The Palaeontology Newsletter

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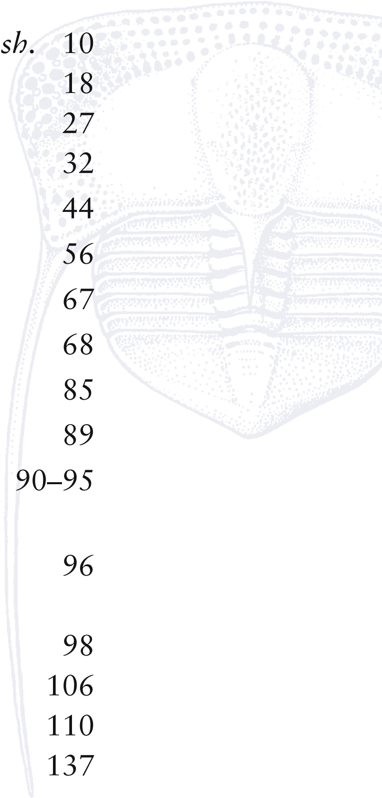
48th Annual Meeting



Reminder: The deadline for copy for Issue no 58 is 11th February 2005

On the Web: <**http://www.palass.org/**>

Association Business

48TH ANNUAL GENERAL MEETING AND ANNUAL ADDRESS

48th Annual General Meeting and Annual Address

Saturday, 18th December 4.45 to 5.10 pm

MACC Congress Centre, USTL campus at Villeneuve d'Ascq.

AGENDA

1. Apologies for absence
2. Annual Report for 2003
3. Accounts and Balance Sheet for 2003
4. Changes to subscription rates
5. Presentation of the Lapworth Medal
6. Presentation of the Hodson Fund
7. Presentation of the Mary Anning Awards
8. Election of Council and vote of thanks to retiring members
9. Annual address

H. A. Armstrong
Secretary

AGM MINUTES 2003

Minutes of the Annual General Meeting held on Wednesday, 7th May 2003 at the Natural History Museum, London.

Apologies for absence: Prof. D.E.G. Briggs, Prof. S.K. Donovan, Dr S. Evans, Dr S. Gabbott, Prof. J. Hancock, Prof. D.A.T. Harper, Dr E. Harper, Dr J. Hilton, Dr A.L.A. Johnson, Dr I.J. Sansom.

1. Annual Report for 2002. Agreed, proposed by Dr Donoghue and seconded by Dr Purnell.

2. Accounts and Balance Sheet for 2002. Agreed, proposed by Dr Polly and seconded by Dr Manning.

3. Election of Council and vote of thanks to retiring members

i. Dr Smith extended a vote of thanks to the retiring members of Council Dr J. Clack, Dr A.L.A. Johnson, Dr I.J. Sansom, Dr S. Gabbott, Dr P. Orr and Dr Milsom. Dr Purnell extended a vote of thanks to Dr Smith.

ii. It was noted the following members of Council would be moving to new posts: Dr M.A. Purnell (Vice president), Prof. E.N.K. Clarkson (Ed.) and Dr Polly (Ed.). Dr Hilton will take over responsibility as Web Officer.

iii. New members of Council include Dr. L. Anderson (Ed., co-opted), Dr Per Ahlberg (Ed.).

4. Sylvester-Bradley Awards

i. Dr Smith announced eight grants had been awarded to Broughton, Gladwell, Harrington, Hernandez-Castillo, Lane, Joomun, Tetlie and Zuykov

5. Proposed change to Constitution article 3

i. It was agreed to include the category of Honorary Life Membership, proposed by Prof. E.N.K. Clarkson, seconded by Dr Cusack.

Howard A. Armstrong
Secretary

Sylvester-Bradley Award

Awards are made to assist palaeontological research (travel, visits to museums, fieldwork *etc.*), with each award having a maximum value of £1,000. Preference is given to applications for a single purpose (rather than top-ups of other grant applications) and no definite age limit is applied, although some preference may be given to younger applicants or those at the start of their careers. The award is open to both amateur and professional palaeontologists, but preference will be given to members of the Association. The awards are announced at the AGM.

Council will also consider awards in excess of £1,000, particularly for pilot projects which are likely to facilitate a future application to a national research funding body.

Electronic submission of applications, through the website, is preferred and will comprise a CV, an account of research aims and objectives (5,000 characters maximum), and a breakdown of the proposed expenditure. Each application should be accompanied by the names of a personal and scientific referee. Successful candidates must produce a report for *Palaeontology Newsletter* and are asked to consider the Association's meetings and publications as media for conveying the research results. **Deadline: Friday 26th November 2004**.

Prestigious new website award from PalAss

“The Golden Trilobite Awards”

Over the past few years there has been an exponential increase in the number of quality websites promoting palaeontology and its allied sciences. These are widely used by professionals and amateurs alike and are a valuable resource for our science. Council has decided to recognise the work that goes into developing these sites by awarding an annual **Website Award**. Awards will be announced at the AGM and published on our website and in the *Newsletter*. There will be two awards, decided by Council members for the best institutional and amateur sites.

To get the ball rolling for this year, two websites have been recognised as reaching the highest standards:

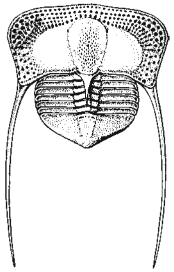
Institutional Award: The echinoid directory

> <**http://www.nhm.ac.uk/palaeontology/echinoids/**>
>
> The echinoid directory is ostensibly a taxonomic resource for the scientific community in which the genera and higher taxa of echinoids can be simply and rapidly identified. There are currently over 350 pages of detailed information about echinoid taxa, including colour images of the highest quality. The site also provides an introduction to the anatomy, biology, ecology, ontogeny and phylogeny of echinoids, as well as a key to aid identification. The site has been designed and created by Andrew Smith of the Department of Palaeontology, Natural History Museum, London.

Amateur Award: Fossils of the Gault Clay and Folkestone Beds of Kent, UK

> <**http://www.gaultammonite.co.uk/home.html**>
>
> This site is dedicated to the fossils of the Lower Cretaceous Albian (Gault Clay and Folkestone Beds) in the county of Kent, south-east England, providing a pictorial identification to the fauna. The colour photographic images are of the highest quality. The site is based on the work and collections (much of which has subsequently been donated to the Natural History Museum, London) of the late Jim Craig, and is maintained by Fred Clouter.

Please send your nominations for the 2005 Awards to <**secretary@palass.org**>.

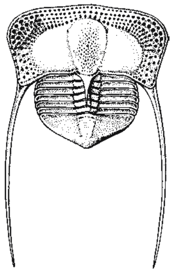


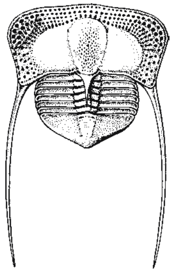
Palaeontology:

CALL FOR SHORT PAPERS!

From January 2005 *Palaeontology* will be published in A4 size with a new layout. In line with this development space will be reserved for rapid publication of short papers on topical issues, exceptional new discoveries, and major developments that have important implications for evolution, palaeoclimate, depositional environments and other matters of general interest to palaeontologists. Papers, which should not exceed 6 printed pages, should be submitted in the normal way, but they will be refereed rapidly and fast tracked, on acceptance, for publication in the next available issue.

Submission of longer review papers is also encouraged, and these too will be given priority for rapid publication. While *Palaeontology* maintains its reputation for scientific quality and presentation, these developments will ensure that the Impact Factor of the journal reflects its status as a leading publication in the field (rising to 1.19 in 2003).





ASSOCIATION MEETINGS

48th Annual Meeting of The Palaeontological Association
Lille, France *17 – 20 December 2004*

The 48th Annual Meeting of the Palaeontological Association will be held in the Congress Centre (MACC) of the Université des Sciences et Technologies de Lille (USTL), on its campus at Villeneuve d'Ascq near Lille. The opening session with a seminar on Palaeobiogeography will be held on Friday afternoon, 17th December, in the lecture hall of the Beaux Arts Museum in the centre of Lille. In the evening the Icebreaker Party will be held in the Natural History Museum of Lille, in the heart of the Capitale Européenne de la Culture 2004 (<**http://www.lille2004.fr/**>).

The technical sessions will consist of two full days of talks in the main lecture hall of the Congress Centre at Villeneuve d'Ascq on Saturday 18th and Sunday 19th December, with poster sessions in an adjoining lecture hall. Technical sessions are open to all aspects of palaeontology. All talks will be scheduled for 15 minutes including five minutes for discussion; there are no parallel sessions so it is possible that some proposed oral contributions will have to be rescheduled as posters. On Monday 20th December two geological excursions will be organised; one to examine the Mesozoic sediments on the coastal sections in the Boullonnais area, the other to the Palaeozoic (Cambrian-Devonian) rocks exposed in the Brabant Massif, Belgium.

Seminar : Palaeobiogeography

Friday, 17th December 2004 (part of the Annual Meeting)

For the second time, an afternoon seminar is added to the Annual Meeting. This afternoon of thematic talks and discussion will focus on palaeobiogeography and take place on Friday, 17th December 2004. The seminar will highlight the importance of fossils to understanding past and present palaeogeographical and biogeographical patterns. The seminar will include lectures by the following speakers:

- Fabrizio Cecca (Paléobiodiversité et Paléoenvironnements, Université Pierre et Marie Curie, Paris)
- Richard Fortey (Department of Palaeontology, The Natural History Museum, London)
- Pascal Neige (Biogéosciences, Université de Bourgogne, Dijon)
- Brian Rosen (Department of Zoology, The Natural History Museum, London)
- Chris Scotese (Department of Geology, University of Texas at Arlington)

Attendance at the seminar is free to conference participants, but only if booked in advance (limited number of seats available in the Musée des Beaux Arts Amphithéatre). Please do not turn up on the day without informing the organisers.

Venue and Travel

Details about the City of Lille can be found on the website at <**http://www.mairie-lille.fr/**>. Lille is less than two hours from London by Eurostar (<**http://www.eurostar.com/**>), and tickets at reduced prices are available if you book some weeks in advance. Lille can also be reached easily from Paris and its airport Charles de Gaulle (about one hour) and from Brussels (about 40 minutes) by TGV high speed trains. The Congress Centre can easily be reached by Metro.

Accommodation

Accommodation will mostly be organised in hotels around the Congress Centre at Villeneuve d'Ascq. This is approximately 15 minutes' walk from the conference venue. Participants are free to book alternative accommodation at a wide range of prices. Please note that the strict deadline for reservation of accommodation through the organisers is **10th September**. After this date, accommodation must be arranged by the participants themselves.

Registration and booking

Booking for accommodation, field excursions and also abstract submission for the conference must be completed by **Midnight on Friday 10th September 2004**. After this date participants will have to organise their own accommodation in Lille in order to attend the meeting. After 10th September registration for the meeting is still possile but will incur additional costs. Final registration for the meeting will be Friday 3rd December.

Registration details and online registration

<**http://www.palass.org/forms/XAnnualRegistration.html**>

For the second time, registration, abstract submission and payment (by credit card) are by online forms at <**http://www.palass.org/**>.

Outline Programme:

Friday 17th December :

Afternoon seminar, Palaeobiogeography

Lecture hall of the Beaux Arts Museum, Lille

Icebreaker party

Natural History Museum of Lille

Saturday 18th December :

Scientific sessions, followed by :

Annual Address: *Palaeontologia de profundis* by S. Bengtson (NRM, Stockholm)

Congress Centre of the Université des Sciences et Technologies de Lille

Members reception & Annual Dinner

University Restaurant 'Charles Barrois'

Sunday 19th December :

Scientific sessions:

Congress Centre of the Université des Sciences et Technologies de Lille

Monday 20th December :

Post conference excursions

Travel grants to help student members (doctoral and earlier) to attend the Lille meeting in order to present a talk or poster

The Palaeontological Association runs a programme of travel grants to assist student members presenting talks or posters at the Annual Meeting. For the Lille meeting, grants of up to £100 (or the Euro equivalents) will be available to student presenters who are travelling from outside continental Europe. The amount payable is dependent on the number of applicants. Payment of these awards is given as a disbursement at the meeting, not as an advance payment. Students interested in applying for a Palass travel grant should contact the Executive Officer, Dr Tim Palmer, by e-mail at <**palass@palass.org**> once the organisers have confirmed that their presentation is accepted and before 10th December 2004.

Annual Address

This year's Annual Address of the Palaeontological Association will be given by Prof. Stefan Bengtson and will take place during the Association's Annual Meeting, on Saturday 18th December 2004, at the Congress Centre of the Université des Sciences et Technologies de Lille.

'Palaeontologia de profundis'
Stefan Bengtson
Swedish Museum of Natural History, Stockholm <Stefan.bengtson@nrm.se>

Palaeontology is about life in deep time. The deeper we go in palaeontological time, however, the more we encounter also other aspects of depth: the depth of our understanding, the depth of our convictions, and indeed the very foundations of our science and of science in general. Through recent work in the depths of palaeontological time, I have experienced various fascinating perspectives of *palaeontologia de profundis*, ranging from the joy of working with people, rocks and fossils Down Under to the despair at the depths of our pigheadedness when deep convictions seem violated. Scientific work needs creativity, scepticism, and even conviction, in a process that can be thought of as Darwinian, but the way we let these interact with each other decides how good our science will be. In addition to scientific examples, I will give a seasonable illustration from music: Arthur Honegger's *Une cantate de noël* (A Christmas Cantata) opens with the ancient cry of despair *De profundis clamavi* (Out of the depths I cry), but the stunningly complex web of carols woven by Honegger later in the same cantata lifts the sense of despair by showing the beauty of multiple ideas in clashing harmony. Palaeontology arises out of the depths, and with the help of clashing opinions it flies. In the end, as every flier knows, convection is better than conviction to keep you in the air.

Lyell Meeting 2005: Applied Phylogeny

London *9 February 2005*

The 2005 Geological Society of London Lyell Meeting, sponsored by the Joint Committee for Palaeontology, is to be organised by The Micropalaeontology Society (Joint Convenors Haydon Bailey and John Gregory). This prestigious one-day meeting will be held at Burlington House, London on 9th February 2005. It is intended that the meeting will comprise three sessions, arranged stratigraphically (Palaeozoic, Mesozoic and Tertiary), each session with an invited keynote speaker, with the opportunity to discuss a complete range of macrofossil and microfossil subject areas within the proposed theme.

Contributors are asked to consider a single phylogenetic lineage and to pursue its development and application, both stratigraphically, and to any other area of applied usage. It is intended to publish the proceedings of the meeting at the earliest possible opportunity as a Special Publication of the Geological Society (authors' notes will be distributed prior to the meeting).

Proposed titles and abstracts should be sent to Haydon Bailey either via e-mail, or to the address below, as soon as possible so that a complete programme can be drawn up. Further details of this meeting will be made available once an initial programme has been established. Details will also be posted on the TMS website at <**http://www.tmsoc.org/**>.

Haydon Bailey (Network Stratigraphic Consulting Ltd, Unit 60,The Enterprise Centre, Cranborne Road, Potters Bar, Hertfordshire <**haydonbailey@btconnect.com**>) and John Gregory (Kronos Consulting, 33 Royston Road, St Albans, Hertfordshire AL1 5NF <**john@jgregory.demon.co.uk**>)

Rewriting the history of life: exceptionally well-preserved fossils and our understanding of evolution

BA Festival of Science, Trinity College Dublin, Ireland *5 – 9 September 2005*

Fossils are familiar objects to many people. The petrified remains of shells, bones and other rot-resistant hard-parts of organisms are the standard fare of museum displays and rock collections. But this view of fossils is misleading: looking only at hard parts gives a very distorted view of the history of life. This session will focus on recent discoveries of amazing fossils that preserve what normally rots away (dinosaurs with feathers, bizarre 500 million year old worms and other ancient oddities) and how they are reshaping our view of the evolution of life on Earth. Check out the BA website or contact the meeting organiser for further details: Dr Patrick Orr <**Patrick.Orr@ucd.ie**>, tel 00353 1 7162323, Department of Geology, University College Dublin.

From our Correspondents

The tainting of *Proc. Biol. Soc. Wash.*

Maybe I was simply obtuse most of my life. Perhaps the blinkers only just now fell from my eyes. I must admit that it never had my explicit interest in the first place, too little time and too many other things to do. Maybe I had never really looked around me before I started noticing it. Sure, I had heard that there were differences between here and there, ‘them’ and ‘us,’ but you hear so much that turns out to be false. Perhaps what you need is to experience both sides. Now I have done that. Now I see. It’s real.

Two weeks ago I moved to the United States after having lived in the UK for the past two years, and in the Netherlands in the preceding 30 years. In trying to find some balance on the tightrope between career and private life, I decided to move to Davis, California, on a long-term tourist-visa, to join my girlfriend, who had recently accepted a postdoctoral position at UC Davis. The current lack of a salaried job has left me ample time to contemplate my experience of the differences between North-Western Europe and the USA. Indeed, the pizzas here are bigger, and so are most cars. Beer is more expensive here than in Amsterdam, but not Cambridge, and the magpies have yellow beaks here, not black. The weather is also certainly better than I’m used to. While friends and family back home are slowly slipping into the inevitable dimness of fall and winter, we are enjoying 30 degrees Celsius in October, and sun most days, unless the smoky clouds from nearby forest fires cast their hazy shadows. However, the difference that I was alluding to in the first paragraph is the striking contrast in the prominence of religion as an overt issue in everyday life.

America is bustling with excitement about the upcoming presidential elections. Eighteen days from now this country will have to choose between president Deficit and senator “I have a plan.” At the moment it is entirely unclear who will win, but one factor that will most certainly weigh into the equation is the religious conviction of both candidates. For example, last week a radio programme was dedicated entirely to discussing the important role of religious views in American politics, and in the third presidential debate a few days ago the moderator asked both presidential candidates about the roles that religion played in their personal lives. Bush, who less than a year ago in his inimitable wisdom stated that creationism is just another ‘theory’ for the origin of biodiversity, confided that he prayed a lot, as well he should. On the university campus many street corners are littered with billboards for a multiplicity of religious fraternities, discussion groups, and social clubs. You need never walk alone here. And this week I applied to become a volunteer docent in the Sacramento Zoo. The fourth question in the application form was: “In training we teach evolution. Would this present a problem for you?” I don’t think they are referring to the difficulty of the topic here. Yesterday, my mentor in the zoo asked me if I knew that evolution is a “sensitive subject here.” “I’ve heard rumours,” I told him. He continued: “You don’t have to dodge the issue when confronted with it, but you know, when it comes up, just let the public know that it’s your own personal view of the world, and there are evidently other opinions.” “Right, don’t worry,” I told him. I’m pretty sure that I will not get into a row when I’m out there in the zoo with my little exhibit wagon filled with pelts, skulls, feathers, photos, and other educational props. Not unless they really ask for it.

While the current state of the world is responsible for my own rapid promotion, or demotion, depending on your perspective, from agnostic to fully fledged atheist, I have no problem at all with these diverse manifestations of faith. To each their own. However, in science, the introduction of faith has always caused, and will continue to cause friction. The commotion that recently ensued after the peer-reviewed journal *Proceedings of the Biological Society of Washington* published a paper that supported intelligent design (ID), is a poignant example.

Stephen Meyer’s article in the June issue of *Proc. Biol. Soc. Wash.* (PBSW), stood out conspicuously from the other papers. Amidst articles reporting the description of new species of crustaceans and sponges, Meyer’s “The origin of biological information and the higher taxonomic categories” was sure to attract attention. And that, indeed, it did. As soon as the loyal supporters of PBSW unwrapped their copies of the new issue, things went pear-shaped. Indignant subscribers bombarded the editorial office of PBSW demanding an explanation (I want to thank Fred Schram here for supplying some juicy information for this piece). Surely this must be a joke, albeit a bad one. It was suggested that it would be wise to retract the paper. It would also be opportune for the journal to issue a formal apology to appease the outraged readers. Some subscribers threatened to resign their membership. Others actually did. The scientific newspapers *Science* and *Nature* got a scent of the action, and they issued editorials on the incident. Websites quickly filled with debates and scathing commentaries.

A sample of the adjectives and nouns that were fired off in printed and electronic commentaries betrays the strongly charged emotions of those involved in this incident. The opposing camps fired at will: ‘outrageous,’ ‘truly frightening,’ ‘rubbish,’ ‘serious damage,’ ‘wolf in sheep’s clothing,’ ‘tactical victory,’ ‘anti-science,’ ‘thwart intellectual freedom,’ ‘inappropriate for publication,’ ‘politically incorrect!’ Who was to blame? Stephen Meyer? The editor who handled Meyer’s manuscript at PBSW, Richard von Sternberg? Didn’t Sternberg have ties to the baraminology study group, a bulwark of, mostly, young earth scientists who are severely challenged to incorporate any earthly productions older than about 10,000 years into their worldview? Were the scientific referees to blame perhaps? A scapegoat was badly needed, and if one couldn’t be found among the living, then perhaps among the dead. Who had appointed Sternberg as research associate at the National Museum of Natural History in the first place? Wasn’t it clear at the time that the blinding glow of Sternberg’s two PhDs was at least partially dulled by the sticky veneer of ID, and its connotations of non-materialistic mysticism? Who knows. The person who nominated Sternberg for his appointment is dead. Drastic measures were contemplated. Should the journal perhaps be killed after taking such a fall? Its soiled reputation might be beyond repair. Never mind that all the fuss is probably lifting the readership of this small quarterly journal, which chiefly caters to the specialist needs of taxonomic experts, to a level unprecedented in its history. When the extensive scientific fraud of Jan Hendrik Schön was discovered in 2002, a host of Schön’s fantastically fabricated papers was retracted from *Science* and *Nature*, but as far as I remember there were no suggestions to kill these beloved tabloids. Euthanasia might be too harsh a medicine. However, a thorough investigation was imperative. The learned council of the Biological Society of Washington convened a meeting. They reached a unanimous verdict. The council’s statement “deemed this paper inappropriate for the pages of the *Proceedings*.” In all of the 124 years of the journal’s existence something like this had never occurred. The council promised to review editorial policies.

