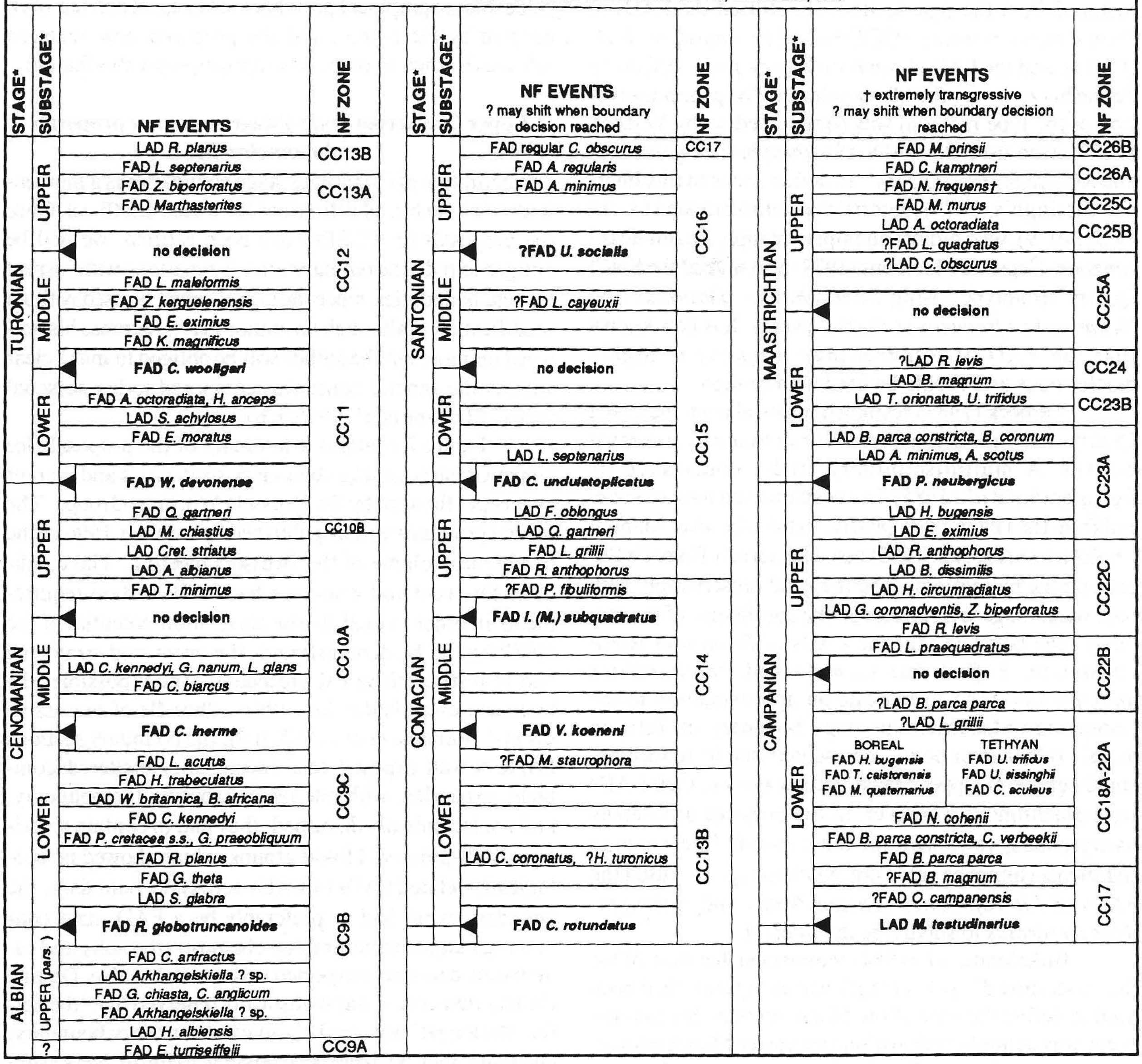
Figure 3 summarises the nannofossil data in relation to the proposed boundaries, using the Sissingh/Perch-Nielsen scheme as a framework but incorporating the author's original work, and thus introducing some novel events (the utility of these and a number of other events is currently being assessed further before a new zonation scheme is published). Gaps in the data are currently being filled, and all of the nannofossil data is being prepared for publication.

The nannofossil data and confirmatory observations come from numerous sections, including: Belgium, Bulgaria, the Czech Republic, Denmark, England, France, Germany, The Netherlands, the North Sea, Poland, Russia, South Africa, Spain, the USA (Arizona, Colorado, Texas, the eastern sea-board), and the Indian, North and South Atlantic, and Pacific Oceans.