Let's take a deep breath, sit back in our chair, and calmly take the measure of the situation. Let me say upfront that I'm not an expert on the topic. Ever since the Jehovah's witnesses, whom, much to my mum's chagrin, I invited inside my parental home for coffee, failed to convince me of their creation story, I have not read any ID literature or creationist pamphlets. The reading I did for this column is intended as a one-off exception to this rule.

Since Meyer did not append an abstract to his paper, let me present a capsule review. Meyer provides a selective critique of the ability of current neo-Darwinian evolutionary theory fully to explain the origin of evolutionary novelties in general, and the evolution of the major animal body plans in particular. Meyer argues that it is highly improbable that 'random' variation and natural selection can lead to the evolution and functional divergence of genes and proteins. Moreover, he argues that current findings from evo-devo provide no insight into the evolution of animal phyla because most changes to genes that are important in establishing body plans are deleterious, if not fatal. According to Meyer, further attempts to explain macroevolutionary change with the help of self-organization, punctuated equilibrium, structural constraints, and generative or morphogenetic rules, or any combination thereof, are equally impotent. Meyer is puzzled. The mystery remains. But despair not, for revelation is on its way. After seventeen pages of biology, Meyer suddenly presents his epiphany: "Could the notion of purposive design help provide a more adequate explanation for the origin of organismal form generally? Are there reasons to consider design as an explanation for the origin of the biological information necessary to produce the higher taxa and their corresponding morphological novelty?" The final four pages of the article argue that, indeed, there are such reasons, and that they are compelling.

Meyer's perspective is distinctly rare in the peer-reviewed scientific literature, which is just as well. But, really, why all the fuss in the media, on the Internet, and in the halls of academia? Should PBSW feel that its reputation is soiled beyond redemption? Should people scream "outrage!" and drop their subscriptions to the journal in a knee-jerk reflex? Could the incident really even be called a "tactical victory" of ID, as *Science* puts it? I think that the only harm done to science is that PBSW published a paper that is evidently slipshod science, due to a flagrant failure of the reviewing process. However unfortunate that may be, it is nothing new, and it happens to the best. As a result, the only trophy that proponents of ID can really boast about at home is that ID is promoted in a paper that should never have passed the reviewing process, as was belatedly realized by the council of PBSW. In fact, that Meyer promotes ID in his article is, I think, largely beside the point.

I will spare you a lengthy scientific response to Meyer's arguments, but I need to qualify my conclusions a bit. If you have the energy, which I haven't, to read a very long, very detailed rebuttal of Meyer's paper, check out <**http://www.pandasthumb.org/pt-archives/000430.html**>. If you want to read an equally long and detailed response, check out the webpages of the Discovery Institute in Seattle, where Meyer is director and senior fellow of the Center for Science and Culture.

In my most favourable judgment, Meyer's paper reads like a student report. He has evidently read a lot of papers, and he has the best intentions of providing a critical discussion of his chosen topic. And, considering what he has read, he does an OK job. I would let him pass, probably with a B. However, he would not get an A or A+ because the literature that he has selected is severely biased. Many readily available papers that depart significantly from his conclusions are omitted without excuse, and the logic of his arguments is not always as tight as it should be. On the most general level, Meyer doesn't understand the bare-bones mechanics of natural selection acting on 'random' variation. He concludes that there are no "functional criteria", or "goals," that natural selection can use to guide evolutionary change. Meyer never even mentions the struggle for survival. Organisms exhibit heritable variation in their traits, and they compete for limited resources. Those with the most favourable traits in a given situation and environment, which, of course, they may help to create through their activities in niche construction, will on average have a better chance of surviving, and on average they will leave more surviving offspring that inherit their traits, in the next generation. There you have your "goal," Dr Meyer. Evolution is about trying to achieve maximum representation of your genes in the next generation while competing with others. No teleological connotations necessary, the language notwithstanding. But, of course, Dr Meyer really knew this all along. He explicitly accepts the power of natural selection in shaping the adaptations of organisms to their environments, and he dutifully takes the customary Galapagos finches out of their dusty box. Here Meyer seems so close to solving his own problem, but, unfortunately, he doesn't.

Meyer doesn't discuss adaptive landscapes, competition between organisms, or differential fitness of organisms. And in his discussions of the high improbability, if not impossibility of the evolution of organismic novelties, from genes and proteins to morphological structures, he never delves more than ankle deep into the corpus of accumulated knowledge. Because mutations of early acting genes often fatally disrupt embryonic development, he concludes that animal body plans must necessarily be locked in stone. Because experimental studies show that many amino acid changes can cause a protein to lose functionality, it must be virtually impossible to navigate protein morphospace to yield the diversity of proteins around us. And where did all the new genes and proteins that are necessary for the development of the first animals come from anyway? These, indeed, are tough questions to answer. But, they are not hopeless, as Meyer seems to imply. But in order to see that, Meyer should have studied a bit harder. The evolution of protein families would show him that structural and functional divergence of proteins is possible, and widespread. It would also show that many of the genes and proteins needed to make animals are already found outside the animals, and that many of the genes with essential roles in the development of complex bilaterians are increasingly identified in cnidarians, and even sponges. Never mind the incredible potential of altering phenotypes via regulatory evolution. Never mind redundancy, gene duplication, and functional divergence of proteins. Never mind the power of changing expression patterns of conserved developmental genes to modify morphology. Never mind that the invention of evolutionary novelties can be underpinned by genes known to be already present, and functional, in other contexts in the animal's development. And never mind the potential for change inherent in the presence of large numbers of putative, but apparently unused, binding sites for developmental regulatory genes, throughout animal genomes. At one point Meyer concludes the insufficiency of natural selection as an evolutionary force acting on genetic variation, because not all of the phenotype is directly determined by genes. Well Dr Meyer, we have known for a very long time that organisms are rife with emergent properties above the level of the gene, and there are epigenetic factors with a role in morphogenesis as well. No surprise for any biologist. If Meyer had touched upon hierarchical selection theory here, he would see there is no real problem, or at least one much smaller than he sees. Haven't some biologists argued that instead of acting strictly on genes, natural selection may also act on morphologies? Never mind all these important findings and ideas. You will not find any of these niceties in Meyer's paper, and yet, he feels confident on the basis of his scanty literature review, that our current understanding of the working of evolutionary mechanisms is grossly insufficient to address in any meaningful way the problems of reconstructing animal deep history. I will not attempt to tackle Meyer's defence of the compelling logic of ID. Suffice it to say that I disagree with his statement that "the possibility of design follows logically from a consideration of the deficiencies of neo-Darwinism and other current theories."

I am the first to admit that we haven't solved the problem of the origin of animal body plans yet. We're not even close. But, there is undeniable progress. The recent advances in evo-devo and molecular phylogenetics are but two examples of how we are managing to get increasing grip on the slippery problems of deep history reconstruction. However, we have no illusions that we already understand everything. But in the spirit of *Science as a way of knowing*, as the late John Moore titled his enjoyable book, we have to continue searching, taking the little loose ends to pull ourselves forward. Meyer doesn't see, or doesn't want to see these loose ends. And that is where the crux of the problem is. Rather than continuing to trust on the ability of science to make progress, as it always has, Meyer is willing to throw up his hands in bewilderment, and exclaim miraculous intervention of an intelligent designer. That's not the spirit of science. Meyer's paper was neither deep nor comprehensive enough to merit being called an adequate review by any standard, certainly not in view of his profound conclusions. But I'm willing to give Meyer the benefit of doubt. I think that he genuinely tried to understand the state of the art of current knowledge. He concluded it couldn't explain the origin of animal body plans, and he proposed an alternative "explanation." If he had indeed delivered an adequate review that concluded that certain questions will forever be beyond the grasp of science, and that ID might provide a helping hand there, then I would have no qualms. After all, that's just metaphysics. I advise Meyer to apply his critical eye to more science, and see if his conclusion is really the only solution. He may yet see the light…

Meyer's criticisms are a bit more taxing than the standard flimsy roadblocks that creationists have tried to erect in the way of evolutionary theory. However, so far evolutionary theory has had no problem in its unwavering march through fundamentalist blockades. No exception here. I think that Meyer's paper shouldn't have been published because it was an inadequate review. The blame for this lies wholly with the refereeing process, for which the editor is ultimately responsible. And here is where it gets interesting.

PBSW's former editor, Richard M. von Sternberg, PhD., PhD., has distanced himself from the council's statement that Meyer's paper should not have been published (see <**http://www.rsternberg.net/**> for Sternberg's defence). He defends his decision to publish Meyer's paper because it "set forth a reasoned view," a decision furthermore supported by the referee reports of three alleged "experts" in evolution and molecular biology. After having read Meyer's paper, I'm baffled why the combined erudition of Sternberg's two PhDs, one in molecular evolution and one in systems theory and theoretical biology, and the judgment of the three external experts didn't stop the publication of Meyer's paper. It does indeed appear that the referee reports were supportive of the paper's publication after revisions. The decision to publish leaves no doubt that Dr Dr Sternberg is an extraordinarily open-minded guy. I wish there were more people like him.

But, wait, there is something wrong. Sternberg is not exactly a mainstream thinker. Although not supporting ID (see <**http://www.apologetics.org/**> for information on ID), he calls himself a "process structuralist." Whereas proponents of ID, such as Meyer, are "agnostic regarding the source of design and ha[ve] no commitment to defending Genesis, the Bible or any other sacred text," Sternberg adopts an intellectual position from which he contemplates the world in a general ahistorical, systems-oriented, and non-evolutionary way (not anti-evolutionary, I hasten to add). Compared to the worldviews of creationists, the necessary commitments of Meyer's and Sternberg's worldviews are minimal. Whereas Meyer is agnostic with respect to the character of the intelligent designer, Sternberg seems to be agnostic even with respect to the passage of time. I would not hesitate to nominate Sternberg's outlook on life as a candidate for another juicy chapter in Michael Shermer's delicious *Why people believe weird things* (1998), if only time's arrow wouldn't prevent me from doing this!

But it becomes much, much weirder if we allow Sternberg to be our admission ticket into a world of extreme bravery and shocking delusion: the world of the baraminologists. Sternberg's outlook on the world may be construed as candidly open-minded, and nothing more. But this conclusion is stretched to its limits when we meet the fellows with whom Sternberg is hanging out. Sternberg is associated with the "Baraminology Study Group," and he is on the editorial board of their "Occasional Papers of the Baraminology Study Group." In many respects baraminology is phylogenetics from the dark side, the almost exact mirror image of systematic biology. It is the study of the taxonomy of "created kinds," or "baramins." The goal of baraminology (see <**www.bryancore.org/bsg/aboutconcepts.html**>) is precisely antithetical to the goal of phylogenetics in biology. Baraminologists search for the discontinuities separating independently created groups of organisms. Using terminology eerily reminiscent of cladistics, baraminologists seek to identify "the unbridgeable chasms between body plans" upon the basis of which they erect holobaramins, monobaramins, polybaramins, and apobaramins. Discontinuities are located between "forms for which there is no empirical evidence that the character-state transformations ever occurred. The mere assumption that the transformation had to occur because cladistic analysis places it at a hypothetical ancestral node does not constitute empirical evidence." Using a range of techniques, such as Analysis of Patterns (ANOPA), baraminologists try to map out the structure of creation. This generates some wonderful, and very brave stuff, especially because the investigations are couched in terms of science, such as "tests," and because the papers endeavour to bring biblical Scripture and the findings of science into congruence with each other. I call this "brave" because the baraminologists first dispose of virtually all hard-won insights from the historical sciences, ranging from archaeology to astronomy. They discard over 99% of geological time by compressing the Earth's history from more than four billion years to a mere couple of thousands of years, and then use scientific reasoning to reconstruct all that happened in this shortened period. As an indication of the amusing results, let me give you some examples from the fourth issue of "Occasional Papers of the Baraminology Study Group," which contains the proceedings of the "Discovering the Creator" conference.

Joseph Francis, co-colleague of Sternberg on the editorial board of the journal, presented a paper documenting the benevolence of God by showing that microbes must have been created as good organisms. Their nasty pathogenic and parasitic habits must have arisen after the Fall of man from the Garden of Eden, because, expectedly, before the Fall there could have been no death and disease. In another paper, of which Francis is co-author, it is similarly argued that viruses must have performed "beneficial functions" before the Fall. Another paper struggles with the question of the implications of death before the Fall, as suggested by evolutionary theory and the fossil record. Another argues that, perhaps, animals that display "natural evil"—*i.e.* predators, pathogens, and parasites that kill other organisms—have two sets of genes, one for "benign morphology and behavior," and one for "malignant morphology and behavior." The former set of genes would then have been expressed before the Fall, while the second set of genes would only have become active after the Fall, with the origin of death and evil. This paper also includes my absolute favourite citation: "Satan *et al.*" And there is more. One paper is concerned with squirrel phylogeny and biogeography. It argues that, of course, squirrel biogeography must have been strongly influenced by the great Flood, since the squirrels, like all other animals, would have had to have dispersed from Ararat after the Ark landed there. I would think that if that were indeed the case, by now we would already have incontrovertible molecular phylogenetic evidence that showed that the highest volcano in Turkey is unambiguously the unique cradle for all animals. And so the papers continue.

Obviously, scientists need not worry. This is just a parallel research programme. If you don't believe in the literal word of the Bible, then you need not be concerned with baraminology. We should hardly expect baraminologist papers infiltrating peer-reviewed science journals. You wouldn't think so, would you? A relatively "scientific" paper, such as the one by Meyer could be excused, but the Ark of Noah? Surely such writings would never slip past our watchful eyes, would they? Unfortunately, it has already happened.

Last year, one time PhD student and research assistant of Stephen Jay Gould, Kurt Wise, presented a talk at the Seattle annual meeting of the Geological Society of America on "The evolution of the creationist perspective on the fossil Equid series." And Wise is no liberal when it comes to the Bible. In his book *Faith, form, and time: what the Bible teaches and science confirms about Creation and the age of the Universe* (2002) Wise argues that biblical and scientific evidence suggests that the universe was created by God in six 24-hour days, less than 10.000 years ago. Wise, quoted in an essay by Richard Dawkins in *Free Inquiry* magazine a few years ago, says that even "if all the evidence in the universe turns against creationism … I would still be a creationist." Now, that is faith, not science. If such opinions receive airtime at our scientific meetings, we are inviting trouble. However, sometimes the creationists are not so easy to spot. For example, they may follow Meyer's strategy of hiding their message, without any clue from the title or abstract of their works. For example, one of the contributors to the fourth issue of "Occasional Papers of the Baraminology Study Group," Paul Nelson, presented a poster at the 2004 annual meeting of the Society of Developmental Biology titled "Problems with characterizing the protostome-deuterostome ancestor." In what is ostensibly a scientific paper, Nelson and co-author argue for the discontinuity of the ontogenies of the bilaterian phyla, and that their evolutionary divergence is not supported by any evidence, but only by the imposition of evolutionary theory.

This kind of investigation neatly answers the goals of baraminology, establishing how obviously unbridgeable the gaps between animal body plans are. However, I think that, even among scientists, there is an exaggerated sense about how different the body plans of animal phyla actually are. Without going into too much detail here, let me open a little can of worms for you. Here is a nice selection of wormy beasties, some acanthocephalans, gastrotrichs, nemerteans, platyhelminths, gnathostomulids, rotifers, nematodes, pogonophorans, and nematomorphs. Now here is a nice microscope for each one of you. Your task it to sort the worms. How many of you will say "Well, there are some smaller and some bigger ones, but Jeez, they all look alike," and how many will say "Easy task! Evidently we are dealing here with precisely nine discontinuous types, phyla I presume, which are separated by unbridgeable gaps in organization"). Right, you get the picture. True, there are famous differences in the organization of different phyla, and if that is all that you want to see, well, that is what you will see. However, if you look in a bit more detail, there are striking similarities, homologies even, which are evident as well. Nobody claims that rotifers and gnathostomulids are members of the same phylum. But ultrastructurally, they show an amazing number of correspondences. Far from an unbridgeable gap separating them, I would argue that they share pretty similar body plans, with modifications, of course.

These incursions of faith into science are worrying. Wherever science has not yet cast its illuminating light, the supernatural or metaphysical can and will always be unwrapped by some of us, to provide an explanation. Ironically, as we push back the limits of our ignorance, and increasingly difficult problems remain to be solved, it will exactly be there where "we" will meet "them." There is no way around it. However, what we can and must do is to battle ignorance to prevent uninvited intrusions of faith into what I think is legitimately the domain of science. As long as we live in a world where State Superintendents of middle and high schools still consider evolution to be merely "a buzz word that causes a lot of negative reaction," as opined early this year by the inimitable Mrs Cox from the state of Georgia, then we have a lot of teaching to do.

And as far as accusations go, that we are intolerant of people who pursue very abstract research, with no proven connection to the material world, and seemingly immune to empirical testing, but where the sheer beauty of ideas becomes an important epistemic value, well, for them I have one answer: Edward Witten is professor at Princeton's Institute for Advanced Study.

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Ronald Jenner
Section of Evolution & Ecology, University of California, Davis, CA 95616, USA
<rajenner@ucdavis.edu>

Time and time-rock again: an essay on the (over)simplification of stratigraphy

Introduction

The recent paper by Zalasiewicz *et al.* (2004a) and the essay by Zalasiewicz (2004) were stimulating and enjoyable. There is much in common between the views of Zalasiewicz *et al.* (2004a) and Walsh (2001; 2003) on this subject, among them being our preferred restriction of chronostratigraphic terms to stratified rocks, and our agreement that geochronologic units necessarily define the content of corresponding chronostratigraphic units (see discussion of the "rock-time," "yin and yang," and "time-rock" models by Harland, 1978 and Walsh *et al.*, 2004). However, although I now also agree with their suggestion regarding the use of temporal modifiers, I am not convinced that chronostratigraphic units and terms should be abandoned, and my views on this subject are quite different from those who have already defended chronostratigraphic units in the Geology Online Forum and in volume 56 of this Newsletter.

Temporal Modifiers

The historical distinction between the concepts of, say, Lower Cretaceous rock and Early Cretaceous time arose when the rock units were originally defined in a local type area, where a physical superpositional relationship between "lower" and "upper" subdivisions could be seen. For example, the span of time subtended by the lower part of the type Cretaceous in the Anglo-Paris-Belgian basin (Greensand and associated strata) was called "Early Cretaceous" and the span of time subtended by the upper part of that succession (the Chalk) was called "Late Cretaceous" (Harland *et al.*, 1990:56). However, the GSSP concept has reduced or eliminated the definitional role of these original type sections (Zalasiewicz *et al.*, 2004a; Walsh *et al.*, 2004). As such, in most places on Earth, the phrase "Lower Cretaceous rocks" has no independent meaning except as a synonym of the phrase "rocks of Early Cretaceous age," which is why Walsh (2001) noted that the term "chronostratigraphic position" was unnecessary. I therefore agree with Zalasiewicz *et al.* that it would be acceptable to abandon the modifiers "lower" and "upper" and use "early" and "late" for geochronologic *and* chronostratigraphic units. The fact that European geologists have employed "inferior" and "superior" in both contexts without issue demonstrates that such usage would not be problematical (J. Ogg, *in* Pratt, 2004). Time of origin is clearly a legitimate attribute of material objects, so phrases like "Early Devonian Series" and "Late Cretaceous rocks" should not be regarded as heretical. I am glad that the Vice-Chair of the International Subcommission for Stratigraphic Classification has come to the same conclusion, albeit from a somewhat different direction (Embry, 2004). The contrary arguments of Heckert and Lucas (2004) are unconvincing because they consist of mere assertions. It is also noteworthy that Bassett *et al.* (2004) do not explicitly address the issue of temporal modifiers, which in my view is where Zalasiewicz *et al.* stand on the most solid logical ground.

Clarifying Some Confusion About Chronostratigraphic Units

Zalasiewicz *et al.* (2004a) have gone one large step beyond just proposing that we simplify our temporal modifiers. They have also suggested that all chronostratigraphic terms (e.g., system) be abandoned in favour of geochronologic terms (*e.g.*, period). They noted that the distinction between geochronologic and chronostratigraphic units has not been clear "to the greater part of the professional (or student) geological community," and I have made the same observation (Walsh, 2001). Unfortunately, the understanding of these simple concepts has been hampered by the failure to illustrate them in major stratigraphic codes and guides (Whittaker *et al.*, 1991; Rawson *et al.*, 2002), or by the use of geologically unrealistic diagrams when they *are* illustrated (*e.g.*, Hedberg 1976, figs. 12, 14). The North American Commission on Stratigraphic Nomenclature (NACSN, 1983) provided clear diagrams of most of the other kinds of stratigraphic units it discusses, but the only diagram that shows geochronologic and chronostratigraphic units is the one explaining what a "diachronic unit" is supposed to be (NACSN, 1983, fig. 10). More importantly, and inexplicably, none of the relevant diagrams in Hedberg (1976) and NACSN (1983) show any unconformities or hiatuses, such that geochronologic and chronostratigraphic units appear to be indistinguishable from one another, and thus indeed "redundant." However, once the relationship between nonmaterial geochronologic and material chronostratigraphic units has been rigorously defined and illustrated in *geologically realistic diagrams* (*i.e.*, showing that most of geologic time in most areas is not represented by strata), then the differences between these two categories are easily understood (Walsh, 2001, fig. 1; Walsh, 2004, fig. 2).

Nevertheless, a philosophical digression must be made here. Chronostratigraphic units consist of all of the actually-existing strata in a given geographic area that were formed during a specified geochronologic unit. Because chronostratigraphic units are composed of material rocks, they are generally considered as material units themselves. In an important sense, however, they are only human abstractions, because their exact content can only be conceptualized after their defining geochronologic units are specified (Walsh, 2001; 2004). Therefore, depending on the context, one can view a chronostratigraphic unit as either a material entity or as an abstraction, without involving a logical contradiction. This situation is not unique to chronostratigraphic units, but is inherent in the conceptualization of all human-defined classes, such as the Baby Boomer Generation (Walsh, 2003).

Problems with the Simplified Nomenclature

Now back to the main issue. In my view there would be two problems with the simplified nomenclature proposed by Zalasiewicz *et al.* (2004a), one immediate and one potential. These are 1) a lack of precision in some contexts, and 2) the probable migration of chronostratigraphic unit-terms to other categories, should their proposal be accepted.

Starting with the first problem, suppose we want to discuss the Maastrichtian Standard Global Stage as it occurs in Western Europe. This is going to be problematical without using the term "stage," because all stratigraphic names like "Maastrichtian" have a large amount of historical baggage associated with them. They have been used in the past in various lithostratigraphic, biostratigraphic, and unconformity-bounded senses, so the phrase "The Maastrichtian strata of western Europe" (one of the formulations suggested by Zalasiewicz *et al.*, 2004a) is just not precise enough for unambiguous communication. Given this phrase, are we talking about the strata that have traditionally been considered to be lithologically characteristic of the Maastrichtian, or biostratigraphically characteristic of the Maastrichtian, or characteristic of the Maastrichtian synthem and/or depositional sequence, regardless of whether these various strata are all now included in the Maastrichtian Stage as formally defined by GSSPs (*e.g.*, Odin and Lamurelle, 2001)? Zalasiewicz *et al.* correctly note that we could be more specific and say "The strata of western Europe that were formed during the Maastrichtian Age," but why use all of these words when a much shorter equivalent ("The Maastrichtian Stage of Western Europe") is already available? Zalasiewicz *et al.* (2004b) acknowledge that the latter version "provides … an effective shorthand means of communication," and this seems to me to be a sufficient reason for retaining chronostratigraphic terms.

Nevertheless, if Zalasiewicz *et al.* are mainly opposed to the *mandatory* use of chronostratigraphic terms, especially in the context of unstratified crystalline rocks (Zalasiewicz, 2004:81; Zalasiewicz *et al.*, 2004b), then I would agree. In my view, stratigraphic codes and guides exist only to give authors and editors guidelines on how a codified term should be used, *if* a given author decides to use it. For example, these documents (and editors who designate them as the arbiters of correct usage for their journal) cannot legitimately require an author to use the term "stage" or "assemblage zone" or "synthem" in his paper; they can only require that if an author *chooses* to use these terms, then he must use them in the sense in which they are codified (see Walsh, 2000, p. 768, for an example of unwarranted editorial heavy-handedness). Thus, geologists who would prefer to write "The strata of Western Europe formed during the Maastrichtian Age" rather than "The Maastrichtian Stage of Western Europe" should not be forced to pen the latter, although such chronostratiphobia would again be idiosyncratic in my view.

A second, potential problem with the simplified nomenclature proposed by Zalasiewicz *et al.* (2004a) involves the likely migration of the unit terms system, series, and stage to other stratigraphic categories if chronostratigraphic units should be abandoned. For example, the currently codified unit-terms for unconformity-bounded units (supersynthem, synthem, and subsynthem; Salvador, 1994) have not been widely used. It therefore seems likely that some would suggest that the newly liberated terms system, series, and stage be appropriated to replace them. Thus, the Karroo System might live again in its original unconformity-bounded sense. However, it seems obvious that by making system, series, and stage more ambiguous than ever, terminological confusion would increase.

Chronostratigraphic Units Are Not Redundant

In my view Zalasiewicz *et al.* (2004a) are incorrect to say that chronostratigraphic units are "redundant." Because the stratigraphic record is riddled with unconformities, chronostratigraphic units (being composed of material rock) cannot be isochronous over any appreciable geographic area. That is, the ages of the boundaries (*i.e.*, the local base and top) of a given chronostratigraphic unit in most areas will usually not correspond to the beginning and ending of its defining geochronologic unit (Wheeler, 1958; Harland, 1978; Walsh, 2001; 2003). This distinction is of great importance in my view, and although I disagree with most of M.-P. Aubry's recent chronostratigraphic philosophy (Walsh, 2004), I do hold the same opinion expressed by Aubry (1995:268) on this point: "Because there is not a one to one relationship between geological time and stratigraphic record, I would argue against Harland and others (1990) and Harland (1992) that it remains essential to use a dual terminology to distinguish between temporal and [chrono]stratigraphic terms."

Now I can already hear some howls of protest out there, so another digression is necessary. Some of you are shouting: "How can Walsh possibly say that the ages of the boundaries of a chronostratigraphic unit usually will not correspond to the boundaries of its defining geochronologic unit?! The boundaries of the Devonian System, by definition, must everywhere correspond in age to the boundaries of the Devonian Period!" If this were true, then Zalasiewicz *et al.* (2004a) would be justified in regarding chronostratigraphic units as redundant. But it is not true. By definition, the "boundaries" of any material entity A occur at the physical interface between "A" and "not A." For example, the boundaries of the United States occur wherever the physical interface between "United States" and "non-United States" occurs. Thus, the southern boundaries of Louisiana, Mississippi and Alabama certainly do form part of the southern boundary of the United States, even though the boundary of the U.S. here is not located as far south as the southernmost points of Texas and Florida, and is also not physically contiguous with the northern boundary of Mexico. For the latter concept, we use the appropriate term—the United States–Mexico boundary.

Similarly, where middle Devonian strata unconformably overlie Cambrian strata, the lowermost Devonian stratum certainly does form the lower boundary or base of the Devonian System *in this section*; this stratum just isn't the same age as the Silurian/Devonian *Period* boundary, and it is that *temporal boundary of fixed age* that the golden spike really defines. Laterally removed from the GSSP and indeed at most places around the world, the material base of the Devonian System will necessarily be younger than the beginning of the Devonian Period. Taking as a concrete example Hutton's famous unconformity at Siccar Point, the upper bounding surface of this unconformity *most certainly is* the base of the Devonian System in this section, even though we are well aware that these beds are substantially younger than the beginning of the Devonian Period as defined by the golden spike at Klonk.

Importantly, the American Commission on Stratigraphic Nomenclature (ACSN, 1965:1700) clearly recognized the fact *that chronostratigraphic boundaries are of variable age* when it stated:

> "… a surface of unconformity inevitably varies in its age or time-value from place to place and hence can not at all fulfil the theoretical requirements of a chronostratigraphic boundary. At the same time it may provide a useful *guide* to the placement of System boundaries **and it is, of course, frequently the local physical boundary of an incompletely represented System** [boldface mine]."

Here the ACSN states the obvious—that the **physical boundary** of a chronostratigraphic unit will frequently be a surface of unconformity, which is precisely the situation illustrated in figure 1 of Walsh (2001). For this very reason, however, and contra NACSN (1983), Hedberg (1976), and Salvador (1994), *synchronous boundaries cannot be a necessary attribute of chronostratigraphic units*, which again must be composed entirely of physical rock if a meaningful distinction between nonmaterial geochronologic units and material chronostratigraphic units is to be upheld.

Chronostratigraphic Units Help Prevent Confusion

The most important reason for retaining chronostratigraphic units stems from the realization that H.D. Hedberg's main purpose in promoting these units was not to separate them from geochronologic units. It was to separate them from several other categories of material stratigraphic units with which they had long been confused, such as lithostratigraphic, biostratigraphic, and unconformity-bounded units, all of which had been assigned the rank terms system, series, and stage by different workers at one time or another (Hedberg, 1976, chapter eight; Salvador, 1994, chapter ten). Recent claims that sequence-stratigraphic units are really chronostratigraphic units, the continuing confusion of biostratigraphic units with chronostratigraphic units, and the persistent misuse of the term "stage" for regional unconformity-bounded units illustrate the point (Walsh, 2004).

Given the current importance of sequence-stratigraphic units, let's clarify the relationship between them and chronostratigraphic units. Sequence-stratigraphic units can be recognized on many scales, but consider the global early Eocene (Ypresian) marine trangression and regression. The set of all strata on Earth that were formed in response to this eustatic event (let's call it the global Ypresian depositional sequence) might include all open-marine deposits, all marginal-marine deposits, and even all non-marine coastal deposits whose deposition was controlled by the fluctuating base level of the world ocean during this transgression and regression. But the *Ypresian Standard Global Stage* consists of *all existing strata on Earth that were formed during the Ypresian Age.* It therefore includes many additional rocks whose origin had nothing to do with the Ypresian transgression, such as the voluminous continental strata deposited in the intermontane basins of North America, and various other early Eocene non-marine and volcanic rocks found on other continents. So, a clear concept of the Standard Global Ypresian Stage (a chronostratigraphic unit) is important in this case simply to help overzealous sequence stratigraphers understand what a sequence-stratigraphic unit *is not*.

Chronostratigraphic units also need to be retained because almost 40 years after Hedberg (1965), prominent workers insist on confusing them with biostratigraphic units. For example, in the biostratigraphy chapter of his textbook *Bringing Fossils to Life*, Prothero (1998, p. 173) stated:

> "As stratigraphers have become more careful in documenting ranges and describing type sections, inevitable disputes over boundaries have arisen. The type section or areas of two successive *biostratigraphic* units are usually in two separated areas, and there may be no overlap. Often, neither section preserves the boundary between the two units, so biostratigraphers must search for a third area where the transition is recorded. Ideally, this section should be as continuous and fossiliferous as possible, with several taxonomic groups to compare [italics mine]."

Clearly, Prothero is here discussing *chronostratigraphic* units, even though he *calls* them "biostratigraphic units." Confirmation is provided on the very next page. After mentioning the definitions of the Ordovician/Silurian, Silurian/Devonian, and Devonian/Carboniferous boundaries, Prothero (1998b, p. 174) then stated: "Many other *biostratigraphic* boundaries are currently under discussion … [italics mine]." These statements would make Schenck and Muller (1941) and Schindewolf (1970) proud, and not surprisingly, Prothero's (1991) detailed treatment of the formal definition of the Silurian/Devonian boundary appears in his chapter on *biostratigraphy* and not in his chapter on *chronostratigraphy* (where it clearly belongs). The point here is that Prothero is an author of numerous top-selling stratigraphy textbooks, unwittingly teaching an entire generation of undergraduates the long-obsolete view that systems, series, and stages are biostratigraphic units! (Walsh, in revision 1, 2, 3).

Zalasiewicz *et al.* (2004a) did not address the application of chronostratigraphic concepts to contexts other than the standard global geologic time scale, so I will briefly do so here. In my view, it can clarify our thinking to say that a given stratum belongs to the Taxon X biochronozone, even if that stratum lacks fossils of Taxon X or indeed lacks fossils of any kind (separation of biostratigraphic from biochronostratigraphic units; Arkell, 1956:5–6; Hedberg, 1965). Similarly, given sufficent evidence we can say that a particular section belongs to the Matuyama Reversed-Polarity Chronozone, even if that section is currently normally polarized (separation of magnetostratigraphic from polarity-chronostratigraphic units). Such a statement helps us to understand that observed magnetozone boundaries are not necesssarily the same age as any actual reversals of the Earth's magnetic field.

The Verdict

Although I agree with several of the suggestions of Zalasiewicz *et al.* (2004a), I cannot go along with their main proposal, because the simplification they have hoped for in one field of stratigraphy would prove to be an oversimplification when applied to other areas of our science. Indeed, if we didn't have chronostratigraphic units now, we would soon have to invent them, just to keep some of our less rigorously-minded colleagues from overestimating the temporal significance of their favourite sequence-stratigraphic, unconformity-bounded, biostratigraphic, lithostratigraphic, and magnetostratigraphic units (cf. Hedberg, 1965).

Nevertheless, Zalasiewicz (2004:81) has offered an alternative that should satisfy all parties because it involves freedom of choice: leaving "a dual option open in such a way as not to clutter up the lives of those scientists who did not need to, or wish to, use and be confused by the time-rock classification." Fortunately, this option already exists, provided that journal editors understand their role in legislating the use of technical terms, as discussed above.

The Real Meaning of Simplification

In regard to the title of this essay, readers of some of my previous papers (Walsh, 1998; 2000; 2001) might think I believe that stratigraphy should be as complicated as possible, but that's not true. I believe as Callomon (2003:263) believes: "Stratigraphy is diverse but simple—provided its concepts are clearly defined and separated." My contention is that a seemingly complex classification will be simple to understand and apply if its hierarchical structure is logical and the definitions of its categories are internally consistent. Unfortunately, significant parts of, for example, the North American Stratigraphic Code (NACSN, 1983) are quite illogical (Harland, 1992; Walsh, 2001; 2003), so of course they are difficult to understand. Who knows how many eager young North American stratigraphy majors who, unable to comprehend the incomprehensible mystery of Article 66, have run screaming to the igneous petrology lab, never to open a stratigraphy textbook again? Fortunately, Lucy Edwards of the NACSN has recently acknowledged that "even the Stratigraphic Guide [*i.e.*, the North American Stratigraphic Code] is unclear on the distinction between the categories of time and time-rock" and that "the solution to the confusion lies in fixing the vagueness in the Stratigraphic Guide [Code]" (*in* Pratt, 2004). These statements are much appreciated given the rather different opinions previously expressed by Easton *et al.* (2003), and I can only hope that Walsh (2003) and the detailed recommendations I made to the NACSN at its annual meeting in 2003 have helped to bring them about.

So, in my view at least, things are looking up. The time is ripe for a genuine simplification of stratigraphy because many and perhaps a majority of active stratigraphers now realize that geochronologic units do indeed define the material content of their corresponding chronostratigraphic units (Harland, 1978; 1992; Walsh, 2001; 2003; 2004; Walsh *et al.* 2004; Zalasiewicz *et al.*, 2004a). This is really half the battle that Zalasiewicz and his colleagues are fighting, and when this fact is formalized in a logical hierarchical classification of various time and time-rock units in future editions of stratigraphic codes and guides, the rest will fall into place. I thank Jan Zalasiewicz for discussions and for suggesting that I submit this essay to *Palaeontology Newsletter*; I look forward to his response.

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Steve Walsh
Departmment of Paleontology. San Diego Natural History Museum, P.O. Box 121390,
San Diego, CA 92112 USA
<**slwalsh@sdnhm.org**>

Reply: Stratigraphy over-simplified? — or a question of perspective?

Steve Walsh does indeed offer a distinct perspective on the utility of time-rock stratigraphy, and draws up a nicely-argued case for its retention. He has an excellent grasp of the relevant literature, so perforce I must match the seven-league boots of considerable scholarship with the crudely-hewn clogs of blunt enquiry. As he says, the points of contention between us are few: the field is narrowed to stratified rocks, and "upper/lower" modifiers have been removed from the discussion. So what are the points of debate now? Let's take them one by one.

- **A lack of precision in a unified nomenclature**. It seems to me still—thus far—that one can be as precise as one wants to be regarding the relation of time, rock and deduced process using either a dual or unified terminology. To take the Maastrichtian, the formulation 'strata deposited during the Maastrichtian Age' is of course a longer phrase than 'the Maastrichtian Stage' but it is just as unambiguous. In this sphere, brevity does not always equate with clarity. Furthermore, I'm not so sure that simply the use of 'Maastrichtian strata' would inevitably lead to dangerous confusion, as the meaning would generally be clear from the context. After all, geologists frequently use time and time-rock terms quite interchangeably in everyday communication (at least, before a sharp-eyed editor hauls them up) with little sign that the Edifice of Geological Thought is imperilled.

There is an acid test here. Can one systematically write papers on stratigraphic topics using *only* geological time terms? Are there any occasions where one cannot get by without time-rock terms? My limited experiments to date suggest that time terms alone will suffice—though the experiments do need to run longer.

Logical possibilities are one thing. There's the important question of the terminology that people *are used to*. Using unified terminology, of course, one can't say that 'the base of the Quaternary' any more than one can say 'the base of January'; one should say rather 'the beginning of the Quaternary' (though one can, of course refer to the base of a Quaternary succession, just as one can refer to the base of a January snowfall). To say the 'beginning of the Quaternary' does not—even to me—roll so neatly off a Pavlovian tongue. Words have a history and force of their own, and evolve to mean different things to different groups of people. Thus, it would be senseless for French-speaking geologists to try to replace the universally-used 'inférieur/supérieur' with 'précoce/tardif'; the former modifiers have come to have a temporal as well as a topological meaning and are universally understood.

Now, as my colleagues on the Stratigraphy Commission and I have argued, the time/time-rock distinction in the English-speaking world is decidedly not universally understood. Nevertheless, the nomenclature of both time and time-rock classification is in common, if frequently mangled, usage. The terms themselves won't fade away quickly, whatever formal recommendations are made. How often, for instance, is the K/T boundary referred to as the K/P boundary? Still, the inextricable tangle of habit and meaning that form an ever-more-burdensome baggage around stratigraphic terms may be illuminated, if not resolved, by trying to be clear about the phenomena they represent. Here I'm entirely at one with Steve Walsh. Which brings us up to the next point…

- **The incompleteness of successions**. Thus, the argument that locally a System has boundaries different from that of the equivalent Period, as in the case of the Devonian strata at Siccar Point. Well, there are probably very few places where a Period is represented by a continuously deposited succession. One can say that there are strata of Devonian age (or Devonian depositional age, if one wanted to exclude all ambiguity) at Siccar Point, without implying that the entirety of the Devonian is represented there by rock. Similarly, one can talk about a January snowfall, without implying that snow fell all through January without a break. And snowfalls generally have diachronous bases, as the snow clouds that produce them scud hither and thither. Yes, one can make a System/Period distinction in this way if one wishes, but I'm not sure that it is necessary to an effective description of what, in geological terms, happened when and where. The Devonian, as defined by GSSPs above and below, is simply an interval of time within which processes, such as the deposition of sediment, took place.
- **Consequent migration of the meaning of terms**. This is a novel slant, and deserves consideration. If, let's say, the formal use of words such as 'System' and 'Series' was abandoned, would those words, now left redundant but still echoing within the crania of tens of thousands of geologists, find—or be found—other phenomena to describe? Safer by far to keep them where they are … or is it?

Words such as 'series' and 'stages' certainly have had different meanings in the past. They even have different meanings today, among different communities of geologists in different parts of the world. Changes of meaning do cause confusion, in the short to medium term. How great is the danger in this instance? I find that hard to judge. In the particular instance quoted, that of synthems, then that particular term does seem destined to fade away, lamented by few. However, the phenomenon it describes – that of unconformity-bounded units, seems mostly to be now subsumed under the general umbrella of sequence stratigraphy (which itself has an evolving terminology).

It's more likely that, whatever (if anything) is formally recommended about the time-rock terms, they will continue to be used—as noted above—by those geologists who find them useful. Such a continued use, even if informal in itself, will likely be some form of barrier to the further evolution of these terms. Of course, the community of geologists who will use these terms will be… I was about to say stratigraphers, but the word stratigraphy itself has of course evolved (between Hedberg and Salvador, I think) to encompass those who decipher earth history from unstratified as well as stratified rocks. We are all stratigraphers now, and about time too.

So we need a new term for stratigraphers dealing with strata, those for whom this argument is germane. Perhaps we should call this group of earth scientists 'strata-types', to avoid terminological confusion. Among the strata-types, there will be those who might prefer to adopt the unified terminology, perhaps because (as in my case) they might lack a little theoretical solidity. Perhaps this group of stratigraphers should be described as 'hollow-types'. The persistence, or not, of the time-rock terms will likely, ultimately, depend on how many hollow-types continue to be preserved among the strata-types, in museums and other places of learning. Now, isn't that a clear and unambiguous enough summary of a Darwinian struggle between competing terminologies?

I think, paddling furiously towards the safety of a sensible shoreline, that it is hard to predict how our stratigraphical language will evolve, except that it undoubtedly will. The danger of sinking deeper into a terminological quagmire shouldn't, therefore, stop us trying to work out which direction we think we should be trying to head towards.

- **Blurring of rock, time and fossil units**. Steve Walsh has nicely demonstrated how the distinctions between biozones, sequence stratigraphic units and chronostratigraphic units can become blurred. The argument here is that Systems, Series and so on should be retained in order that the fossil- and sea-level-based units do not encroach too much upon the territory of geological time. I'm not sure of this: the holy trinity of rocks, fossils and time helps me, at least, maintain a grasp of the distinction. Is a holy quartet of rocks, fossils, time and time-rock quite as elegant? Here, I'll offer the observation that it's quite easy for time-proxy units to slip towards being thought of as time-units, especially if the proxies are pretty good. Perhaps we ask too much of them sometimes. Which brings us to…
- **Biochronozones**… which might just be an example of where the lily might be being gilded to achieve a bewitching sheen, like that of fool's gold. Now fossils offer excellent proxies for the time record, agreed. Biozones are a useful way of constructing effective quasi-temporal pigeon-holes out of a plexus of evolving lineages of any major fossil group. Biozones, though, are also imperfect, even in the Jurassic. They are always diachronous (even the base of an ignimbrite is diachronous, for a pyroclastic flow takes many billions of nanoseconds to traverse from a crater rim to the plains below; I exaggerate here, but perhaps not altogether ludicrously, as my colleagues Richard Brown and Mike Branney (2004) have resolved very finely-spaced depositional events in the accretion of a single ignimbrite).