Nannofossil taxon names referred to herein are those in current usage and authors can be found in Perch-Nielsen (1985).

FIGURE 3: POTENTIALLY USEFUL NANNOFOSSIL EVENTS AROUND UPPER CRETACEOUS (SUB-)STAGE BOUNDARIES - STATE OF THE ART

*BASED ON STAGE -BOUNDARY WORKING GROUP PROPOSALS, BRUSSELS, 1995



Acknowledgements

This research was originally funded by the NERC (GR/6767, 1988-1991) and a NERC/ODP Special Topic Fellowship (1991-1993). The Royal Society and the Department of Geological Sciences, UCL facilitated my attendance at the Stage Boundaries conference in Brussels, where a summary of this research was presented as a poster. I am grateful to both of these institutions. I would, however, especially like to thank those people who have allowed (and helped) me to carry on with this research despite a recent, crippling lack of funding. They know who they are.

REFERENCES

Bailey, H.W., Gale, A.S., Mortimore, R.N.,Swiecicki, A. & Wood, C.J. 1984: Biostratigraphical criteria for the recognition of the Coniacian to Maastrichtian stage boundaries in the chalk of north-west Europe, with particular reference to southern England. *Bulletin of the Geological Society of Denmark*, **33**(1/2): 31-40.

Birkelund, T., Hancock, J.M., Hart, M.B., Rawson, P.F., Remane, J., Robaszynski, F., Schmid, F. & Surlyk, F. 1984: Cretaceous stage boundaries - Proposals. *Bulletin of the Geological Society of Denmark*, **33**(1/2): 3-20.

Bless, M.J.M., Djaiz, R., Felder, P.J., Jagt, J.W.M. & Roebroeks, W. 1987: "Session extraordinaire" of the two Belgian Geological Societies on the Late Cretaceous and Quaternary in the Liége-Maastricht-Heerlen area, 12-14 June, 1987. *Bulletin de la Societé belge de la Géologie*, **96**(4): 309-323.

Bown, P.R., Burnett, J.A. & Gallagher, L.T. 1991: Critical events in the evolutionary history of calcareous nannoplankton. *Historical Biology*, **5**: 279-290.

Bown, P.R., Burnett, J.A. & Gallagher, L.T. 1992: Calcareous nannoplankton evolution. *Memorie di Scienze Geologiche. Memorie degli Instituti di Geologia e Mineralogia dell'Universita di Padova*, **43**: 1-17.

Bralower, T.J. 1988: Calcareous nannofossil biostratigraphy and assemblages of the Cenomanian-Turonian boundary interval: implications for the origin and timing of oceanic anoxia. *Paleoceangraphy*, **3**(3): 275-316.

Bramlette, M.N. & Martini, E. 1964: The great change in calcareous nannoplankton fossils between the Maestrichtian and Danian. *Micropaleontology*, **10**(3): 291-322.

Burnett, J. A. 1990: New nannofossil zonation scheme for the Boreal Campanian. *International Nannoplankton Association Newsletter*, **12**(3): 67-70.

Burnett, J.A. In prep., a: Upper Cretaceous. *In*: P.R. Bown (Ed.). *New Stratigraphical Atlas of Calcareous Nannofossils*. British Micropalaeontological Society.

Burnett, J.A. In prep., b: The Indian Ocean: an improved trans-latitudinal Late Cretaceous calcareous nannofossil zonation scheme with implications for palaeobiogeography, palaeoclimatology and palaeoceanography. (For submission to *Marine Micropalaeontology*).

Burnett, J.A. In prep., c: The Atlantic Ocean: trans-latitudinal Late Cretaceous calcareous nannofossil zonal correlation and implications for palaeobiogeography, palaeoclimatology and palaeoceanography. (For submission to *Cretaceous Research*)..

Burnett, J.A. In prep., d: Note on the nannofloras of the Salzgitter-Salder Quarry, Germany, and the Turonian/Coniacian boundary.

Burnett, J.A. In prep., e: Nannofloras from the Boreal Santonian to Maastrichtian: northern England, northern Germany and Poland.

Burnett, J.A., Hancock, J.M. & Kennedy, W.J. In prep. (a) : Nannofossil and macrofossil biozonation of the Turonian to Coniacian interval: a correlation between northern Germany, the Czech Republic and England.

Burnett, J.A., Hancock, J.M., Kennedy, W.J. & Lord, A.R. 1992(a):. Macrofossil, planktonic foraminiferal and nannofossil zonation at the Campanian/Maastrichtian boundary. *Newsletters on Stratigraphy*, **27**(3): 157-172.

Burnett, J., Kennedy, J., Hancock, J. & Lord, A. 1992 (b): Towards an integration of biostratigraphical zonation schemes at the Campanian/Maastrichtian boundary. *Géologie Africaine: Colloques de Géologie de Libreville, 6-8 Mai 1991, Recueil des Communications. Bulletin des Centres de Récherches Exploration-Production Elf-Aquitaine, Mémoire* **13**: 189-194.

Burnett, J.A., Kennedy, W.J. & Ward, P.D. 1992 (c): Maastrichtian nannofossil biostratigraphy in the Biscay region (south-western France, northern Spain). *Newsletters on Stratigraphy*, **26**(2/3): 145-155.

Čepek, P. & Moorkens, T. 1979: Cretaceous/Tertiary boundary and Maastrichtian-Danian biostratigraphy (coccoliths and foraminifera) in the Maastrichtian type area. *In*: W.K. Christensen & T. Birkelund (Eds). *Cretaceous-Tertiary Boundary Events, Symposium: II. Proceedings*. University of Copenhagen, pp.137-142.

Cobban, W.A., Gale, A.S. & Kennedy, W.J. 1995: Pueblo, Colorado: a candidate boundary stratotype for the base of the Turonian stage. Unpublished discussion document for the Turonian Working Group.

Crux, J.A. 1982: Upper Cretaceous (Cenomanian to Campanian) calcareous nannofossils. *In*: A.R. Lord (Ed.). *A Stratigraphical Index of Calcareous Nannofossils*: 81-135. British Micropalaeontological Society Series/Ellis Horwood Limited, Chichester.

Felder, P.J., Felder, W.M. & Bromley, R.G. 1980: The type area of the Maastrichtian stage. *In*: T. Birkelund & R.G. Bromley (Eds). *The Upper Cretaceous and Danian of NW Europe: guide to excursion A-69. 26th International Geological Congress, Paris, 7-17 July, 1980*: 118-137.

Gale, A.S., Hancock, J.M., Kennedy, W.J., Burnett, J.A. & McLeod, N. In prep. (a): Recognition of the Coniacian/Santonian boundary in Texas using integrated biostratigraphy.

Gale, A.S. *et al.* In prep. (b). Recognition of the Santonian/Campanian boundary in Texas using integrated biostratigraphy.

Gale, A.S., Kennedy, W.J., Burnett, J.A., Caron, M. & Marshall, J.D. In press (a): The Late Albian to Early Cenomanian succession near Rosans (Drôme, SE France); an integrated study (ammonites, inoceramids, planktonic foraminifera, nannofossils, oxygen and carbon isotopes). *Cretaceous Research*. (Accepted).

Gale, A.S., Montgomery, P., Kennedy, W.J., Hancock, J.M., Burnett, J.A. & McArthur, J.M. In press (b): Definition and global correlation of the Santonian-Campanian boundary. *Terra Nova*. (Accepted).

Gradstein, F.M., Agterberg, F.P., Ogg, J.G., Hardenbol, J., Veen, P. van, Thierry, J. & Huang, Z. 1994: A Mesozoic time scale. *Journal of Geophysical Research*, **99**(B12): 24 051-24 074.

Hancock, J.M., Peake, N.B., Burnett, J., Dhondt, A.V., Kennedy, W.J. & Stokes, R.B. 1993: High Cretaceous biostratigraphy at Tercis, south-west France. *Bulletin de l'Institute Royal des Sciences Naturelles de Belgique. Sciences de la Terre*, **63**: 133-148.

Heck, S.E. van 1979: Nannoplankton contents of the Type-Maastrichtian. *International Nannoplanklton Association Newsletter*, **1**(1): N5-N6.

Jagt, J.W.M., Burnett, J. & Kennedy, W.J. In press. Upper Campanian ammonites and nannofossils from South Limburg, The Netherlands. *Mededelingen van's Rijks Geologischen Dienst Leiden*. (Accepted).

Jagt, J.W.M., Kennedy, W.J. & Burnett, J. 1992.: *Acanthoscaphites tridens* (Kner, 1848) (Ammonoidea) from the Vijlen Member (Lower Maastrichtian) of Gulpen, Limburg, The Netherlands. *Geologie en Mijnbouw*, **71**: 15-21.

Jarvis, I., Carson, G.A., Cooper, M.K.E., Hart, M.B., Leary, P.N., Tocher, B.A., Horne, D. & Rosenfeld, A. 1988: Microfossil Assemblages and the Cenomanian-Turonian (late Cretaceous) Oceanic Anoxic Event. *Cretaceous Research*, **9**: 3-103.