Even on the standard rough-hewn geological timescale, biozones are often demonstrably diachronous. The (relative) range of my favourite graptolite—the short-ranged and beautifully distinctive *Monograptus crispus*—is, for instance, decidedly diachronous—on standard biostratigraphic grounds—between Wales and Bohemia. So fossils, while a splendid guide to time, need watching like a hawk at the high-resolution end of things.

So biozones I understand. But the role of a biochronozone… Now, as I understand it (and I stand to be corrected on this), this encompasses all the time subtended by the maximum temporal range of the defining taxon of that biozone, and represents an interval to be extended into all of the strata deposited during that time, whether fossiliferous or not. I more or less understand this idea in general, but am a little puzzled as to how it might work in practice.

Inasmuch as I understand evolution, at least that of the graptolites that I work with, they generally don't seem to show the kind of gradual evolution that Peter Sheldon (1987) painstakingly demonstrated for the Builth trilobites. Most graptolite taxa tend to, well, just appear in any individual section, as more or less distinct entities, the spirit of punctuated equilibrium presumably hovering somewhere nearby. Evolution always, dammit, seems to have happened somewhere else. Presumably a taxon arises somewhere out there, generally as a small isolated population *pace* Ernst Mayr. Then, some time later, it breaks out of its geographic confines to spread around the world. It may spread quickly, like wildfire, or more slowly, or stepwise, and part of that spread will have been modulated by climatic or oceanographic conditions, and the way these changed with time. The taxon flourishes for a while, and then, outcompeted by its successors or wrongfooted by some environmental change, it dies out, but isolated relict populations may hang on for a while here and there before finally succumbing—though perhaps one or two of these may give rise to successor species which might in turn spread over a good part of the world.

As biostratigraphers, we mainly, I think, see the arrival of our key taxa into sections (sampling, at best, a few square metres of seafloor, if that, and recalling the strictures of Messrs Signor & Lipps), and we also see its local demise. These are our tie-lines, for practical purposes. We normally don't chance upon the birthplace of a new taxon: I can recall only one half-way decent candidate of this phenomenon in the graptolitic successions I've looked at. And we don't normally find the relict late populations; hence the flurry of excitement a few years ago over the Wrangel Island mammoths, which we now know were grazing that tiny portion of steppe while the Pyramids were being built. A more pronounced example of diachronous extinction was of course mooted by Sir Arthur Conan Doyle in his *Lost World*, an example of entirely ridiculous proportions, until, that is, one remembers the coelacanth.

Even if we had wonderful geographical control, and locate birthplaces and final resting places of taxa, we would simply encounter a different type of uncertainty: where, in a continuous and continuously recorded lineage, does one draw a boundary between two successive taxa? Peter Sheldon's Builth trilobites, in this situation and at this scale, don't lend themselves easily to taxonomic pigeon-holing.

So, while to seek to correlate biostratigraphic tie-lines into unfossiliferous strata is a perfectly valid exercise, the attempt to formalize this into time-units based upon ideally compartmentalized taxa takes me, at least, into unfamiliar and potentially treacherous terrain, given the amoeba-like, fuzzy-edged geometries encompassed by taxa through space and time. At least a golden spike represents a single point of certainty, even if all correlation that follows is uncertain.

So in conclusion… and after something of a detour—where should we go? Of all the reasons quoted for retention of the dual time-scale, the most telling seem to me to be the familiarity and convenience of the time-rock terms for part of the geological community working today. Tomorrow, though, a generation on, stratigraphy will have moved on (think how far it has moved in the last quarter-century), and the eternal verities may have shifted a little also. Even today, we can operate effectively without using the time-rock terms, though at times we have to use unfamiliar language, and need to consider exactly what we want to express. The last point may not be altogether a Bad Thing.

I'm conscious of the growing importance of stratigraphy to much broader-based studies of how the Earth functions, and especially of climate change. These are pressing matters, for time is short and the water around us is quite literally rising. Time is part of the lingua franca of science as a whole while time-rock is not. A simplified—*i.e.* unified—time-scale should not, of course, be mandatory; it might be recommended, perhaps. Nevertheless, if widely applied in practice, it might just help the sciences talk to each other more easily. They certainly need to.

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Jan Zalasiewicz
Department of Geology, University of Leicester, UK
<jaz1@leicester.ac.uk>

Palaeo-math 101
Regression 3: How to avoid Lying with Regression Analysis

Thus far in this series we've been focusing on how to perform a linear regression analysis; what error-minimization models are available, the circumstances under which use of different linear models may be appropriate, and the effects of data standardization. By this time you should understand that linear regression is actually a bit more complex a topic than is usually portrayed in textbooks, but you should also feel confident that this complexity can be turned to your advantage in planning and carrying out such analyses. Before we plunge even deeper into this subject, though, it would be a good idea to devote at least one column to the topic of interpreting the results of a regression analysis. Here we'll see, as we have before, things are not as straightforward as they might seem.

Let's start by considering the very first regression result we obtained for our example trilobite data from the first essay in this series (see Regression 1 and the Regression 1 worksheet). In that first analysis we used the standard least-squares error-minimization model to estimate the following linear relation between glabellar length (x) and glabellar width (y) that minimized deviation in the latter.

$$y = 0.64\,x + 2.51 \tag{3.1}$$

Is this a good model of variation within those data? Is it adequate for the purpose of data characterization? Or could these numbers be hiding some underlying pattern that might affect our interpretation of these data? By just looking at (or presenting) the raw slope and intercept coefficients it's difficult to know what to make of this result other than to accept that this is the equation of the straight line which minimizes deviation along the glabellar-width axis. The problem, of course, is that the same line may be calculated for a large number of data geometries (Fig. 1).

Given the vastly different interpretations we would give to the glabellar length–width relationship under these different circumstances (*e.g.*, a regular and predictable relation in Fig. 1A, no relation whatsoever in Fig, 1D), and the failure of the estimated regression lines to distinguish between these alternative patterns *per se*, it seems clear that we need to look beyond the simple calculation of a linear regression line's equation if we are to use regression to gain a deeper understanding of our variables (which, after all, is the real point of any quantitative data analysis). Fortunately, our friends over in the statistics department have anticipated our problem and relatively easy-to-apply solutions are available.

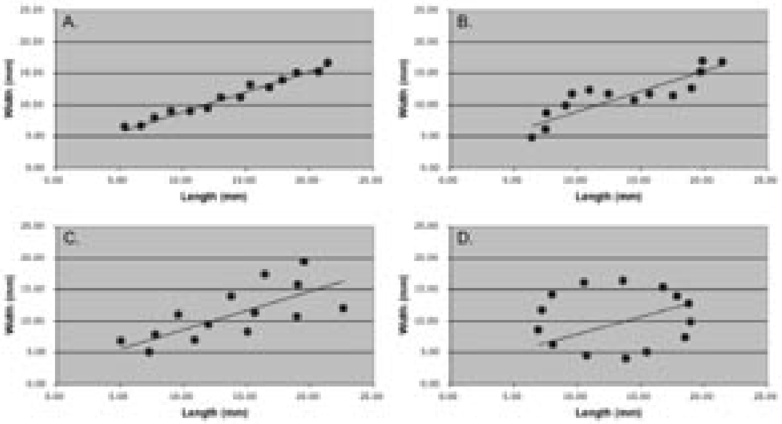

Figure 1. Four alternative data patterns that produce linear regressions of non-zero slope. A. Linear regression through linearly distributed data. B. Linear regression through data with a linear trend but non-linear distribution. C. Linear regression through data in which the error is proportional to variable magnitude. D. Linear regression through data exhibiting no linear trend, but a heterogeneous distribution of point density (heterogeneous point densities are characteristic of random data).

Obviously, the four cases illustrated in Figure 1 differ from one another primarily in magnitude and distribution of the deviations between the linear model's predictions—represented by the regression line—and the observed data points. Although we previously referred to these deviations as errors, they are also often referred to as 'residuals' in the sense of being a proportion of the observed data left over after the (in this case) linear pattern has been accounted for or 'explained' by the regression model. Residuals are easiest to calculate for least-squares regressions where they are defined as the difference between the observed y-value (y_i) and the y-value predicted by the regression equation ($\hat{y}_i$)[1].

$$\begin{aligned} y'_i &= y_i - \hat{y}_i \\ y'_i &= y_i - (\,mx_i + b\,) \end{aligned} \tag{3.2}$$

where m and b represent the least-squares regression slope and y-intercept respectively. Figure 2 illustrates the residual plots for each of the alternative data geometries shown in Figure 1.

Although the data patterns in Figure 1 were devised to be obvious, it is, in most instances, a good idea to inspect residual plots like these to determine whether a linear regression analysis has been an appropriate model for the characterization of any particular dataset. If your residual plot looks like the pattern shown in Figure 2A, a linear regression analysis was appropriate. More specifically, in order to be regarded as appropriate the residual plot should (1) exhibit no linear trend in itself, (2) form a scatter about a flat, horizontal line through the residual bivariate mean whose deviations approximate a normal distribution, and (3) be arranged such that the standard deviation of variability in the residual values is the same everywhere along the regression line, regardless of the x-axis interval selected (a feature known by the rather scary term 'homoscedasticity'). Any other residual plot geometry is problematic.

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[1] Throughout this essay I will be assuming a 'y on x' least squares regression. For an 'x on y' least squares regression reverse the xs and ys in the equations.

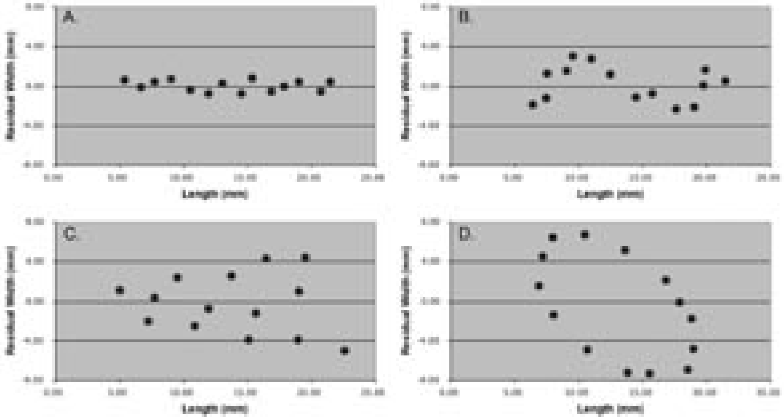

Figure 2. Plots of least-squares residuals about the linear regression lines for the alternative data geometries in Fig. 1.

In Figure 2B, even though the data pattern contains a consistent linear trend, the fact that the residuals exhibit such a well-defined, non-random structure suggests the linear model did not provide an appropriate characterization. In this case, the marked wave-like pattern indicates that the positions of successive points are dependent on the positions of preceding points (the signal of strong autocorrelation). The form of this particular autocorrelated pattern indicates use of a curvilinear regression model would be preferable.

Figure 2C represents a problem of a different kind; one that is even more common than autocorrelation. In this instance the standard deviation of the residuals from the linear model increases as a function of the x-variable's magnitude. This is the 'heteroscedastic' condition. Pronounced heteroscedasticity usually means that large variable values are not being estimated with the same precision as smaller values. Alternatively, this situation could signal the effects of a fundamental structural constraint, such as allometry. Regardless of its origin, the greater variability of the data at one or the other end of the distribution affects the precision with which a linear relation can be estimated. The usual solution to this problem is to apply a data transformation (*e.g.*, logarithmic transform) which minimizes the effect of such scaling differences, and then repeating the regression analysis on the transformed data.

Finally, the somewhat artificial example of Figure 4D is there to remind us that linear regression analysis can find structure in data that deviate only slightly from being structure-less. In this instance, the appearance of a non-zero regression slope is due solely to a slight asymmetry in the density of the data distribution. This residual plot also suggests marked non-linear (and autocorrelated) structure.

Graphically determining whether a linear regression model is appropriate to apply to a bivariate dataset is only the beginning. From here it is appropriate to ask how well does the linear model fit these data? This question is usually approached by partitioning the variance exhibited by the observed data into parts. Once again, the calculations are most easily approached for least-squares regression analysis, since the variance of interest is subsumed entirely by a single variable (the y–axis).

As we discussed last time, the variance is based on calculation of the sum of the squared deviations from the sample mean.

$$SS_T = \sum (y_i - \bar{y})^2 \tag{3.3}$$

If this quantity is taken to be the total sum of squares, another quantity can be defined as the sum of squares of the regression and calculated as the sum of the squared deviations of the y-values estimated by the regression equation ($\hat{y}_i$) from the sample mean.

$$SS_R = \sum (\hat{y}_i - \bar{y})^2 \tag{3.4}$$

In the simplest case, where all data points lie precisely on the regression line, $SS_T = SS_R$. In all practical cases, though, there will be some degree of deviation between the observed and estimated points. The difference between these values, then, is a measure of the dispersion of residual values about the regression line, a quantity termed the sum of squares of the error.

$$SS_E = SS_T - SS_R \tag{3.5}$$

While SS_E is a measure of the absolute error of regression, an arguably more useful comparative statistic can be determined from the ratio of SS_T and SS_R. This is the so-called r^2-value, also termed the coefficient of dispersion.

$$r^2 = SS_R \,/\, SS_T \tag{3.6}$$

Whereas the SS_E can adopt any positive value and is sensitive to scaling differences between the variables of different regression analyses, r^2 is a measure of relative dispersion and constrained to vary between 0 and 1. Thus, this statistic measures the goodness of fit between the data and a linear model in a manner that is comparable across analyses involving different datasets. Because it is a ratio, r^2 also has no units (whereas the SS_T, SS_R and SS_E unit is the square of whatever unit in which variable y was measured). For this reason r^2 is often reported as a percentage. If $r^2 = 0$ no linear relation exists between x and y. If $r^2 = 1$ a scatterplot of x and y forms a perfectly straight line.

If you read statistical textbooks you will often come across statements to the effect that the square-root of r^2 is the 'correlation coefficient' (usually represented symbolically by r). This is not precisely true. We will discuss the correlation coefficient in detail in a future essay. For now, suffice it to say that r^2 is related to r mathematically, but differs in that r may adopt any value between –1 and 1 whereas r^2 is constrained to vary between 0 and 1 (see equations 3.3–3.6). Thus, $\sqrt{r^2}$, which is technically called the multiple correlation coefficient and which I will refer to as r_m , is also constrained to vary between 0 and 1, unlike the Pearson product-moment correlation coefficient (r).

If you have had a course in statistics or read the regression section of a statistics text you will know that the 'significance' of a least-squares linear regression is typically tested with an *F*-statistic. The *F*-distribution (which was named for the eminent British statistician Sir Ronald Fisher) is the distribution of values expected by drawing two samples of varying sizes randomly from a normal distribution and calculating, for all possible combinations of such samples, the ratio of their variances. Because the precision with which the population variance can be estimated by samples varies with the size of the sample drawn, the form of the *F*-distribution changes for different combinations of sample sizes. Hence, the large number of tables devoted to the *F*-distribution in textbook appendices.

Basically the *F*-distribution tabulates how different the ratios of sample variances drawn from the same normal distribution can be expected to be. If the observed difference between variance ratios exceeds (say) 95 percent of the expected values, one is justified in rejecting the null hypothesis that the samples were drawn from the same distribution. An *F*-test is typically applied to regression problems by comparing the ratio of the variances attributed to the regression and residual (or error) sums of squares. By choosing this statistic to examine we are implicitly asking the question 'Did performing a linear regression analysis have any effect on reducing the deviation of observations from the sample mean?' If the regression analysis 'explains' a large component of variation observed in the sample, this should be reflected in a marked difference between SS_R and SS_E, such that the distribution of the values used in their calculation differs from the 'single sample' expectations of the *F*-test.

In order to perform this *F*-Test we first need to change the SS_R and SS_E values into variances. As we saw in the last essay, this is done by turning these component estimates of the total deviation into mean values. The mean squared deviation (= variance) of the total deviation is calculated by dividing SS_T by one less than total sample size ($n - 1$, see previous essay for an explanation of this convention). The mean squared deviation (= variance) of the values estimated by the regression is calculated by dividing SS_R by one less than the number of factors involved in the regression's calculation. Since, for a linear regression, there are two such factors (the slope and the y-intercept), this value is 1. The mean squared deviation (= variance) of the residual values is calculated by dividing SS_E by the difference between these two denominators, $(n - 1) - 1$, or $n - 2$. Once these values are in hand, the *F*-statistic is calculated as follows.

$$F = (SS_R) \; / \; (SS_E / n - 2) \qquad (3.7)$$

To illustrate these calculations on a real dataset, let us return to the trilobite glabellar data from the first essay of this series.

Table 1. Trilobite Data

	Genus	Length (mm)	Width (mm)
1	*Acaste*	5.10	3.46
2	*Balizoma*	4.60	6.53
3	*Calymene*	12.98	14.15
4	*Ceraurus*	7.90	5.32
5	*Cheirurus*	12.83	12.96
6	*Cybantyx*	16.41	13.08
7	*Cybeloides*	6.60	6.84
8	*Dalmanites*	10.00	9.12
9	*Delphion*	8.08	10.77
10	*Narroia*	15.67	9.25
11	*Ormathops*	4.53	4.11
12	*Phacopdina*	6.44	6.94
13	*Pricyclopyge*	21.53	14.64
14	*Ptychoparia*	12.82	9.36
15	*Rhenops*	22.27	17.56
16	*Sphaerexochus*	4.93	6.21
17	*Trimerus*	16.35	15.02
18	*Zachanthoides*	13.41	8.51

The equation of the least-squares regression through these data is $y = 0.64x + 2.51$. What we now want to know is whether this a good linear model of these data? Whether a linear model is appropriate for these data? And whether this linear model has had any significant effect on the error structure of these data?

We start graphically, by calculating the least-squares regression residuals and plotting these on a scatter diagram (Fig. 3).

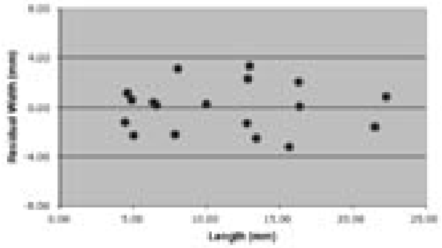

Figure 3. Scatterplot of least-squares regression residuals from the trilobite data (see equation 3.2).

Overall these residuals look pretty good. While there is an aspect of heteroscedasticity in the fact that the two most extreme values are separated from the remainder by what appears to be a noticeable gap both ends of the scatter exhibit a somewhat smaller deviation from the regression line than the middle group of points, I would not judge these to be serious problems for this dataset. Such effects could easily be a by-product of the small size of this dataset. Based on this graphic evidence, I would conclude that a linear model was appropriate. But is this particular linear model a good fit? To assess that we use equations 3.3 to 3.6 to complete the following table.

Regression Equation	$y = 0.64x + 2.51$
SS_T	286.92mm^2
SS_R	223.95mm^2
SS_E	62.97mm^2
r^2	0.78

Based on these statistics there does seem to be a large amount of the total dispersion accounted for by the regression (SS_R) (implying a corresponding marked reduction in the residual dispersion SS_E). The r^2 value estimates the proportional variance accounted for by the regression at 78 per cent and provides us with a means for comparing this result to the results of other regression analyses. But is this error reduction result good enough to be considered statistically significant? To ask this question another way, 'Can I assure myself that the difference between SS_R and SS_E reflects the linear trends and accounts for a meaningful proportion of the variance in the population from which the sample was drawn?' To answer this question we use the terms of equation 3.7 to complete the following table.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	*F*-statistic
Total	286.92mm^2	17	16.88mm^2	56.90
Regression	223.95mm^2	1	223.95mm^2	
Error	62.97mm^2	16	3.93mm^2	

Consulting a table of *F*-statistic critical values for a significance level (one-sided) of 0.5, degrees of freedom (numerator) of 1, and degrees of freedom (denominator) of 16 we see that any *F*-statistic ≥ 4.49 is considered adequate for rejecting the hypothesis that there is no difference between the variance attributable to the regression and the residual (or error) variance with a 95 per cent certainty. Since our calculated *F*-statistic is much greater than this critical value, the least-squares regression of these data has passed the statistical significance test.

Up to this point we've been focusing on least-squares regression because the equations used to quantify the quality of such regressions are fairly straightforward, easy to calculate, and backed-up by extensive theoretical investigation. In no small measure, this is because least-squares regression concerns itself with deviation in only a single variable. Reduced major axis (RMA) and major axis (MA) regressions are different beasts entirely because they both involve estimation of the joint variation of both x and y variables. This is much more complex and, for some reason, has not been explored extensively by theoreticians in the context of regression analysis. With a little imagination and a bit of plane geometry, though, one can imagine what an equivalent set of calculations would look like for the RMA and MA cases.