Kennedy, W.J. 1995a: Ammonite definitions of Cenomanian Substages. Unpublished discussion document for the Cenomanian Working Group.

Kennedy, W.J. 1995b: Defining the base of the Coniacian and its substages. Unpublished discussion document for the Coniacian Working Group.

Kennedy, W.J. 1995c: Defining the base of the Santonian and its substages using macrofossils. Unpublished discussion document for the Santonian Working Group.

Kennedy, W.J., Burnett, J.A., Christensen, W.K., Dhondt, A.V. & Jagt, J.W.M. In press: Santonian macrofauna and nannofossils from northeast Belgium. *Bulletin de l'Institute Royal des Sciences Naturelles de Belgique. Sciences de la Terre*, **65**. (Accepted).

Kennedy, W.J., Christensen, W.K. & Hancock, J.M. 1995: Defining the base of the Maastrichtian and its substages. Unpublished discussion document for the Maastrichtian Working Group.

Kennedy, W.J. & Hancock, J.M. 1995: Macrofossil definitions of the base of the Campanian and its substages. Unpublished discussion document for the Campanian Working Group.

Kennedy, W.J., Hansotte, M., Bilotte, M. & Burnett, J. 1992: Ammonites and nannofossils from the Campanian of Nalzen (Ariége, France). *Geobios*, **25**(2): 263-278.

Lambert, B. 1980: Étude de la nannoflore calcaire du Campanien Charentais. *Cahiers de Micropaléontologie*, **3**: 39-53.

Manivit, H. 1971: Nannofossiles calcaires du Crétacé français (Aptien-Maestrichtien). Essai de Biozonation appuyée sur les stratotypes. Thése, Université de Paris.

Manivit, H., Perch-Nielsen, K., Prins, B. & Verbeek, J.W. 1977: Mid Cretaceous calcareous nannofossil biostratigraphy. *Proceedings of the Koninklijke Akademie van Wetenschappen Amsterdam (Physical Sciences)*, **B80**: 169-181.

McArthur, J.M., Kennedy, W.J., Gale, A.S., Thirlwall, M.F., Chen, M., Burnett, J. & Hancock, J.M. 1992: Strontium isotope stratigraphy in the Late Cretaceous: intercontinental correlation of the Campanian/Maastrichtian boundary. *Terra Nova*, **4**: 385-393.

Naji, F. 1995: Calcareous nannoplankton biostratigraphy of the Salzgitter-Salder Limestone Quarry, Lower Saxony, Germany. *Journal of Nannoplankton Research*, **17**(2). Abstract.

Obradowich, J. 1993: A Cretaceous Time Scale. *Geological Association of Canada Special Paper*, **39**: 379-396.

Perch-Nielsen, K. 1979: Calcareous Nannofossils from the Cretaceous between the North Sea and Mediterranean. *Aspekte der Kreide Europas. IUGS Series a*, **No.6**: 223-272.

Perch-Nielsen,, K. 1983: Recognition of Cretaceous stage boundaries by means of calcareous nannofossils. In: T. Birkelund, R. Bromley, W.K. Christensen, E. Hakansson & F. Surlyk (Eds). *Symposioum on Cretaceous Stage Boundaries, Copenhagen , October 18-21, 1983, Abstracts*: 152-156. University of Copenhagen.

Perch-Nielsen,, K. 1985: Mesozoic calcareous nannofossils. *In*: H.M. Bolli, J.B. Saunders & K. Perch-Nielsen (Eds). *Plankton Stratigraphy*: 329-426. Cambridge University Press.

Perch-Nielsen,, K. 1986: Call for help. *INA Newsletter*, **8**(2): 64-65.

Remane, J., Bassett, M.G., Cowie, J.W., Gohbandt, K.H. & Wand, N. with the cooperation of members of ICS 1995: Guidelines for the establishment of global chronostratigraphic standards by ICS (revised). Unpublished discussion document.

Robaszynski, F. 1983: Conclusions to the Colloquium on the Turtonian stage: Integrated biostratigraphic charts and facies maps (France and adjacent areas). *Zitteliana*, **10**: 585-594.

Robaszynski, F. (Co-ord.), Alcayde, G., Amedro, F., Badillet, G., Damotte, R., Foucher, J.-C., Jardine, S., Legoux, O., Manivit, H., Monciardini, C. & Sornay, J. 1982: Le Turonien de la région-type: Saumurois et Touraine. Stratigraphie, biozonations, sédimentologie. *Bulletin des Centres de Récherches Exploration-Production Elf-Aquitaine*, **6**(1): 119-225.