Reasoning from analogy, the univariate, least-squares SS_T and SS_R parameters, both of which are represented as squared deviations (distances) from the $\bar{y}$, need to be replaced by equivalent squared deviations from observed and estimated data points referenced to the bivariate or joint mean ($\bar{x}, \bar{y}$). In the case of the SS_T this is a simple sum of squares of the straight-line (Euclidean) distances between each point in the dataset and the bivariate mean.

$$SS_T = \sum (x_i - \bar{x})^2 + (y_i - \bar{y})^2 \tag{3.9}$$

The SS_R value, then, represents an equivalent quantity after the estimated positions of the observed data points have been projected onto ^ the linear regression line.

$$SS_R = \sum (\hat{x}_i - \bar{x})^2 + (\hat{y}_i - \bar{y})^2 \tag{3.10}$$

The trick in dealing with RMA and MA regressions lies in obtaining these estimated $\hat{x}_i \hat{y}_i$ values. Recall that, unlike least-squares regressions, both RMA and MA regressions estimate regression lines by minimizing the combined lengths of the line segments between the observed data points and the regression model arranged such that each segment is oriented perpendicular to the model (see Regression 1, Fig. 4; Regression 2, Fig. 2). Given these geometric relations, the estimated $\hat{x}_i \hat{y}_i$ values for a RMA or MA regression must be obtained by projecting the observed data points onto the regression line in a manner that respects this error-minimization geometry. One way of accomplishing this is by determining the intersection point between the regression line and the equations of a series of lines that pass through each data point and have slopes perpendicular to that of the regression line (Fig. 4).

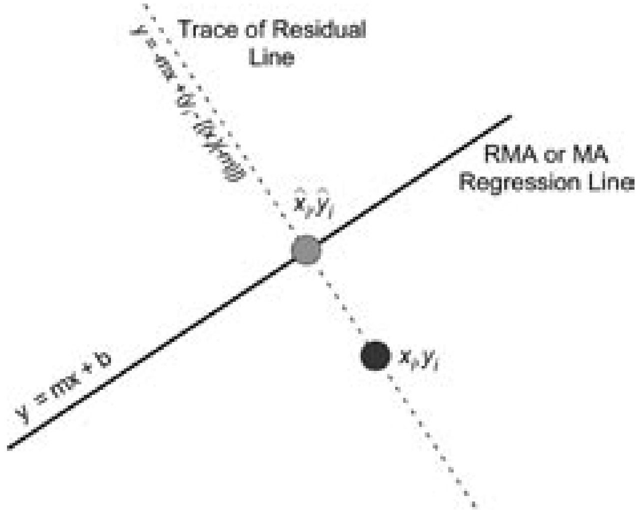

Figure 4. Geometric relations used to estimate the projections of observed points onto a reduced major axis or major axis regression line. The black dot represents an observed data point lying at some distance from the regression line. The position of the projected point (grey dot) can be estimated as the intersection point of the regression line and a line perpendicular to the regression line that passes through the observed data point.

Equations you can use to project data points (x_i, y_i) onto a RMA or MA regression line follow.

Slope of a line perpendicular to regression line $y = mx + b$

$$m_{residual} = (m) (-1) \tag{3.11}$$

Intercept of a line perpendicular to regression line $y = mx + b$ and passing through point (x_i, y_i)

$$b_{residual} = y_i - [(x_i) (m_{residual})] \tag{3.12}$$

Projected x_i-value ($\hat{x}_i$) onto regression line $y = mx + b$

$$\hat{x}_i = (-1) [(b - b_{residual}) / (m - m_{residual})] \tag{3.13}$$

Projected y_i-value ($\hat{y}_i$) onto regression line $y = mx + b$

$$\hat{y}_i = m\hat{x}_i + b \tag{3.14}$$

Once these values have been obtained, quantities analogous to SS_E and/or r^2 can be calculated (see equations 3.5 and 3.6). The Excel worksheet that accompanies this column summarizes these calculations for the trilobite glabellar data. As you will see, use of the RMA and MA approaches to estimating a linear model improves the overall fit of a linear model to these data markedly.

Let me close this column with a few observations, an encouragement, and an exception. The complications involved in obtaining $\hat{x}_i \hat{y}_i$ values for RMA and MA regressions (equations 3.11 to 3.14) go some way to explaining why few statistical textbooks discuss these regression models. Whereas $\hat{y}_i$ can be obtained by a simple subtraction and $\hat{x}_i = x_i$ in the world of least squares, a rather complicated and non-intuitive geometric construction was necessary to accomplish the same estimations for linear models determined under the RMA and MA conventions. The methods I have outlined above, however, show that, contrary to many textbooks, it is not correct to say that RMA and MA regressions cannot be used to estimate the values of such variables. Least-squares regression still has the edge in terms of being able to estimate a value of y in the absence of any information other than the corresponding value of x. But, given an observed x, y value and the equation of a RMA or MA regression line, either $\hat{x}$ or $\hat{y}$ or both can be estimated; the calculations required are just a bit more involved. To the extent that the regression relation is the 'true' relation between two variables, and deviations from the regression model are 'true' error, the equations I develop above allow RMA and MA regressions to be used in a manner completely analogous to least-squared regressions.

Moreover, because $\hat{x}$ and $\hat{y}$ can be estimated for RMA and MA regressions, significance testing using the classic *F*-test approach is also possible for these models. The alternative *F*-test method I have proposed here is *ad hoc* only in the sense that other approaches to these calculations are possible. I have modelled my approach on a procedure that is analogous geometrically to the *F*-test used in least-squares regression analysis. If you are willing to assume—or if you have evidence—that both variables are distributed in a bivariate normal manner, you may apply the *F*-test I've outlined with as much confidence as the least-squares *F*-test. If you suspect your data may not follow normal distributions you may still apply it as a rough-and-ready tool for indicating (not demonstrating) the statistical significance of a RMA or MA regression; just as you would a least-squares *F*-test. I created the RMA–MA versions of the *F*-test to fill an obvious gap in the pantheon of regression analysis techniques and I would be interested to know how it performs. The results obtained for the trilobite dataset appear reasonable; even a bit better than I had hoped.

As for the exception, I began this discussion by citing an example of an autocorrelated data pattern (Fig. 1B) that, I claimed, should not be analyzed by linear regression methods because to do so violated the assumption of homoscedasticity. I stand by that claim in the sense that, if you did attempt to characterize such patterns using linear models your models would ignore what is arguably the most interesting aspect of these patterns. Still, this is not to say that linear methods could not be used as part of an analytic approach to such data.

Figure 5A shows the well-known Sepkoski (2002) Phanerozoic extinction-intensity data. Note that this data set, like the example shown in Figure 5B, is composed of a complexly autocorrelated data sequence representing the contrast between so-called mass-extinction and background-extinction events, all superimposed on a declining trend: the background extinction gradient. When Jack Sepkoski and David Raup first published their family-level extinction data they recognized these patterns and wanted a way to separate them so as to estimate better the relative magnitudes of the extinction-intensity peaks. To do this they selected the standard approach to removing a linear trend from such data and performed a least-squares linear regression analysis of percent extinction magnitude on time. The resultant residual data (shown for the 2002 genus-level dataset in Fig. 5B) served as the basis for most of their (and others') subsequent analyses. The point is, these quantitative tools, which are extraordinarily useful in and of themselves, become even more so when deployed in sympathetic combination with other such tools.

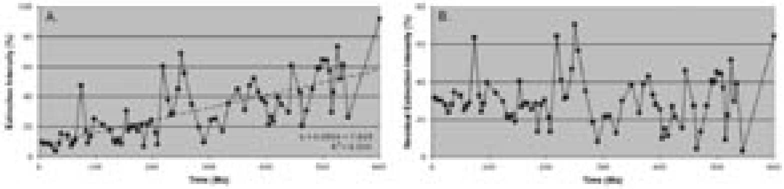

Figure 5. Use of least-squares linear regression analysis to estimate and remove the Phanerozoic background extinction gradient from extinction intensity data.

A. Raw extinction intensity data (from Sepkoski 2002) with a plot of the regression trace and equation.

B. Patterns of residual extinction intensities after removal of the declining linear trend. Trend normalization via regression analysis is a typical first-step in the analysis of many time series.

Letters

Several interesting responses-comments-questions have come in since last time. Perhaps the most technical was the following.

> *Do you know of a simple method for determining whether a value within a set of data differs significantly from the mean for that data set? Relatively small numbers (n = 7 to 14).*
>
> *Anonymous*

There are two ways to answer this question, both of which are relevant to the material I covered in the last newsletter. As with most statistical questions, the first step to getting a clear handle on the correct approach is to get a handle on what question you're really asking. This question can be read to be asking "What is the probability that observation x was drawn from a distribution (characterized by mean $\bar{x}$ and standard deviation s)?" If this is the question you're interested in, let's take the following set of observations (also supplied by the questioner)…

n	x
1	2.42
2	2.45
3	4.52
4	5.00
5	5.06
6	5.08
7	5.09
8	5.19
9	5.26
10	5.48
11	6.60
12	7.19

…and let's say we want to know how likely we were to draw the observation 8.18 from this population. The question is not idle. The average interval between values is 0.43 whereas 8.81 is 1.62 units from the largest previously recorded value. That having been said, there is one interval (2.45–4.52) in which the difference is larger than 1.62. What to do?

The first thing to check is where 8.81 falls in terms of standard deviation units from the mean. We discussed this last time in the section on data standardization. Conversion to standard deviation units is accomplished by calculating the z-score of 8.81 which involves subtracting the sample mean (5.17) from this value and dividing the difference by the sample standard deviation (1.38). This z-score is 2.63, which means that 8.81 is 2.63 standard deviation units from the sample mean. If we are willing assume the sample was drawn from a normal population, we can look up the proportion of the normal distribution that lies beyond to 2.63 standard deviation units above the mean. This value in 0.0043. If we are willing to accept a 5 per cent chance of being wrong we can regard it as very unlikely that the value of 8.81 was part of the distribution from which we drew our sample, provided our sample (1) was drawn from a single population, (2) was drawn from a population of values that did conform to the normal distribution and (3) is composed of values that were drawn randomly and independently from that distribution. If we are unhappy with assumption 2 (and few palaeontological populations are normally distributed) we can relax it by using Chebyshev's Theorem to estimate a non-parametric version of the same test. This theorem holds that the fraction of any dataset lying within at least k standard deviations from the mean is:

$$p = 1 - (1 / k^2)$$

Applying this equation to the example data we can say that at least 0.86 (86%) of a population with a mean of 5.17 and a standard deviation of 1.38 would lie at or below 2.63 standard deviations above the mean. That of course, means that as much as 0.14 (14%) of the distribution could lie beyond 2.63 standard deviations above the mean. Thus, we are left with an ambiguous result. The value 8.81 would seem to lie outside the bounds of a normal distribution so constituted, but perhaps not outside the bounds of a non-normal distribution. The obvious next step (other than to collect a larger sample) would be to check to see if the 12-point sample conforms to the expectations of a normal distribution. Unfortunately, a discussion of procedures for normality testing will need to await a future column.

Norman MacLeod
Palaeontology Department, The Natural History Museum

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Sepkoski, J. J., Jr. 2002. A compendium of fossil marine animals. **563**. *In* **D. Jablonski and M. Foote** (eds.), *Bulletins of American Palaeontology* **363**. Palaeontological Research Institution, Ithaca, New York.

Don't forget the PalaeoMath 101 web page at

<**http://www.palass.org/pages/Palaeomath101.html**>

Meeting REPORTS

International Geobiology Course
University of Southern California – Agouron Institute
Catalina Island *11 June – 23 July 2004*

The rapidly evolving interdisciplinary field of geobiology studies the interaction of life and its environment on Earth and beyond. Here I report on a very stimulating geobiology course that I attended this Summer run by the University of Southern California, Wrigley Marine Science Institute and supported by the Agouron Institute. This intensive six-week graduate-level training course was an extremely challenging and rewarding opportunity that is open to young scientists (pre and post doctoral) interested in the field of geobiology.

The course began with a week-long field excursion in the Canadian Rockies led by **John Grotzinger** (MIT), **Andy Knoll** (Harvard), **Dawn Sumner** (UCD), **Frank Corsetti** (USC) and colleagues. The twenty student participants were drawn from around the world and with diverse backgrounds in geology and microbiology, but with the common aim of developing an interdisciplinary language and understanding of geobiology. The field sites studied included Devonian stromatoporid-renalsis reefs near Banff, anoxic shales of the Frasnian-Famennian boundary, Mississippian carbonates near Lake Louise and a tourist stop near the Burgess Shale. These localities provided a great introduction to the geobiological puzzles of the rock record and provoked excellent discussions on the outcrop of Phanerozoic ocean chemistry, biosphere evolution and climate change. We then travelled west across the rooftop of the Rockies visiting the Radon Hot Springs and the “Paint Pots” of Kootenay National Park, where we discussed microbial-mediated iron precipitation, BIFs and extremophiles whilst paddling in the ochre-rich mud. We concluded the fieldtrip near Waterton Lakes in the Belt Supergroup, where we were treated to **Don Winston***’s* (U. Montana-Missoula) great wealth of field experience, stories and banjo playing! Our field discussions focused on the stromatolites and ‘molar tooth’ fabrics of the MesoProterozoic carbonates, themes that were developed further in the course.

Students and instructors in the field near Waterton Lakes, the Belt Supergroup Alberta, Canada.

The second, five-week phase of the course was spent at the Wrigley Marine Science Centre (WMSC) on Catalina Island California.

Wrigley Marine Science Centre Catalina Island, with labs, accommodation and waterfront facilities all on site.

Here course directors **Kurt Hanselmann** (U. Zurich) and **Will Berelson** (USC) led an intensive schedule of lectures, labs, workshops and symposia, joined by visiting tutors and speakers every week. The topics covered were diverse, including: genetic approaches to geobiological problems (**D. Newman**); applications of microelectrodes in biogeochemistry (**W. Ziebis**, **C. Riemers**); techniques in molecular biology (**B. Stevenson**, **J. Spears**, **S. Dawson**, **P. Hugenholtz**); manganese cycling and biogeochemistry (**B. Tebo**, **D. Burdige**); anaerobic methane oxidation, rates and zones of diagenesis (**M. Alperin**, **W. Berelson**); microbial culturing techniques and biosignatures (**K. Nealson**, **K Hanselmann**) anammox and giant sulphur bacteria (**G. Kuenen**). (A more complete list of the lectures is available at <**http://wrigley.usc.edu/geobiology/#dates**>). To accompany these lectures there were hands-on lab exercises with highlights including: the development of genetic screens for iron-oxide reductants; DNA extraction and the sequencing of microbial samples; and sediment profiling using microelectrodes. We also undertook a class research cruise to collect and analyse water and sediment samples from the nearby San Pedro

Basin. For many of us this was our first experience of a research cruise and we were joined by two alumni of the course, who had returned to investigate further a possible microbial origin for anomalous nitrate peaks in the sediment pore waters.

Students and instructors taking sediments cores from the San Pedro Basin, California.

Whilst we were on the island the course also hosted three research symposia with international speakers and attendees joining us on the island. At the first symposium, "Early Evolution of Microbial Eukaryotes," we heard about protisan life cycles in the modern ocean (**Dave Caron** USC); ongoing studies of Proterozoic protozoa and vase-shaped microfossils (**Susannah Porter**, UCSB); insights into cytoskeleton development in basal eukaryotes (**Scott Dawson**, UCB); the origins of photosynthetic organelles in eukaryotes (**Charles Delwiche**, University of Maryland); and finally molecular trees and the misnomer of "prokaryotes" (**Norman Pace**, University of Colorado, Boulder). The second symposium discussed "Anoxic Marine Sediments Ancient and Modern," with talks on: the metazoans and protists that inhabit steep redox boundaries (**Joan Bernhard**, WHOI); the latest on clathrates and microbially-mediated seafloor methane systems (**Jerry Dickins**, Rice University); new palaeo-oceanography proxies and Late Quaternary oxygenation of the West coast of North America (**Tom Pedersen**, U. Victoria); the sulphur cycle of marine sediments (**Bo Barker Joergensen**, MPI Bremen); and the role of anoxic sediments in the global sulphate and carbon cycles (**Dan Schrag**, Harvard). The third and final symposium was equally ambitious, covering "Redox Changes in Earth History," with talks on genomic and biochemical approaches to the transition from an anaerobic to an aerobic world (**Robert Blankenship**, ASU); the oxygenation of the early terrestrial atmosphere from three different approaches, atmospheric modelling (**David Catling**, U. Washington), Palaeoproterozoic snowball events and manganese deposits (**Joe Kirschvink**, Caltech), and oceanic redox models (**Paul Falkowski**, Rutgers University).

This final symposium closed with the latest news from the Mars Exploration Rover (**David Des Marais**, NASA Ames) that provided a further, much discussed perspective on early habitable environments.

In the final three weeks on Catalina Island we also had the opportunity to design and conduct a research project to test and develop some of our new ideas and skills. I chose to work with co-student **Nina Knab** (MPI Bremen) on intertidal microbial mats at a local site on Catalina Island that complemented my DPhil research on stromatolites. We investigated the relationship between the composition of the microbial mat community, the mat morphology and the inter-tidal regime, discovering a new cyanobacterial group in the process. We tested the effects of metazoan and protistan grazing on the mats, and concluded that grazing is a constructive force essential to maintaining the "fitness" of the mat. We also investigated the capability of the mat to trap and bind different volumes and grain sizes of sediment, an important mechanism of stromatolite accretion. This was just one of the many research projects that was presented at the end of the course, to illustrate the diversity covered; others included: experiments with yeast and plaster to investigate a microbial origin for molar tooth fabrics (**E. Flemming**, UCD); halophilic microbes from the Salton Sea (**J. Bailey**, USC); experiments to produce a/biotic manganese oxides (**A. Toes**, TU Delft). It was perhaps the unique setting of the WMSC with the labs, accommodation and waterfront facilities all on site, that encouraged a friendly, supportive atmosphere and enabled us all to immerse ourselves fully in the geobiology course, with the odd canoeing and snorkelling trip (including late night phosphorescent dinoflagellates!).

In summary, this Geobiology course was an amazing scientific experience and I would strongly encourage other graduate students to apply. The opportunities to learn and practise new techniques, discuss ideas with other students and leaders in the field was unparalleled. I made many new friendships and initiated exciting new scientific collaborations. At present the UK and Europe perhaps lag behind the USA in nurturing the growing field of Geobiology. As a young scientist in this field I see great scope for comparable workshops, Summer schools and conferences here in Europe. For further information on the USC-Agouron Institute Geobiology course check out the website below and links to other geobiology resources.

University of Southern California-Agouron Institute Geobiology course:

<**http://wrigley.usc.edu/geobiology/**>

Geobiology Oxford:

<**http://www.earth.ox.ac.uk/research/geobiology/geobiology.htm**>

NSF Biogeosciences:

<**http://www.biogeosciences.org/index.htm**>

Virtual Journal of Geobiology (Elsivier):

<**http://earth.elsevier.com/geobiology/**>

Geobiology (Blackwell-Synergy):

<**http://www.blackwellpublishing.com/journal.asp?ref=1472-4677**>

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Nicola McLoughlin
Oxford University
<nicolam@earth.ox.ac.uk>

Fossils, fakes and forgeries

BA Festival of Science, Exeter University 6 *September 2004*

Fossils fire the imagination, but to what extent can fancy interfere with the communication of science? When does a life-like reconstruction of an extinct creature, even made with the best intentions, grade into fantasy? How do we know? What criteria should we employ? And how can we tell if we're being spoofed? Such were the weighty issues on the table at the Palaeontological Association's session at the BA Festival of Science in Exeter on 6th September.

First, there's outright fraud, and the most notorious fossil fraud was Piltdown Man. In 1912, fossils purporting to come from a new and ancient species of hominid were unearthed in gravels near Piltdown in Sussex. As everyone knows, the fossils were fake—even though it took four decades to expose the hoax. Even less tractable has been the mystery of the hoaxer's identity. Local solicitor Charles Dawson, who 'discovered' the finds, has always been the prime suspect, although blame has, over the years, been attached to one or more of a cast of characters to rival the most lurid crime novel—from palaeontologist and Jesuit Pierre Teilhard de Chardin to author Sir Arthur Conan Doyle. Brian Gardiner (King's College, London) has long maintained that Martin A. C. Hinton, Late Keeper of Zoology was the guilty man, which is why his recent paper on the case (Gardiner, 2003) is particularly welcome as a statement of record—a paper presented at this meeting.

How can frauds persist for so long, even when—in retrospect—they seem crude? Self delusion is an important factor. The idea that human ancestors would have had large brains and ape-like jaws was so ingrained among turn-of-the-century anthropologists that Piltdown Man, with its modern-looking (indeed, modern!) skull and ape-like (indeed, from an ape!) jaw was precisely what people wanted to see.

Another instance of the persistence of fraud, fuelled by self-delusion, was the case of Beringer and his 'iconoliths,' discussed by Paul Taylor (Natural History Museum, London), who has had a chance to examine such material that remains, and has recently published a full account (Taylor, 2004). One Johann Beringer (1667–1740), a prominent physician from Würzburg, received around 2,000 faked fossils, purportedly from limestone exposures at Eivelstadt, and published some of them in his now-notorious *Lithographiae Wurcebergensis* (1726). By today's standards the fossils are transparently fraudulent—among the cornucopia of improbability are birds preserved in flight; plants complete with flowers and roots; spiders on their webs, even celestial objects and Hebrew inscriptions of the ineffable name of God. The fraud was soon exposed as the work of jealous rivals. To be fair to Beringer, he resisted the temptation of formally naming the fossils (no *Eoanthropus dawsoni* for him), and even wrote extensively on the possibility that the fossils were faked, an idea he dismissed. That he got as far as publishing them says much about the imperfect knowledge of fossilization in Beringer's time—people did not have a clear idea of what fossils ought to have looked like—as well as the degree to which Beringer took the truth of the fossils on trust.