Robaszynski, F., Bless, M.J.M., Felder, P.J., Foucher, J.-C., Legoux, O., Manivit, H., Meessen, J.P.M.T. & Tuuk, L.A. van der 1985: The Campanian-Maastrichtian boundary in the chalky facies close to the type-Maastrichtian area. *Bulletin des Centres de Récherches Exploration-Production Elf-Aquitaine*, **9**(1): 1-113.

Robaszynski, F., Caron, M., Amedro, F., Dupuis, C., Hardenbol, J., Gonzales-Donoso, J.M., Linares, D. & Gartner, S. 1994: Le Cénomanien de la région de Kalaat Senan (Tunisie Centrale). *Révue de Paléobiologie*, **12**: 351-505.

Robaszynski, F., Hardenbol, J., Caron, M., Amedro, F., Dupuis, C., Gonzales-Donoso, J.M., Linares, D. & Gartner, S. 1993: Sequence stratigraphy in a distal environment: the Cenomanian of the Kalaat Senan region (Central Tunisia). *Bulletin des Centres de Récherches Exploration-Production Elf-Aquitaine*, **17**: 395-433.

Schönfeld, J. & Burnett, J. 1991: Biostratigraphical correlation of the Campanian-Maastrichtian boundary: Lägerdorf-Hemmoor (northwestern Germany), DSDP Sites 548A, 549 and 551 (eastern North Atlantic) with palaeobiogeographical and palaeoceanographical implications. *Geological Magazine*, **128**(5): 479-503.

Schönfeld, J. & Schulz, M.-G. (Co-ords), McArthur, J.M., Burnett, J., Gale, A., Hambach, U., Hansen, H.J., Kennedy, W.J., Rasmussen, K.L., Thirlwall, M.F. & Wray, D. In press: New results on biostratigraphy, palaeomagnetism, geochemistry and correlation from the standard section for the Upper Cretaceous White Chalk of northern Germany (Lägerdorf-Kronsmoor-Hemmoor). *Proceedings of the 4th International Cretaceous Symposium, Hamburg 1992. Mitteilungen des Geologisch-Paläontologischen Instituts der Universität Hamburg, Special Issue*. (Accepted).

Sissingh, W. 1977: Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw*, **56**(1): 37-65.

Sissingh, W. 1978: Microfossil biostratigraphy and stage-stratotypes of the Cretaceous. *Geologie en Mijnbouw*, **57**(3): 433-440.

Thierstein, H.R. 1976: Mesozoic calcareous nannoplankton biostratigraphy of marine sediments. *Marine Micropaleontology*, **1**: 325-362.

Verbeek, J.W. 1976: Upper Cretaceous calcareous nannoplankton from Ballon and Théligny in the type area of the Cenomanian stage (Sarthe, France). *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen*, **B79**: 69-82.

Verbeek, J.W. 1977: Calcareous nannoplankton biostratigraphy of Middle and Upper Cretaceous deposits in Tunisia, southern Spain and France. *Utrecht Micropaleontological Bulletins*, **16**: 157pp.

Verbeek, J.W. 1983: The calcareous nannofossils from the Campanian and Maastrichtian rocks of southern Limburg (The Netherlands) and the adjacent Belgian area. *In*: T. Birkelund, R. Bromley, W.K. Christensen, E. Hakansson & F. Surlyk (Eds). *Abstracts - Symposium on Cretaceous Stage Boundaries, Copenhagen, October 18-21, 1983*. University of Copenhagen, pp.197-200.

Watkins, D.K. 1985: Biostratigraphy and paleoecology of calcareous nannofossils in the Greenhorn marine cycle. *Society of Economic Paleontologists and Mineralogists Guidebook*, **4**: 151-156.

Watkins, D.K., Wise, S.W., Pospichal, J.J. & Crux, J. In press: Upper Cretaceous calcareous nannofossil biostratigraphy of the Southern Ocean. *Proceedings of the British Micropalaeontological Society ODP Meeting, 1994*.

Wood, C.J., Ernst, G. & Rasemann, G. 1984: The Turonian-Coniacian stage boundary in Lower Saxony (Germany) and adjacent areas: the Salzgitter-Salder Quarry as a proposed international standard section. *Bulletin of the Geological Society of Denmark*, **33**(1/2): 225-238.

BIBLIOGRAPHY AND TAXA OF CALCAREOUS NANNOPLANKTON -26

Compiled by William G. Siesser

A5193 **AKSU, A.E., YASAR, D., & MUDIE, P.J.** **1995** Ecol.
Paleoclimatic and paleoceanographic conditions leading to development of sapropel layer S1 in the Aegean Sea. QUAT. Mediterr.
♦ Paleogeogr., Palaeoclimatol., Palaeoecol., 116: 71-101.

A5194 **BEIERSDORF, H., BICKERT, T., ČEPEK, P., FENNER, J., PETERSEN, N., SCHONFELD, J., WEISS, W., WON, M.-Z.** **1995** (Strat.); (Syst.)
High-resolution stratigraphy and the response of biota to late Cenozoic environmental changes in the central equatorial Pacific Ocean (Manihiki Plateau). QUAT.; TERT.U. Pacific C.
♦ Mar. Geol., 125(1-2): 29-59.

A5195 **BELLANCA, A., DI STEFANO, P., & NERI, R.** **1995** Ecol.
Sedimentology and isotope geochemistry of Carnian deep-water marl/limestone deposits from the Sicani Mountains, Sicily: environmental implications and evidence for a planktonic source of lime mud. TRI.U. Europe W.
♦ Palaeogeogr., Palaeoclimatol., Palaeoecol., 114: 111-129.

A5196 **BUSSON, G., NOËL, D., CORNEE, A., AMEDRO, F., MANGIN, A.M., & COLLETE, C.** **1995** Strat;Ecol.
The dawn of the chalk. CRET.
♦ Bull. Soc. Geol. France, 166(2): 193-206. Europe W.
(In French with English abstract)

A5197 **CHEPSTOW-LUSTY, A. & CHAPMAN, M.** **1995** (Strat.); Ecol.
The decline and extinction of upper Pliocene discoasters: a comparison of two equatorial Pacific Ocean records. TERT.U. Pacific C.
♦ J. Nannoplankton Res., 17(1): 15-19.

A5198 **COBIANCHI, M. & VILLA, G.** **1992** Strat.; (Syst.)
Biostratigraphy of the Calpionella Limestone and Palombini Shales in the Statale section (Val Graveglia, Ligurian Appennine). CRET.L; JURA.U.
♦ Atti Tic. Sci. Terra., 35: 199-211.
(In Italian with English abstract)

A5199 **CONTI, M.H., THOMPSON, A., EGLINTON, G., & GREEN, J.C.** **1995** Biol.;Ecol.
Lipid biomarker diversity in the coccolithophorid *Emiliania huxleyi* (Prymnesiophyceae) and the related species *Gephyrocapsa oceanica*. Living
♦ J. Phycol., 31: 272-282.

A5200 **GIRAUDEAU, J. & BAILEY, G.W.** **1995** Ecol.;Syst.
Spatial dynamics of coccolithophore communities during an upwelling event in the Southern Benguela system. Living Atlantic S.
♦ Cont. Shelf Res., 15(14): 1825-1852.

A5201 **HAYS, G.C., WARNER, A.J., JOHN, A.W.G., HARBOUR, D.S., & HOLLIGAN, P.M.** **1995** Ecol.
Coccolithophores and the Continuous Plankton Recorder survey. Living
♦ J. Mar. Biol. Assn., 75: 503-506. Atlantic N.

A5202 **HECK, S.E. van** **1995** Syst.
The ICBN: things you need to know – 12.
♦ J. Nannoplankton Res., 17(1): 5-7.

A5203 **LARSEN, H.C., SAUNDERS, A.D., CLIFT, P.D. & THE SHIPBOARD SCIENTIFIC PARTY.** **1994** Strat. TERT.L-U.
♦ Proc. ODP, Init. Reports, v. 152 (East Greenland Margin: Sites 914-919). 977 pp. Atlantic N.
[Nannofossils by W. Wei].

A5204 **MAI, H.** **1995** Tech.
Uncoated, low-voltage SEM analysis of both proximal and distal views of the same coccoliths.
♦ J. Nannoplankton Res., 17(1): 9-13.

A5205 **MARTIN, R.E.** **1995** Ecol.
Cyclic and secular variation in microfossil biomineralization: clues to the biogeochemical evolution of Phanerozoic oceans. TRI-QUAT.
♦ Global Planet. Change, 11: 1-23.

A5206 **MILLER, K.G. et al.** **1994** Strat.
♦ Proc. ODP, Init. Reports, v. 150X (Island Beach and Atlantic City Sites, New Jersey Coastal Plain). 55 pp. TERT.L-U.; CRET.U.
[Nannofossils by M.-P. Aubry and D. Bukry]. America N.