Self-delusion is clearly something for which scientists should be watchful: in my own presentation, I argued that it is an even greater problem than malicious fraud. It is a wonder, in fact, that fraud does not occur particularly often, given that the entire scientific enterprise rests on trust. The informal motto of the Federal Bureau of Investigation may well be 'In God we trust—everyone else we check out,' but scientists and publishers cannot afford the luxury of such scrupulous oversight. When a manuscript arrives at the office of a journal editor, the editor cannot afford to repeat the experiments described in any one paper, nor travel to a remote location to check matters for himself. He is forced by circumstances to assume that what is presented therein is an honest account. The same constraints apply to the referees asked to assess the technical merits of the manuscript.

At first sight, the mechanisms of science publication leave themselves wide open to outrageous abuses of trust. There are two reasons, I think, why fraud is less of a problem than it might be. The first is that the community of science is small and interdependent. The same person who submits a manuscript on Monday will be asked to review the manuscript of a colleague on Tuesday, edit a journal on Wednesday, and serve on an ethics panel on Thursday, so there is a strong incentive to Do As You Would Be Done By.

The second reason is that even in a general climate of mutual trust, the truth will out, even if it takes a long time to emerge. When research after 1912 on genuine fossil hominids suggested that they generally had small brains and modern-looking jaws, the opposite situation as found in Piltdown Man, the Piltdown fossils were cited more as anomalies than fakes. After all, given that scientists and editors are almost completely unable to police themselves except by example, one cannot afford to doubt the veracity of any scientific account—for once started, when would you stop? That way madness lies. One could argue that Beringer was a victim of a similar set of circumstances: he was unwilling to believe that he had been tricked, despite the copious evidence before his own eyes. The same might be said of the suspension of disbelief attendant on the examination of one of the Piltdown artefacts, a bone carved in the shape of a cricket bat. The first Englishman, the hoaxer seems to be saying, would not be properly accoutred without such an object—and yet the scientific establishment still fell for it.

Beringer is thought to have been a pompous and self-opinionated person, ripe for a fall. The same might have been said of Arthur Smith Woodward, the curator at the Natural History Museum thought to be the principal intended victim of Piltdown. Beyond practical jokes, however, the Piltdown and Beringer cases raise questions about the degree to which we are all complicit in reconstructions and restorations of past life, all of which require a measure of imagination. The line between responsible reconstruction and outright fantasy was the focus of opposing presentations from Paul Barratt (Natural History Museum, London) and Mike Benton (University of Bristol). The presentation of reconstructions depends very much on the context in which they are placed. In other words, we, the viewers, must be given information *additional* to the reconstruction before we can judge whether or not to believe it as 'truth'.

Criticisms of the TV series *Walking With Dinosaurs* concern not the reconstructions themselves—which all agree were breathtaking—but the fact that the script was constrained by its documentary format to present, with equal weight, contentions that varied from known fact to unsupported hypothesis. Benton, an adviser on the series, defended it stoutly by appealing to our general sense that any and all reconstructions of prehistoric animals must, by their very nature, be speculative, even in a documentary format or, for that matter, a scientific paper. In other words, the subtext of the programme asked us to be complicit in the suspension of disbelief, despite its format. As Barrett showed, contextual—or explicit—health warnings can be useful, even in the most unlikely cases. When reconstructions are presented in an explicitly fictional setting (Barrett used B-movies such as *One Million Years BC* to make the point), one can still learn useful things about science.

So, does Racquel Welch's fur-lined lingerie represent a greater contribution to human wisdom than Beringer's iconoliths? The question is less easy to answer than it might first appear. For, as we have seen, appearances are deceptive rather than objective, as any object requires for its comprehension a contract of complicity between our own perceptions and the world around us.

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Henry Gee
<h.gee@nature.com>

IGCP 503 Early Palaeozoic Palaeogeography and Palaeoclimate

Erlangen, Germany *1 – 4 September 2004*

<**http://www.pal.uni-erlangen.de/IGCP503/**>

Following the success of the IGCP Project 410: *The Great Ordovician Biodiversification Event: Implication for Global Correlation and Resources* (1997–2002), UNESCO-IUGS has endorsed its successor project, ICGP 503: *Early Palaeozoic Palaeogeography and Palaeoclimate.* The project will last five years, each year having a specific theme that will contribute to the overall project synthesis:

Year 1: Ocean and climate modelling integrating C, O and Sr isotopes.

Year 2: Evolutionary palaeoecology.

Year 3: Changing palaeogeographical patterns.

Year 4: Early Palaeozoic events and stratigraphy.

Year 5: Early Palaeozoic sea-level change.

The historical Erlangen Schloss (castle), set in the spectacularly symmetrical Schlossgarten of the small university town of Erlangen, Franconia, Germany, was the venue for the first international symposium of the IGCP 503 project. For a first symposium, attendance was astonishing: in excess of 200 delegates from over 20 countries, 43 speakers and 38 poster presentations made for an enthusiastic start to this project.

Axel Munnecke (Erlangen, Germany), the symposium chair, opened the symposium and welcomed all to the first session. He must be given special mention for providing all delegates with a smooth running and efficient conference.

Florentin Paris (Universite de Rennes) summarised the achievements and lessons learnt from IGCP 410 (see review by H. Armstrong in this volume of *The Great Ordovician Biodiversification Event* for a detailed synopsis). The take-home message from IGCP 410 was that through close integration and collaboration, we now have a bountiful database of clade-group diversity patterns in the Early Palaeozoic from which Ordovician researchers can now apply total Earth systems models.

The Ordovician records several abrupt C and O isotope excursion events that are documented globally and can clearly be associated with specific environmental perturbations; for instance, **Dimitri Kaljo** (Tallinn University, Estonia) reported mid-late Ordovician carbon isotope excursions from Baltoscandia and recognised two periods of high variability in the mid-Darriwilian and the Caradoc-Hirnantian. The mechanisms influencing these changes and the subtle interplay with biotas are poorly understood, especially with regard to changing ecosystems: *e.g.* how does the global carbon sink budget and distribution change with the demise of planktonic organisms in the late Ordovician? However, before we can begin to consider such questions, we must be aware that our interpretations of stable isotopic data from biominerals may be seriously jeopardised without considering and accounting for the effects of inter-generic isotope fractionation (in strophomenids and pentamerid brachiopods at least; **Torsten Bickert**, Universistät Bremen). This was reiterated by **Michael Joachimski** (Erlangen, Germany) who separately documented dissimilar palaeotemperatures from Silurian conodonts and brachiopods, differing by as much as 8^{0}C. With this point in mind, Torsten demonstrated that the Llandovery-Wenlock trilobite-conodont extinction occurs at the base of a major $\partial^{13}C$ perturbation indicating that the process (antiestuarine circulation and salinity change from high evaporation) was a driving force of local extinction and not the mechanism causing the isotopic shift itself. Resolving one aspect of biotic and abiotic system interactions, **Bradley Cramer** (Ohio State University, USA) enthusiastically and eloquently demonstrated how rising pCO_2 in the Wenlock of Tenessee was concurrent with an increase in organic carbon burial in deep marine waters and that the site of deep water formation changed from low to high latitudes during this time. This was a fine example of an approach to investigation that should now to be applied to established Ordovician events.

It has long been established that the end-Ordovician (Hirnantian) glaciation is synchronous with definite $\partial^{13}C$ and $\partial^{18}O$ excursions. These shifts are taken to be associated with the two-phase mass extinction at this time, though in light of the lectures received in the first session, we should perhaps be looking towards more substantial physical evidence for subtle patterns in the development and decline of the Gondwanan polar ice cap. To constrain the true cause and effect of the pre-Hirnantian pCO_2 fall, **Achim Herrmann** (Washington University, USA) proposed, from atmospheric and ocean general circulation models, that the fall in atmospheric pCO_2 would only be a direct cause of glaciation if it fell below eight times that of present day atmospheric levels (PAL). This is significantly lower than calculations made previously of a pCO_2 decrease twelve to twenty times PAL. This figure may fall further still if estimates of mean global elevation are increased in models. In addition to this, the spatial distribution of marine organisms in the Caradoc conforms to climatic and oceanographic simulation models following this pattern.

Of a similar level of controversy is the exact process and mechanism by which the end-Ordovician glaciation came to a close. Current thought proposes two short scale (<1Ma) eccentricity cycles controlling the melting of a Laurentide-scale ice sheet. However, **Javier Álvaro** (Université de Lille, France) documented six minor regional Hirnantian cycles during glacial regression in the eastern Anti-Atlas of Morocco from newly recognised terrestrial geomorphological features. From the same school**, Julien Moreau** (Université de Strasbourg, France) used seismic sections to identify five small-scale sequence stratigraphic events representative of sporadic glacial melting cycles in western Gondwana from North and West African Hirnantian sediments. This is further supported by geophysical mass-balance models expressing the extent and waxing and waning of the North African Gondwanan ice sheet **(Daniel Le Heron**, Université de Strasbourg, France). Focusing on physical evidence in the marine realm, **Pat Brenchley** (University of Liverpool, UK) described, from rather esoteric quarry outcrops in east Wales, limestones composed of erosional debris derived from Rawtheyan material in an otherwise clastic submarine channel. The limestone became karstified during marine regression and subsequently covered by shallow marine sand during marine transgression. These physical features therefore record subtle end-Ordovician glacio-eustatic sealevel fluctuations. Physical evidence such as this surely now paves the way for work investigating the geochemical and biological counterparts both locally and globally, but to do so we must be aware of the global changes that such a cyclical pattern would produce. Taking a geochemical stance, **Howard Armstrong** (University of Durham, UK) applied a present-day model of anoxia to understand the formation of ubiquitous 'hot' black shale deposition on the periglacial continental shelf of northern Gondwana. In their study area, the Batra Formation, Jordan, sequence stratigraphy, microfacies analysis, biomarkers and spectral markers of TOC data were used to show anoxia developed as a consequence of obliquity-forced seasonal variations, ice sheet melting and eutrophication resulting in elevated bioproductivity and anoxia (Strakhov hypothesis).

The final session of the day was an open session and consisted of a number of presentations on various aspects of Ordovician, Silurian systems and even a mention of the Devonian. **Guillermo Albanesi** (Universidad Nacional de Córdoba, Argentinia) shed some light on the metamorphic history of the enigmatic Argentine Precordillera representing the north-western Gondwanan margin by applying the conodont colouration index. **Li Yue** (Nanjing Institute, China) discussed the pattern of recovery of Silurian reef development in the Ord-Sil of the Yangtze Platform in south China. These form a sensitive proxy for equatorial climate reefs. Development was favoured during interglacial episodes but following the glaciation, did not then reappear until the Aeronian.

Day Two commenced with an invited lecture from **Robin Cocks** (NHM, UK) who gave a comprehensive review of known Ordovician palaeogeography and highlighted areas of current controversy. Problems concerning Ordovician palaeogeography were the key issue in this session, a problem that **Chris Scotese** (University of Texas) suggested may be rectified through greater incorporation of GIS systems. He emphasised the need for a standard approach to palaeogeographical reconstruction and the need for accessible datasets for GIS systems. This he again reiterated in the final closing lecture of the conference.

Of great concern was the exact position and rotation of the Baltica palaeocontinent throughout the Ordovician. The well-established exposition that Baltica rotated by a full 90^{o} was challenged by the palaeogeographical models of Scotese and plate tectonic theory. To complement this controversy, recent geomagnetic work from the Urals places Baltica at a palaeolatitide of 20^{o}S throughout the early to mid-Ordovician and at 30^{o}S in the late-Ordovician rather than at 10^{o}S by the late Ordovician (**Natalia Lubnina**, Moscow State University, Russia).

The fifth session saw an attempt by workers to begin to integrate phylogeny-based abundance data with palaeogeographical models, one of the aims of IGCP 410 and a major objective of this new project. However, **Thomas Servais** (Lille, France) highlighted potential flaws with such approaches if one does not choose the fossils carefully. Extant dinocysts and acritarchs exhibit distinct provinces in modern oceans; however, those in the Arenig are particularly bad for provincial studies for they appear to be more cosmopolitan. Servais and co-workers identify provinciality in assumed cosmopolitan fauna and suggest that for each previously disregarded organism one needs to be identified for specific types of water body; hot and cold for instance, that will hence be a good biogeographic marker.

The final day started with a series of presentations to inspire a movement for the integration of biotic-abiotic palaeomodelling and addressed several key issues pertaining to climate in the Early Palaeozoic; notably, was there actually an end-Ordovician warming event prior to glaciation, and whether or not the significant decrease in $p\mathrm{CO}_2$ that is observed in the Hirnantian was one of the actual causes of glaciation that thus drove extinction. **Richard Fortey** (NHM, UK) drew attention to the pole-ward migration and distribution of endemic trilobite and brachiopod faunas prior to the initial onset of the Hirnantian glaciation. The encroachment into high latitudes by equatorial taxa and an accompanying global gondwanan bryozoan limestone distribution between clastic intervals point to an episode of warmth prior to glaciation. This is contrary to the conclusion made the previous day by **Lesley Cherns** (Cardiff University, UK) of a cool episode at this time. By analogy with cool water Quaternary bryozoan mud mounds from Australia, she attributes bryozoan mud mounds from Libya, interpreted from seismic sections, in the Ashgill to represent mud mound development in a high latitude cool water slope or outer ramp environment. The constraints on the exact age of these mounds are uncertain and rely on unresolved conodont data.

Documenting clade-group diversity patterns, as in IGCP 410, is essential for understanding Palaeozoic Earth system processes, and forms a strong platform and database that can now be utilised in IGCP 503. Many of the works in the seventh and eighth sessions represented the final legacy of IGCP 410 and avoided a holistic discipline integration that is the essence of IGCP 503. This point aside, we now have, amongst others, complementary data regarding chitinozoan diversification (**Aicha Achab**, Centre Géoscientifique de Quebec), the disparity of Orthid brachiopod diversity and distribution (**Dave Harper**, University of Copenhagen, Denmark), Avalonian trilobite diversity (**Alan Owen**, University of Glasgow, UK), conodonts from the Urals (**Svetlana Dubinina**, Russian Academy of Sciences), Tremadocian stylophoran echinoderms from Korea (**Bertrand Lefebvre**, Universitié de Bourgogne, France) and endemic Silurian thelodonts from Central Asia and the Siberian Platform (**Zivile Zigaite**, Vilnius University, Estonia).

The final session of the symposium was a second open session, with a broad and varied range of topics covering many general aspects of Early Palaeozoic life, sediments and systems even including glaciation in the mid-Cambrian (**Andrei Dronov**, St Petersburg State University, Russia). **Enrique Díaz-Martínez** (Spanish Geological Survey) presented a variety of data from the Ordovician-Silurian boundary near La Paz (Bolivia) that could be integrated in the future in order to gain an understanding of western gondwana evolution at the end of the Ordovician. The closing address was a second presentation by **Chris Scotese** who demonstrated an alternative GIS palaeoclimate model, the Parametric Climate Model (PCM), to previous computer simulations such as global climate models (GCMs). In essence, Scotese demonstrated an impressive use of geological data to set conditions from which his PCM model will run, applied this to the Palaeozoic but then went on to extrapolate some twenty million years into the future. This may seem ludicrous, but when one identifies the confidence with which we can reliably use geological, geochemical and palaeontological evidence for interpretations, as Scotese did, extrapolation a short distance into the future is just as plausible as interpreting from the deep past.

The conference was supported by a quality social programme to relieve all from each day's intense aural barrage. Following the closure of the first day, all delegates had the opportunity to sample the delights of the rich history and architecture of Erlangen under the enthusiastic guidance of the official Erlangen tour guide team. Of particular interest was the old university prison-come-gentlemens' club in the Schlossgarten fountain water tower where it was considered a rite of passage to be an inmate. Modern university justice systems just don't seem to compare with those of the eighteenth century.

The afternoon of the second day was occupied by an excursion to the infamous palaeontological Mecca of Solnhofen, offering all delegates the chance to visit one of the working quarries and try their hand at finding the tenth *Archaeopteryx* specimen. Unfortunately, not being accustomed to such young rocks and large fossils, the discovery of the day was two small-fry fish and plenty of the pelagic crinoid *Saccocomas*. To avoid disappointment, everybody did get the chance to see two of the real *Archaeopteryx* specimens. In the evening, after everyone had dusted themselves down and slipped into their finery, delegates moved on to the vaulted cellars of the Hotel Bayerischer Hof to sample a smorgasbord of delicious German culinary delights at the conference dinner. This was accompanied by the soothing voice of the hotel's very own in-house valkerie and a fine accompanying accordion soloist.

To add the perfect ending to the final day, a trip to the Kitzmann brewery was organised where all received four bottles of complimentary beer. Thus the first International Symposium on Early Palaeozoic Palaeogeography and Palaeoclimate (IGCP 503) was a major success. In a project such as this it would seem quite easy to continue to produce lists and patterns of organism distribution and diversity but IGCP 503 goes further than this. It takes this initial data and combines it with similar lists and patterns from other disciplines. It is a strongly interdisciplinary project that focuses on the Palaeozoic world as a system and aims to explain the curves produced by IGCP 410. We now have the resources and data to begin to explain palaeontological systems, and why not start with the Ordovician?

Tom Challands
Earth Systems Processes, University of Durham
<t.j.challands@durham.ac.uk>

>>*Future* Meetings of Other Bodies

Society of Integrative and Comparative Biology
San Diego, California *4 – 8 Jan 2005*

For details of this meeting see <**http://www.sicb.org/meetings/2005/index.php3**>.

The following two items are part of this meeting.

Symposium on Terminal Addition, Segmentation, and the Evolution of Metazoan Body Plan Regionalization

Recent insights into the developmental basis of body plan specification provide a new perspective upon major patterns of Metazoan diversification. Terminal addition, a process by which the body of bilaterian animals grows at a posterior growth zone that is most clearly displayed in segmented animals, is a common condition found among disparate metazoan groups. Terminal addition is both a morphologic and a developmental phenomenon. Consequently, it can be examined through the study of development of modern organisms where molecular tools are available for the comparison of developmental process among taxa. The symposium aims to balance discussion of developmental mechanisms against historical evidence chronicled in the phylogenies of both living and fossil groups. We hope that it, and the resultant volume, will play a significant role in emphasizing the strengths of an integrated approach to the evolution of posterior body patterning.

Meeting sponsored by: SICB Divisions of Evolutionary Developmental Biology, Systematic Biology, Vertebrate Morphology and Invertebrate Zoology, the Paleontological Society and the Palaeontological Associations. This two-day symposium, organized by Nigel Hughes and David Jacobs, will be held at the Annual Meeting of the Society for Integrative and Comparative Biology, 4 – 8 January 2005,at the Town & Country Hotel, San Diego, California. For full details of the programme, including field trips, see <**http://www.sicb.org/meetings/2005/symposia/terminal.php3**>

Evolution and Development of the Vertebrate Dentition

The programme includes the following speakers: Moya Smith (KCL, UK: 'Developmental models for the origin of vertebrate dentitions'), Philip Donoghue (Bristol, UK: 'Evolution and development of the skeleton in the earliest vertebrates'), Anne Huysseune (Ghent, Belgium; 'Patterning of development in tooth replacement in osteichthyan dentitions'), Robert Reisz (Toronto, Canada; 'Origin of dental occlusion in tetrapods, signals for terrestrial vertebrate evolution'), Tim Mitsiadis (KCL, UK; 'Recovery of teeth in birds'), Renata Peterkova (Czech; 'Phylogenetic memory of developing mammalian dentition'), Todd Streelman (New Hampshire, USA; 'Genetics and development of the cichlid dentition'), Ken Weiss (Penn State, USA; 'Evolutionary genetics of dental development'), Paul Sharpe (KCL, UK; 'Development and evolution of dental pattern') and Jukka Jernvall (Helsinki, Finland; 'Mammalian dental diversity').

Sponsored by SICB Divisions of Evolutionary and Developmental Biology, Vertebrate Morphology, Cell Biology, and Systematic and Evolutionary Biology (primary).

Organizer: Moya Smith, e-mail <**moya.smith@kcl.ac.uk**>.

4th International School on Planktonic Foraminifera: Oligocene to Middle Miocene Planktonic Foraminifera
Perugia, Italy *14 – 18 February 2005*

The course will include lectures (taxonomy, biostratigraphy and palaeoceanography) on Oligocene to Middle Miocene Planktonic Foraminifera and practical sessions studying washed assemblages. The maximum number of participants is 30. Registration and payment deadline: 30th November 2004. Course organised by Prof. Silvia IACCARINO University of Parma (Italy) and Prof. Isabella PREMOLI SILVA University of Milano (Italy) with the collaboration of Drs Milena Biolzi, Luca Maria Foresi and Fabrizio Lirer. For further details, please contact Dr Roberto Rettori, Dipartimento di Scienze della Terra, Piazza Università, 1, I-06100 Perugia, Italy, e-mail <**rrettori@unipg.it**>, tel 00390755852664, fax 00390755852603, or visit the website at <**http://www.unipg.it/~denz/**>.

Geologic problem solving with microfossils
Rice University, Houston, Texas, USA *6 – 11 March 2005*

The aim of the meeting is to draw together a diverse array of geoscientists to showcase the problem-solving power of microfossils in a variety of geologic settings. Call for abstracts via the website from 1st April to 14th October 2004. Registration begins 6th September 2004, via the website.