A5207 **MOUNTAIN, G.S., MILLER, K.G., BLUM, P., & THE SHIPBOARD SCIENTIFIC PARTY.** **1994** Strat.
♦ Proc. ODP., Init. Reports, v. 150 (New Jersey Continental Slope and Rise: Sites 902-906). 885 pp. TERT.L-U. Atlantic N.
[Nannofossils by M.-P. Aubry and S. Gartner].

A5208 **PRAHL, F.G., PISIAS, N., SPARROW, M.A., & SABIN, A.** **1995** Ecol.
Assessment of sea-surface temperature at 42 degrees N in the California Current over the last 30,000 years. Living Pacific N.
♦ Paleoceanography, 10(4): 763-773.

A5209 **RAHMAN, A.** **1995** (Strat.)
Reworked nannofossils in the North Atlantic Ocean and subpolar basins: implications for Heinrich events and ocean circulation. QUAT. Atlantic N; Europe W.
♦ Geology, 23(6): 487-490.

A5210 **RIAUX-GOBIN, C., CHRETIENNOT-DINET, M.-J., & DESCOLAS-GROS, C.** **1995** (Syst.); Ecol.
Undamaged sedimented coccolithophorids in a deep environment (continental slope of the Gulf of Lions). Mediterr.
♦ Mar. Geol., 123: 239-252.

A5211 **SAMTLEBEN, C., SCHAFER, P., ANDRULEIT, H., BAUMANN, A., BAUMANN, K.-H., KOHLY, A., MATTHIESSEN, J., & SCHRODER-RITZRAU, A.** **1995** Ecol. Living
Plankton in the Norwegian-Greenland Sea: from living communities to sediment assemblages -- an acualistic approach. Atlantic N.
♦ Geol. Rundschau, 84: 108-136.

A5212 **SAXENA, R.K. & MISRA, C.M.** **1995** Strat.; (Syst.)
Campanian-Maastrichtian nannoplankton biostratigraphy of the Narsapur claystone Formation, Krishna-Godvari Basin, India. CRET.U. Asia S.
♦ J. Geol. Soc. India, 45: 323-329.

A5213 **SIESSER, W.G.** **1995** Ecol.
Paleoproductivity of the Indian Ocean during the Tertiary Period. TERT.L-U.
♦ Global Planet. Change, 11: 71-88. Indian

A5214 **SIESSER, W.G.** **1995** Bibl.
Bibliography and taxa of calcareous nannoplankton -- 25.
♦ J. Nannoplankton Res., 17(1): 21-27.

A5215 **TEW, B.H. & MANCINI, E.A.** **1995** Strat.
An integrated stratigraphic method for paleogeographic reconstruction; examples from the Jackson and Vicksburg Groups of the eastern Gulf Coastal Plain. TERT.L. America N.
♦ Palaios, 10: 133-153.

A5216 **THOMPSON, P.A.** **1995** Biol.; Ecol.
Carbon isotope fractionation by *Emiliania huxleyi*. Isot.
♦ Limnol. Oceanogr., 40(4): 673-679. Living

A5217 **THOMSEN, E.** **1987** Strat; Syst.
Lower Cretaceous calcareous nannofossil biostratigraphy in the Danish Central Trough. CRET.L.
♦ Dan. Geol. Undersogelse, Ser. A (20). 89 pp. Europe W.

A5218 **THOMSEN, E. & JENSEN, T.F.** **1989** Strat.
Aptian to Cenomanian stratigraphy in the Central Trough of the Danish North Sea sector. CRET.L-U.
♦ Geol. Jb., 113: 337-358. Europe W.

A5219 **VANFOSSEN, M.C., CHANNELL, J.E.T., & BRALOWER, T.J.** **1995** (Strat.) K/T BDY America C.
Geomagnetic polarity stratigraphy and nannofossil biostratigraphy at the K/T boundary section near Beloc, Haiti.
♦ Cretaceous Res., 16(1): 131-140.

A5220 **WEI, W.** **1995** Strat. TERT.L. Worldwide
How many impact-generated microspherule layers in the upper Eocene?
♦ Palaeogeogr., Palaeoclimatol., Palaeoecol., 114: 101-110.

A5221 **WEI, W.** **1995** (Strat.) TERT.L-U. Worldwide
Revised age calibration points for the geomagnetic polarity time scale.
♦ Geophys. Res. Lett., 22(8): 957-960.

A5222 **WILLIAMS, J.R. & BRALOWER, T.J.** **1995** Strat; Ecol. Isot. Atlantic N; Europe W.
Nannofossil assemblages, fine fraction stable isotopes, and the paleoceanography of the Valanginian-Barremian (Early Cretaceous) North Sea Basin.
♦ Paleoceanography, 10(4): 815-839.

OTHER TITLES

A5223 **FIRTH, J.** **1995** Report
Ocean Drilling Program News.
♦ J. Nannoplankton Res., 17(1): 4-5.

A5224 **PAASCHE, E.** **1995** Review
Book Review – Coccolithophores.
♦ Limnol. Oceanogr., 40(3): 645-646.

A5225 **VON SALIS, K.** **1995** Review
Book Review – Coccolithophores.
♦ Mar. Geol., 123: 117-123.

A5226 **YOUNG, J.R. & BURNETT, J.A. on behalf of INA COMMITTEE.** **1995** Reports; Reviews
News and Gossip.
♦ J. Nannoplankton Res., 17(1): 2-4.

TAXA

No new taxa were reported in these publications.

INA MEMBERSHIP CHANGES

Compiled by Kevin Cooper

NEW MEMBERS

O. Dmitrenko
Institute of Oceanology
Krasikova 23
Moscow 117218
RUSSIA

Hanno Kinkel
FB Geowissenschaften
University of Bremen
Postfach 330 440
D-28334 Bremen
GERMANY

Erik Thomsen
Dept. of Geology
CF Mollers Alle
Aarhus University
DK-8000 Arhus C
DENMARK

Alexandra Zeltner
GPI Tübingen
Sigwartstrasse 10
72076 Tübingen
GERMANY

Christianne Ellison
Dept. of Geological Sciences
University College London
Gower Street
London WCE BT
UK

Cecile Laporte - Galaa
CST TOTAL
Route de Vesailles
Domaine de Beauplan
78470 St. Remy les Chevieuse
FRANCE

M. Ushakova
Institute of Oceanology
Krasikova 23
Moscow 117218
RUSSIA

CHANGES OF ADDRESS

Heinz Hekel
120 Rainbow Street
Sandgate
4017 Queensland
AUSTRALIA

David Rutledge
1 Moss Road
Ballynahinch
County Down
N. Ireland BT24 8EG
UK

Steve Starkie
Geochem Group Limited
Stratigraphy Division
Chester Street
Chester CH4 84D
UK

Patrizia Ziveri
via Manzoni 5
43100 Parma
ITALY

Michael Knappertsbusch
Naturhistorisches Museum
Augustinergasse 2
Postfach 4001-Basel
SWITZERLAND

Shell UK Explor.&Prod. UET Library-UETC/31
Shell Mex House
The Strand
London WC2R 0DX
UK

Dawn Windley
59 Hungerford Road
Lower Weston
Bath BA1
Avon
UK

INTERNATIONAL NANNOPLANKTON ASSOCIATION ACCOUNTS APRIL 1994 to MARCH 1995

UK ACCOUNT	**Ł STERLING**
OPENING BALANCE	**3060.19**
INCOME	
SUBSCRIPTIONS	1866.50
SALE OF BACK ISSUES	247.80
FLORENCE PROCEEDINGS	204.00
PRAGUE PROCEEDINGS (INA STOCK *[1])	30.00
INTEREST	2.24
TOTAL	**2350.54**
EXPENDITURE	
16(2) [printing, postage, labour, bank charges]	1239.03
16(3) [printing, postage, labour, bank charges]	1151.00
FLOAT *[2]	500.00
DORSET FIELD TRIP*[3]	120.00
PRAGUE PROCEEDINGS	111.00
UNPAID CHEQUE *[4]	82.00
POSTAGE	172.17
PHOTOCOPYING	65.69
MISCELLANEOUS	34.58
TOTAL	**3475.47**

USA ACCOUNT	**US $**
OPENING BALANCE	**4646.03**
INCOME	
SUBSCRIPTIONS	2150.53
TOTAL	**2150.53**

BALANCE	**Opening balance**	**Income**	**Expenditure**	**Closing balance**
UK account	Ł3060.19	Ł2350.54	Ł3475.47	**Ł1935.26**
US account	$4646.03	$2150.53 $0		**$6796.56**

*[1] INA purchased sets of the Prague Proceedings. These are held in storage at University College London, c/o Paul Bown.

*[2] A float of Ł500.00 is held by Bohumil Hamršmíd in the Czech Republic where the Journal is now printed.

*[3] Arranged and authorised by Jeremy Young for payment of accommodation of three Czech Republic INA members visiting the UK.

*[4] This cheque was reissued and has now cleared through the account. It will be included in the 1995-96 accounts.