For details visit the conference website at <**http://www.sepm.org/microfossils2005.htm**>, or contact <**thomas.d.demchuk@conocophillips.com**>.

Tracking Dinosaur Origins: the Triassic/Jurassic terrestrial transition
Dixie State College of Utah, St. George, Utah *22 – 24 March 2005*

Utah Friends of Paleontology Annual Meeting
Dixie State College of Utah, St. George, Utah *25 – 26 March 2005*

The Triassic/Jurassic transition is a critical time in Earth history, recording the origins and early radiation of dinosaurs, pterosaurs, crocodilians, mammals, and several other significant

Mesozoic vertebrate clades. Additionally, a major interval of faunal stepwise extinction is recorded in both the marine and terrestrial environments that may be linked to impact events, setting the stage for the ascendance of dinosaurs to a position of dominance for the remainder of the Mesozoic. Current research in this area is dynamic, with important implications for a number of areas in palaeobiology and geology. A number of recently discovered fossil localities in a little researched area of southwestern Utah preserves a thick sequence of rocks spanning the Triassic/Jurassic interval. These localities are proving to be a catalyst for new studies on this time period. Many of these studies have centred on the basal Jurassic St. George Dinosaur Tracksite at Johnson Farm. This remarkable new site preserves an extraordinary series of track levels along the margin of a Hettangian lake ("Lake Dixie"); associated fossil plants, invertebrates, fish, and dinosaur remains make it particularly significant. These discoveries, along with a new interpretive centre slated to open in the Summer of 2004, provide an impetus to bring scientists together to discuss terrestrial faunas across the Triassic/Jurassic transition in a dramatic geologic setting unfamiliar to most attendees. A proceedings volume to be published by the New Mexico Museum of Natural History and Science, and a full colour overview volume, are planned by the Utah Geological Survey for initial distribution to attendees at the conference. This volume will include short review papers on areas of critical interest regarding the Triassic/Jurassic terrestrial transition in various areas of the world, summary papers on these rocks, and their preserved fossils in southwestern Utah.

Preliminary programme:

March 22: plenary papers;
23: general conference papers;
24: field trip: Triassic/Jurassic geology and palaeontology in the St. George and Zion National Park areas.

Conference participants may fly into St. George, Utah directly, or speakers may fly into Las Vegas, Nevada and then be transported by volunteers to St. George. Conference participants are invited to remain for the Utah Friends of Paleontology Annual Meeting, which will include additional afternoon field trips on 25th and 26th March.

Information on the St. George tracksite may be viewed starting on page 4 of Survey Notes v. 34, no. 5. at <**http://geology.utah.gov/surveynotes/snt34-3.pdf**>.

10th Conference on Australasian Vertebrate Evolution, Palaeontology and Systematics (CAVEPS)

Naracoorte Caves, South Australia *29 March – 2 April 2005*

The 10th CAVEPS will be held at the World Heritage listed Naracoorte Caves National Park and nearby Naracoorte township, approximately 360 km SE of Adelaide (capital city of South Australia), in the Limestone Coast region of South Australia. The Limestone Coast is well known for its Pleistocene vertebrate sites, with the most significant of these within the Naracoorte Caves World Heritage Area (serial nomination with Riversleigh, Queensland). The region is also famous for its high quality wine, wetlands and significant karst and geological features.

CAVEPS is a biennial meeting of vertebrate palaeontologists from around Australia and overseas. CAVEPS 2005 will consist of three days of general sessions including papers on all aspects of vertebrate palaeontology, culminating in a two-day symposium which will focus on Quaternary extinctions and dating applications. Included in the general sessions will be a special session on cave palaeontology which will be held in the historic Blanche Cave. In addition to the main sessions, a student forum is proposed where students can present their project proposals or work in progress and benefit from professional input. The conference will be held during the AVCC (Australian Vice Chancellors Commission) common vacation week and will commence on Tuesday 29th March (Monday 28th is Easter Monday), and culminate on Saturday 2nd April.

For further details visit <**http://www.environment.sa.gov.au/parks/naracoorte/events.html**>, contact Liz Reed <**liz.reed@flinders.edu.au**> or Steven Bourne <**Bourne.Steven@saugov.sa.gov.au**>, or write to CAVEPS 2005 c/o Naracoorte Caves National Park, PO Box 134, Naracoorte South Australia 5271, Australia.

The Palms: an International Symposium

The Linnean Society and Royal Botanic Gardens, Kew *6 – 8 April 2005*

This international symposium aims to draw on recent advances by focusing on the current status of palm research both in evolutionary biology and in the environment. The symposium will take place at the Linnean Society and at the Royal Botanic Gardens, Kew. Invited papers will be given at the Linnean Society following the four main themes of Phylogeny & Evolution, Conservation & Sustainable Use, Structural Biology and Ecology.

A poster session will be held at Kew, as well as a series of workshops, including one on bioinformatics. Tours of Kew's extensive living collections of palms and the Herbarium and Library will be available. All participants will be encouraged to present posters at the meeting.

The symposium is held in honour of Dr John Dransfield, Head of Palm Research at Kew, in recognition of his outstanding contribution to global knowledge of palms over the past four decades. John is well known as co-author with Natalie Uhl of Genera Palmarum, the benchmark monograph of the palm family.

To receive further information, contact <**janet@linnean.org**> (subject: **Palms 2005**) or write to the Linnean Society of London, Burlington House, Piccadilly, London W1J 0BF.

Palynology Specialist Group of the Linnean Society of London: Spring Meeting 2005

Linnean Society, Burlington House, Piccadilly, London *27 April 2005*

This is to mark the retirement from the Royal Botanic Gardens, Kew, of former Palynology Specialist Group Secretary, Madeline Harley. Speakers so far include: Peter Crane (Kew), Bill Chaloner and Margaret Collinson (Royal Holloway University of London), Hannah Banks

(Kew), Raymond van der Ham (Leiden), Alan Hemsley (Cardiff), Michael Hesse (Vienna), Simon Owens (Kew). Offers of talks from people who know Madeline are welcome.

Please come along to wish Madeline well in her retirement (though I'm sure she won't be giving up palynology)! For further details, or if you wish to attend the meeting, please contact Carol Furness at, e-mail <**c.furness@rbgkew.org.uk**>, or at The Palynology Unit, RBG Kew, Richmond, Surrey, TW9 3AE, U.K, Tel: +44 (0)20 8332 5263.

Palaeobotany Specialist Group of the Linnean Society of London: Spring Meeting 2005

The Linnean Society of London, Piccadilly, London *28 April 2005*

This is a one-day open meeting with contributions welcome on **any area** of the **study of fossil plants**. Speakers who would like to make a presentation are requested to contact the Palaeobotany Group Secretary, who will compile the meeting programme. This should include the title of the presentation, name(s) of author(s), institutional affiliations (if applicable), and a short abstract of the presentation, preferably less than half a page of A4, and including images if required. This meeting will follow on from a one-day meeting of the Palynology Specialist Group of the Linnean Society of London.

For further details, and to submit presentations, contact the Palaeobotany Specialist Group Secretary, e-mail <**webmaster@palass.org**>.

Devonian vertebrates of the continental margins, IGCP 491 meeting

Yerevan, Armenia *22 – 27 May 2005*

The meeting will be dealing with all aspects of taxonomy, biostratigraphy, palaeoecology and biogeography of early vertebrates as listed in the scopes of IGCP 491: "Middle Palaeozoic Vertebrate Biogeography, Palaeogeography and Climate." Special focus will be on the neritic to hemipelagic vertebrate faunas of the Middle to Upper Devonian on the northern edge of Gondwana and their relationships to contemporaneous faunas of Laurasia and the rest of Gondwana. An IGCP 491 business meeting and a post-conference field trip to Armenian Devonian–Carboniferous sites are also planned. The meeting will be hosted by the Institute of Geological Sciences, National Academy of Sciences, Marshall Baghramian Ave., Yerevan, Armenia on 22–27 May 2005. The scientific sessions are planned for 23–25 May. A post-conference field trip of two days is proposed, on 26–27 May, to visit four Upper Devonian–Lower Carboniferous sections (Erdich and Noravank in the east of Armenia; Sevakavan and Khor Virap in the west). The approximate cost for the field trip is about US$70.

For further details, please contact the organisers, Dr Araik Grigoryan (Institute of Geological Sciences, Armenia), Dr Michal Ginter (University of Warsaw, Poland), e-mail <**fiszbit@uw.edu.pl**>, or Vachik Hairapetian (Islamic Azad University, Iran), e-mail <**vachik@khuisf.ac.ir**> or <**vh_hai@yahoo.com**>.

The Seventh International Congress on Rudists

Austin, Texas *5 – 11 June 2005*

The International Congress on Rudists calls together Cretaceous sedimentologists, palaeontologists, stratigraphers, and explorationists every three years to pursue research goals set forth in 1988 by the Cretaceous Resources, Events and Rhythms project of the Global Sedimentary Geology Programme. The 2005 Congress theme is "Cretaceous Rudists and Carbonate Platforms: Environmental Feedback." This theme will be developed in three sessions, "Depositional Environments of Cretaceous Carbonates," "Origins, Events, and Demise of Rudist Paleocommunities," and "Towards Rudist Taxonomy, Biogeography, and Phylogeny." Oral and poster sessions are planned.

Before the meeting participants will enjoy a one-day field trip to see the Texas Hill Country geology. Following the meeting a three-day excursion will give participants the opportunity to examine rudist-bearing outcrops and collect from classic middle Cretaceous carbonate buildups. The Texas Memorial Museum has developed a new exhibit of Cretaceous life, and the Museum will give access to its extensive and important collections of Cretaceous fossils for qualified specialists.

The University of Texas and the University of Tulsa will co-sponsor this seven-day conference and field trip. The John A. and Katherine G. Jackson School of Geosciences has made a very generous grant to the Congress, and the Department of Geosciences of Tulsa University is providing financial and logistical support.

To register and submit abstracts contact Debra Sue Trinque, Treasurer, 7th International Congress on Rudists, PO Box B, Austin TX 78713-8901, USA, or see the website at <**http://www.tmm.utexas.edu/npl/rudist2005/**>.

TAPHOS-05

Barcelona, Spain *16 – 18 June 2005*

The Facultat de Geologia of the Universitat de Barcelona and the Museu de la Ciència (Fundació La Caixa) are pleased to announce the celebration of the 4ª Reunión de Tafonomía y Fosilización / 2nd International Meeting TAPHOS-05 that will take place in Barcelona between 16th and 18th June 2005. The Reunión de Tafonomía y Fosilización will be celebrated for its fourth time, after the success of previous meetings in Madrid (1990), Zaragoza (1996) and Valencia (2002).

The growing number of participants in previous meetings and their variety of countries of origin show the increasing interest in this science and its utility in very different fields. The aim is to provide a periodically updated vision of the state of knowledge on the topic, which is achieved in two parallel ways: invited lectures by outstanding researchers, and poster/oral contributions by the rest of participants. In this meeting it is planned to give a great weight to participants' contributions through the organization of topic sessions coordinated by a specialist in the topic. Young researchers working in or having finished their Ph.D. concerning taphonomic aspects are particularly encouraged to participate. To register for circulars concerning this meeting send an e-mail to <**rosa.domenech@ub.edu**> with the message 'preinscription Taphos05' in the 'subject' field and including your name and complete postal address. Otherwise, further information on the meeting can be obtained by contacting the meeting secretary, Rosa Domènech, at <**rosa.domenech@ub.edu**>.

American Association of Petroleum Geologists Annual Convention

Calgary, Canada *19 – 22 June 2005*

At this meeting, the North American Micropaleontology Section of SEPM (NAMS) will sponsor a poster session on the 'Integration of Micropaleontology and Petroleum Exploration.' This session falls within AAPG Meeting Theme 5: 'Depositional Systems in Time and Space.' The NAMS session will be co-chaired by Dave McNeil (Geological Survey of Canada, Calgary) and Pete McLaughlin (Delaware Geological Survey/University of Delaware, NAMS President), who extend an open invitation to micropalaeontologists to submit an Abstract for consideration and come to Calgary to attend this major international conference. Our AAPG 2005 session topic was chosen so that virtually any aspect of micropalaeontology within any hydrocarbon basin from around the world could be included. The deadline for Abstract submission is 12th November 2004. We encourage you to present your data and interpretations, which we feel are important to understanding 'Depositional Systems in Time and Space.' Please note that last-day traffic for submissions is heavy and can cause 'gridlock.' If at all possible, don't procrastinate—submit before the last day!

Visit the meeting website for further details, at <**http://www.aapg.org/calgary/index.cfm**>.

North American Paleontological Convention (NAPC 2005)

Dalhousie University, Halifax, Nova Scotia, Canada *19 – 26 June 2005*

The meeting will include field trips to Horton Bluff (Dev/Carb boundary: early tetrapod trackways), Wassen's Bluff (Tria/Jur: link fossil between dinosaurs and mammals), Joggins (Carboniferous: world heritage site), and Arisaig (a world class Silurian invertebrate site). Major field trips will include the Gaspé Peninsula (Quebec). The local organizer is David B. Scott (Centre for Environmental and Marine Geology, Dalhousie University, Halifax, Nova Scotia B3H3J5 Canada). The meeting website is at <**http://meguma.earthsciences.dal.ca/napc/napc.htm**>.

Sixth International Crustacean Congress

University of Glasgow, Scotland, UK *18 – 22 July 2005*

The conference is organised on behalf of the International Crustacean Council by The Institute of Biomedical and Life Sciences, University of Glasgow. The Meeting will also host the 5th European Crustacean Conference, the 4th Crustacean Larval Conference, and the 2005 Summer Meeting of the Crustacean Society. For more details see <**http://www.gla.ac.uk/icc6**>.

The Fifth International Brachiopod Congress

Natural History Museum, Denmark; University of Copenhagen *4 – 8 July 2005*

The Copenhagen conference follows the successful meetings in Brest (1985), Dunedin (1990), Sudbury (1995) and London (2000). The main events, lectures and posters will be held in the Geological Museum of the University of Copenhagen. The Museum has a strong tradition in palaeontological research particularly in the Arctic and Baltic regions. The congress is being organised by David Harper (Chair), Lars Holmer, Sarah Long, Claus Nielsen and Nina Topp. There will be a pre-congress field excursion to Gotland and two post-congress field excursions, one to Jutland and one to Estonia. For more details see <**http://www.nathimus.ku.dk/geomus/index.htm**> or e-mail David Harper at <**dharper@savik.geomus.ku.dk**>.

Fourth International Symposium on the Cambrian System

Nanjing, China *18 – 24 August 2005*

More than thirteen years after the successful Third International Symposium on the Cambrian System in Novosibirsk, former Soviet Union (1990), the time has come to focus on a new target and to create a platform for all scientists working on the Cambrian to meet and calibrate their information. This meeting will accumulate not only the most influential colleagues but create the intellectual guidelines for the next decades. The symposium will focus on (i) meetings to discuss latest research findings relating to the System, especially in the global context, (ii) discussions and workshops of the IUGS Subcommission of Cambrian Stratigraphy and related geosciences, and (iii) field trips to examine the best exposed Cambrian rocks in China and South Korea. Further details can be found on the symposium website at <**http://www.nigpas.ac.cn/cambrian-conference.htm**>.

Algorithmetic Approaches to the Identification problem in Systematics

Natural History Museum, Cromwell Road, London *19 August 2005*

Sponsors: The Systematics Association and The Natural History Museum, London.

The automated identification of biological objects (individuals) and/or groups (*e.g.*, species, guilds, characters) has been a dream among systematists for centuries. Despite much preliminary work in the 1950s and 60s, progress in designing and implementing practical systems for fully automated object identification has proven frustratingly slow. However, recent developments in computer architectures, and innovations in software design have finally placed the tools needed to make the development of generalized, automated, specimen and/or group-identification systems a practical reality. In order to summarize the current state-of-the-art in automated group-recognition systems, and assess their potential to make practical contributions to systematics and taxonomy both now and into the future, the Systematics Association and The Natural History Museum, London have agreed to sponsor a free, one-day symposium, to he held in the Flett Theatre of The Natural History Museum, London on 19th August 2005.

The purpose of this symposium is to provide leaders of research groups, researchers, post-doctoral research assistants, and students working or studying in any area of systematics with an opportunity to (1) learn about current trends in quantitative approaches to the group-recognition problem, (2) become familiar with the capabilities of various software systems currently available for identifying systematic objects/groups and (3) evaluate various applications of this technology to present and future systematic problems. Special attention will be paid to showing how different approaches to automated identification can be applied to various organismal groups and in various applied research contexts (*e.g.*, biodiversity studies, biostratigraphy, conservation, agriculture, curation). Ample programme time will also be provided for discussions of issues relating to how these approaches and technologies can play a larger role in meeting the needs of current and future systematists. This free symposium is being held in association with the Biennial Meeting of The Systematics Association which begins on Monday 22nd August 2005 at the University of Cardiff. Attendees of the Systematics Association meeting are encouraged to include attendance at this symposium in their Biennial Meeting plans.

If you would like to attend this symposium, provide a demonstration or contribute a chapter to a book of collected technical articles, please send your contact details to Norman MacLeod, Palaeontology Department, The Natural History Museum, Cromwell Road, London SW7 5BD (tel: +44 (0)207 942-5204/5295, fax: +44 (0)207 942-5546, e-mail: <**N.MacLeod@nhm.ac.uk**>. A symposium website is also available at <**http://www.nhm.ac.uk/hosted_sites/paleonet/aaips_symposium/**>.

6th Baltic Stratigraphic Conference

St. Petersburg, Russia *22 – 26 August 2005*

The Conference will be held at the A.P.Karpinsky All-Russian Geological Research Institute (Sredniy prospect 74) and St. Petersburg University (Universitetskaya nab. 7/9 and 16 Liniya 29). The scientific sessions and workshops are planned on 23–25 August. Pre-conference field trips (Lower Paleozoic and Carboniferous) will take place on 19–21 August, post-conference field trip (Devonian) on 26–28 August. In parallel with the scientific session, a business meeting of the IGCP 491 Project 'Middle Palaeozoic Vertebrate Biogeography, Palaeogeography' will be held. The main issue of the Conference will be every kind of problem relating to the sedimentary basin stratigraphy of Baltic and neighbouring regions. The number of sessions and topics of symposia could be specified according to the preferences of registered participants. Participants are invited to submit abstracts of both oral and poster presentations that will be published in a special issue. For further details please contact Andrey Zhuravlev, e-mail <**stratigr@mail.wplus.net**>, or Alexander Ivanov, e-mail <**aoi@AI1205.spb.edu**>.

IGCP 491 meeting: Middle Palaeozoic vertebrates of Laurussia; relationships with Siberia, Kazakhstan, Asia and Gondwana

St. Petersburg University, Russia *22 – 26 August 2005*

In conjunction with the 6th Baltic Stratigraphical Conference.

The meeting will deal with any aspect of research on Middle Palaeozoic vertebrates (taxonomy, morphology, palaeogeography, palaeoecology, biostratigraphy), with a focus on the vertebrate fauna of Laurussia and its relationship to the faunas of other palaeogeographic provinces. Participants are invited to submit abstracts for both oral and poster presentations (details below). An abstract volume will be published as a Special Publication of *Ichthyolith Issues*.

The IGCP meeting is organised by the Department of Palaeontology, St. Petersburg University. For further details, contact Dr. Alexander Ivanov Department of Palaeontology, St. Petersburg University, e-mail <**aoi@ai1205.spb.edu**>.

7th International Symposium on the Cretaceous

Neuchâtel, Switzerland *5 – 9 September 2005*

The meeting will be held in the University of Neuchâtel.

For more details see <**http://www.unine.ch/geologie/isc7/**>.

15th International Symposium on Ostracoda

Freie Universität Berlin *12 – 15 September 2005*

The First Circular can be downloaded from the Symposium website. We will offer a number of field trips with various contents (stratigraphically and ecologically), each also including an extensive touristic and cultural programme. Please have a look at our website at regular intervals, at <**http://www.palaeo.de/iso15/**>. We are perpetually updating and extending these pages, in order to inform you about congress, programme, excursions, accommodation possibilities *etc.*, to be as complete and up-to-date as possible.

Seventh International Workshop on Agglutinated Foraminifera

University of Urbino, Italy *2 – 8 October 2005*

This Workshop will be held at the Scientific Campus of the University of Urbino. For further information please contact Rodolfo Coccioni <**cron@info-net.it**>.

Paleontological Society Annual Short Courses at GSA 2005
Salt Lake City, USA *16 – 19 October 2005*

Organiser: Bruce Lieberman.
Paleobiogeography: Generating New Insights into the Coevolution of the Earth and its Biota.
For more details see <**http://www.paleosoc.org/futureprograms.html**>.

Palaeobotany Specialist Group of the Linnean Society of London
Autumn Meeting 2005: New discoveries in old collections
Linnean Society, Burlington House, Piccadilly, London *26 October 2005*

This one-day meeting will focus on the continuing nature of discovery in historically collected fossil plant collections. Potential speakers are asked to contact the meeting organiser, Dr Chris Cleal, directly, by e-mail to <**chris.cleal@nmgw.ac.uk**> (National Museums and Galleries of Wales).

9th Symposium on Mesozoic Terrestrial Ecosystems
Manchester, UK *July 2006*

The 9th Symposium on Mesozoic Terrestrial Ecosystems (sponsored by the Palaeontological Association) will take place at the University of Manchester in July 2006. The scientific programme will run over three days, with a short pre-conference field trip to Lower Cretaceous localities on the Isle of Wight, and a longer post-conference field trip to explore the Mesozoic succession of southern England. Further details will be posted later and in the next issue of the PalAss Newsletter. Preliminary enquiries can be made to <**ucgasue@ucl.ac.uk**>.

Palaeobotany Specialist Group of the Linnean Society of London,
Spring Meeting 2006: A life of ferns and seed ferns
Montpellier, France *July 2006*

This is the initial announcement for a meeting to be held in Montpellier, the city where Jean Galtier has spent his academic life. Presentations will be on topics of special interest to Jean, specifically the early radiations of ferns and seed ferns. The meeting will (hopefully) be accompanied by an excursion to visit famous fossil plant localities in the south of France. Additional details will made available shortly. Meeting organisers: Brigitte Meyer-Berthaud <**meyerberthaud@cirad.fr**> and Nick Rowe <**nrowe@cirad.fr**>(Montpellier, France).

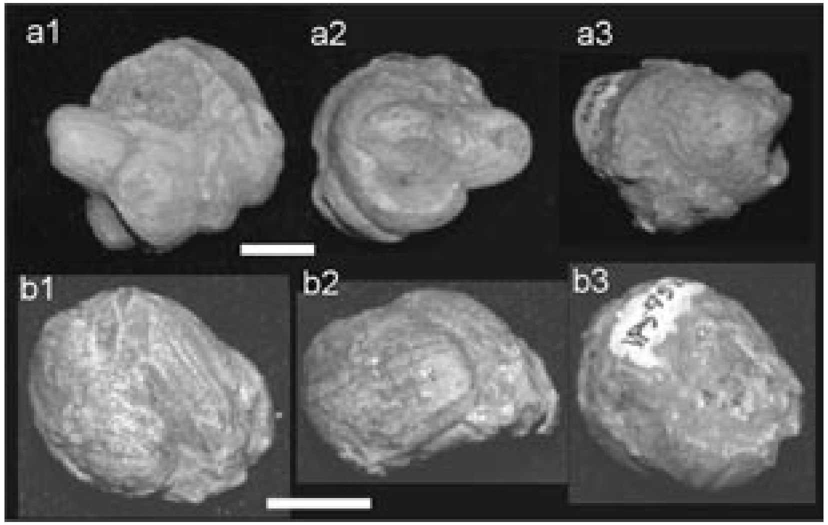
Please help us to help you! Send announcements of forthcoming meetings to <**newsletter@palass.org**>.

MYSTERIOUS FOSSILS:

Palass Newsletter mystery fossil 6

Mystery Fossil Numbers Two to Five remain mysteries, although Marc Philippe at the Université Claude Bernard Lyon 1 says he has seen an amazingly similar structure to Mystery Fossil Number Two in the basal Cretaceous of Byers Peninsula, Livingston Island, South Shetland Islands. He has a photo and will be happy to send a copy to anyone who is interested. Marc's e-mail is <**philippe@univ-lyon1.fr**>.

Mystery Fossil Six is actually two fossils with three views of each, collected by Xavier Panades I Blas from the Ludwig-Maximilians-Universität München and housed in the Museum Miquel Crusafont de Sabadell (Sabadell, Catalonia). Both specimens come from Eocene-aged continental lacustrine sediments in the Catalan Pyrenees and are formed of a white hard mineral. Fossil A (IPS 3738) was found at the Mas del Faro locality; fossil B (IPS9522) was found at the La Roca locality. The Miquel Crusafont de Sabadell Museum database has the fossils variously identified as snails, corals, claws, small mammal horns, coprolites, and unidentified. The photographs are courtesy of Drs J. Agusti and A. Galobart. Scale bars = 1 cm.



Please send insights to <c.little@earth.leeds.ac.uk>

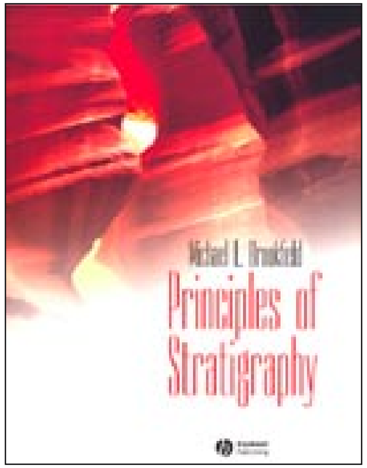
Cris Little

School of Earth Sciences, University of Leeds, UK
<c.little@earth.leeds.ac.uk>

Book Reviews

Principles of Stratigraphy

Michael E. Brookfield (2003). Blackwell Publishing, Oxford, 340pp.
ISBN 140511164X, £29.99 (paperback).



This book comprises 15 chapters divided into three sections of approximately equal length; part I 'Basics', part II 'Tracing environments in space and time', and part III 'Interpreting geologic history'. The book opens with a short introduction (chapter 1) covering the scope of stratigraphy and its historical perspective and origins.

Part I is a straightforward treatment of sedimentary rocks (chapters 2-4), competently describing the classification of rock types, weathering, sedimentary structures, fabrics and depositional settings.

Part II covers the main theme of the book, 'stratigraphic principles', although the emphasis is more sympathetic with 'environments through time' as acknowledged by the author in the preface. This part examines the vertical dimension (chapter 5), horizontal dimension (chapter 6) and temporal dimension (chapter 7). There then follows a chapter on basin analysis (chapter 8), (which includes the topic of sequence stratigraphy which is more fully dealt with in the next chapter). Chapter 8 might have been better included as the final chapter of Part I, focusing as it does on sedimentology. The concluding chapter 9 deals with cycle and sequence stratigraphy.

Part III concentrates more on the impact of tectonics and geophysical techniques on stratigraphy and interpreting geological history, which is a major driving force behind the book. Chapter 10 examines the role of tectonics on sedimentation, particularly the generation of sedimentary basins and their fill, and chapter 11 focuses on the effect of sea-level changes on sedimentation (transgressions, regressions and facies changes). Chapter 12 is a short study of the climatic effects on sediments and biota, as well as the controls on climate. Chapter 13 is an even smaller chapter (only five pages) on biology. This is a very brief nod to atmospheric evolution in the Precambrian, and biogeography (faunal provinciality in the Lower Palaeozoic Iapetus Ocean). Chapter 14 addresses some useful stratigraphic problems, and the book concludes with a short chapter (15) on extraterrestrial stratigraphy (featuring the topical sedimentology of Mars, and impact craters and eruptions on the Moon and Mercury, courtesy of NASA photographs).

It is questionable whether or not there is a market for this book, as despite its generalized title, it is in competition with many other sedimentology/stratigraphy text books, some from the same stable (*e.g.* Blatt *et al.* (1991), Reading (1996), Nichols (1999), and Leeder (1999), which cover most of the material in chapters 2–4 (sedimentary rocks and depositional environments) of Part I, and chapter 8 (basin analysis) of Part II, and Chapter 10 (tectonics) and Chapter 11 (sea-level changes) of Part III, and to a much greater depth.

The visual aspect of the illustrations in the book is very mixed. The four colour plates in the middle of the book are very effective and informative, but several of the black and white field photographs are very dark and too small to be of much use. Moreover, many of them lack any scale and thus their impact is diminished.

It would have been very helpful to the reader to identify which geochronological time scale was used in Chapter 9 (Table 9.6) and in Appendix 3. Unfortunately, not all of the calibrated times for the base of the Periods are exactly the same in both tables: for example, the Cambrian is shown as both 545 and 544Ma, and the Silurian as 441 and 440Ma.

In summary, I think this is quite a useful addition to text-books on stratigraphy and is both a stimulating and an interesting read. It is primarily designed for undergraduate geology courses, with strong emphasis on the role of tectonics and geophysics on sedimentology, and ultimately, the rock record preserved for stratigraphical analysis and interpretation. The author sees one of the main aims of the book as to 'decodify' stratigraphy, *i.e.* to remove it from the bonds of terminology in which it appears to be entrapped. I think with his different perspective and emphasis he has made a noble effort. However, I do not think that many palaeontologists will be attracted to this book, because of the limited use of faunal/biological/palaeobiological examples. Furthermore, the author is not likely to endear himself to this group of geologists with his cavalier attitude in dispensing with most types of biozones and index fossils that he regards as either useless or redundant.

REFERENCES

BLATT, H., BERRY, W.B. and BRANDE, S. 1991. *Principles of Stratigraphic Analysis* Blackwell Science Ltd, Oxford.

READING, H.G. (1996). *Sedimentary Environments: Processes, Facies and Stratigraphy*. Blackwell Science Ltd, Oxford.

NICHOLS, G. (1999). *Sedimentology and Stratigraphy*, Blackwell Science Ltd, Oxford.

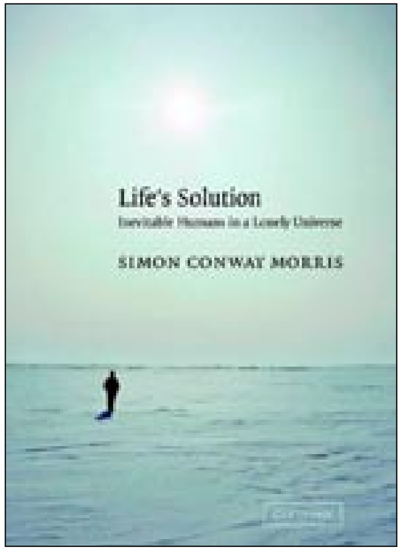
LEEDER, M. (1999). *Sedimentology and Sedimentary Basins: From turbulence to Tectonics*, Blackwell Science Ltd, Oxford.

Ian D. Somerville
Department of Geology, University College Dublin, Dublin, Ireland
<Ian.somerville@ucd.ie>

Life's Solution: Inevitable Humans in a Lonely Universe

Simon Conway Morris (2003). Cambridge University Press.
ISBN 0-521-82704-3, £18.99, $30.00 (hardback).

Within an appropriately numinous dust-cover (one of my colleagues remarked that it would not look out of place in Wesley Owen), Conway Morris presents a heuristic thesis: he asserts that the



apparent difficulty of generating life—based on the hitherto failure to replicate the process artificially—demonstrates that the origin of life is improbable (so it's a lonely universe) but given that life did evolve, humans, or more realistically sentience, were an unavoidable outcome (so we're inevitable humans). The latter statement contrasts with the late S.J. Gould's view that, if evolution were repeatedly replayed from the 'Cambrian explosion', each outcome would be substantially different and concomitantly the evolution of humans would not be guaranteed. In *Life's Solution*, Conway Morris argues why Gould's appeal to the dominance of contingency in evolution does not represent a true picture.

The first chapter of the book discusses the quintessence of life, DNA, and its striking chemical stability and efficiency as a replicating information store. Conway Morris describes its origin as a 'one in a million' chance: although as it probably took many millions of years to develop, this probability seems somewhat unremarkable. Still, Conway Morris marvels at the ability of life to "home in" on adaptive solutions within the vast expanse of potential alternatives. He likens all adaptive solutions (further dealt with in chapter two), including the development of the DNA code, to the improbable navigation of the Polynesians to that remotest speck of *terra firma*, Easter Island. To carry this analogy further, I would note that Polynesians used not only astral navigation, but also scanned the monotonous horizon for seabirds as indicators of proximal land. Day by day, they would have steered towards the general direction in which the density of birds was highest and be virtually assured of landfall. Any deviation, and they would become lost in the watery wastes of the Pacific. One can envisage a similar process (albeit a blind one) operating as organisms navigate generation by generation with seeming precision through, for example, potential morphospace, towards the most adaptive solution, with selection culling those straying into the wilderness of maladaptation. Consequently, no astonishment need be engendered by the repeated navigation toward any particular morphotype.

Chapters three and four deal with the origin of life and its improbability. Despite the appropriate raw materials being present on primordial Earth, these still required abiotic assembly, and therein lies a perceived problem. Conway Morris briefly mentions one of the greatest difficulties: that the exact chemistry of Earth during this deepest of time is unknown and will be forever unknowable. Since only the generalities are constrained, and until we stumble across the precise mix within these broad boundaries, our Frankensteinian efforts will continue to be thwarted. As Conway Morris argues, it is because such precise requirements apparently need to be met before his "universal goo" will come alive, that the emergence of life is so unlikely. However, I think it likely that the primeval chemistry of Earth would have been in flux for millions of years, providing a variety of conditions and ample time for a process of chemical trial and error to operate and produce successfully replicating molecules.

The apparent oddity of our solar system is discussed in chapter five: its structure and resultant suitability for life. Numerous other planetary systems have been identified (one hundred and thirty last time I checked), yet Conway Morris notes that there is a general feeling that all differ, some markedly, from our own. Based on this, he suggests that our system may be uniquely predisposed to the development of life. I think this conclusion is premature: although current telescopic resolution is insufficient to detect small rocky planets similar to the one we inhabit, this will change soon. We might then be in a better position to judge the clemency towards life in other systems.

In chapters six to ten Conway Morris reels off example after example of convergence to support his argument for the repeated and inevitable development of the same "biological properties," the same adaptive solutions, across a range of organisms. All the examples are interesting for anyone with a fascination for natural history and evolutionary biology (including myself), but although I appreciate the point he is trying to make, after a while (I think it was around example one hundred and sixty-four) I felt that this point had been sufficiently made. And that was before I discovered the dedicated convergence index. It at least allows easy location of your favourite example.

With chapter twelve forming a facetious coda, chapter eleven finishes the core of the book, considering some of the connections between religion and science; specifically those on which the topic of the book has bearing. This is the only section where the science plays second fiddle to more metaphysical considerations. The aim of the chapter seems to be to encourage a greater fusion of religious belief and scientific thinking, with Conway Morris arguing against the reductionist assertions of the ultra-Darwinists, incorporating some implicit anthropic thinking and hinting that humans were perhaps destined to appear. These are subjective and contentious issues, so make of this last chapter what you will.

Throughout the book, Conway Morris's writing is lucid; although it is liberally scattered with technical terms, most of these are explained. *Life's Solution* is not about palaeontology *per se* (although trilobites and spinosaurs get a brief mention) but everything within it is very pertinent to the palaeontologist. In terms of wider appeal as popular science, it is very much directed at the educated reader with some prior knowledge of evolutionary theory. One hundred and twelve pages of notes (to my shame I have not followed up on all the references) provide ample referrals to further reading on the topics discussed. As a point and counterpoint in an important debate, *Wonderful Life* and *Life's Solution* are worth reading and considering together.

So, are we inevitable humans? I would say that intelligence, and probably sentience, seems equally likely to evolve under the inexorable drive of selection as any other adaptation, be it sabre teeth or eusociality, given time and apposite conditions. However, contingency surely plays an important role in determining which organisms acquire a given adaptation. But do we inhabit a lonely universe? We've been attempting for less than a century to get those amino acids to club together and start replicating, yet it probably took millions of years first time round—I think we should give it time. And in the interim, we may still happen upon an obelisk to settle the issue.

EXTRASOLAR PLANETS ENCYCLOPAEDIA. 1995. Extrasolar Planets Catalogue <**http://www.obspm.fr/encycl/cat1.html**>.

GOULD, S. J. 1989. *Wonderful Life: The Burgess Shale and the Nature of History*. Hutchinson Radius, London.

David Jones
Department of Geology, University of Leicester
<**doj2@le.ac.uk**>

The Great Ordovician Biodiversification Event

Barry D. Webby, Florentin Paris, Mary L. Droser and Ian G. Percival. (editors) (2004). Columbia University Press, New York. ISBN 0231-12678-6, $99-50 (cloth)

Over the past 30 years considerable effort has been put into understanding the mechanisms and evolutionary importance of major faunal turnover; scenarios have been developed but too few hypotheses tested. This book, the results of IGCP Project 410 of the same title, brings into focus how little we really understand about the evolutionary processes of faunal turnover, in this case radiations, adaptive or otherwise. The stated aim of the project was to provide a global and quantified evaluation of the Great Ordovician Biodiversification Event, arguably the second most important event in Earth history, after the advent of mineralised skeletons. To achieve this, the project included a number of sub-goals:

1) The development of a global and integrated time scale using conodont, graptolites and other zonal fossils, bio-events and graphical correlation methods. This was largely achieved by using CONOP9 software.
2) To analyse onshore to offshore biofacies profiles across palaeolatitudes; achieved only in a few clades.
3) To identify biotic responses to climate change, not achieved, largely because clade diversity data were not mapped into a framework of global change.
4) To identify extrinsic factors (*e.g.* plate tectonics, volcanism) which favoured biodiversification; not achieved.
5) To compare organic matter assemblages from economically important oil shales; not attempted?

These were ambitious tasks indeed, particularly within the structure of international collaborative teams. It is a credit to the project leaders that the impressive amount of data collected has finally emerged for public scrutiny. In essence this book provides the opportunity to judge whether the project objectives were fulfilled and summarise our current understanding of radiations.

The project was clearly an administrative success, gaining an additional non-funded year, bringing together groups of scientists from a wide range of backgrounds and increasing our knowledge of Ordovician faunas. However, in an age of hypothesis-driven science and limited research funds, did the project answer some of the fundamental questions raised by the Ordovician radiation, not least why and how did it occur, and can any lessons be learnt from the Ordovician that will help us understand other radiation events? As readers of this book, you will undoubtedly be seeking the answers to these questions, as I was.

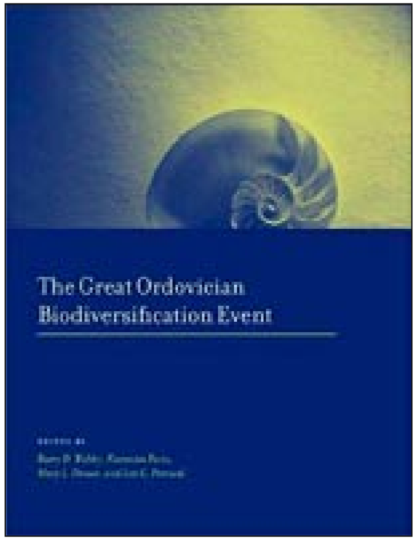
Seven regional teams and clade teams were formed to collate, analyse and interpret the primary data, taxonomic diversity change through time. The desire was to compile all relevant data on a regional-global web-based database, in effect a (Sepkoski Jr, 2002) by Ordovician specialists. Unfortunately a single database was not adopted across the project by all workers and two databases have emerged compiled by Arnold Miller and Alan Owen; each has a different focus and to date neither is web-based nor accessible to the wider scientific community. I guess hard-won raw data are too valuable for general release. This book provides the only widely available datasets from the project (see below). Declared scientific highlights of the project include a 19 time-slice subdivision of the Ordovician System tied to conodont, graptolite and chitionozoan biozones and calibrated by radiometric dates, progress on refining the global eustatic sea level curve (a new curve is presented for Baltica), development of global-regional databases for some groups and an assessment of the regional and global rate of diversity changes through time. Over 1,000 publications are attributed to the project, culminating and partly synthesized in the book under review.

First, we turn to the nitty gritty and the structure of the book. The book is divided into four sections. Section I comprises principles and methodology, including establishment and calibration of the time scale and a novel method for the measurement of diversity. Section II sets the Ordovician scene in a series of short review essays on various aspects of the Ordovician, palaeogeography; stable and radiogenic isotope patterns, an aspect of Ordovician science still in its infancy and plagued by geological over-prints; oceans and climate; Hirnantian glaciation and sea levels. A separate chapter is devoted to existence of a superplume event in the mid-Ordovician, which, if corroborated, would have implications for unifying many aspects of Ordovician earth systems and biodiversity. Most of these essays will be of use to those of you teaching Earth history modules and provide a reasonable set of illustrations and references. They do not however provide insight into a chronology of global events that may have moulded biodiversity.

Section III and the greater portion of this book (23 chapters) is devoted to documenting taxonomic richness at regional and global scales for groups as wide ranging as ‘tube-shaped things’ to ‘plants’ and vertebrates. I will not bore you with the details of each of these chapters, you will no doubt read the chapter on your pet group for yourself; suffice to say that each is stand-alone, datasets are comprehensive as far as the fossil record of each group allows, but data collection methods and analysis are not uniform across the chapters (some include species and genera counts, some only genera). The coverage is reasonably comprehensive with the exception of notable gaps in Middle and Upper Ordovician conodonts and foraminifera, and a few minor groups including the hyolithelminthes and hydroids. Unfortunately, inconsistency of approach is noticeable and leads to problems in trying to compare the diversity trajectories of each group; indeed no summary figure showing the diversity plots for all clades against timescale is included. Three chapters, bryozoa, brachiopods and trilobites, utilise cladistic classifications; the rest do not. Some chapters include attempts to correct for sampling biases; the majority do not. Some chapters ignore the 19 time-slice framework, presumably because of poor fossil record or poor biostratigraphical resolution; why include these poorly known groups, what do they add to the understanding of the radiation? Few chapters include separate diversity patterns for different biofacies, provinces and/or palaeocontinents. Universally none of the chapters provides access to the original database beyond the inclusion of time–genera range charts (conodonts as an exception), or tables of diversity metrics (graptolites as an exception)—an omission I consider woeful when supplementary data are easily hosted on websites. Indeed from a geochemical standpoint, if original data cannot be accessed, checked and interpretations tested then papers are not published, a lesson that could be well learned in future IGCP projects. These differences of approach and an inability easily to synthesize diversity patterns across the groups means it is difficult to go beyond a very subjective and generalised discussion of patterns; quantitative testing of hypotheses of processes is impossible. The final section includes a chapter on trace fossils and a synthesis, with a view to the future.

The chapters on bryozoa, closely followed by the trilobites, brachiopods and graptolites, together provide a template of good practice. These are based on cladistic classification, have quantified assessments (by gap analysis) of completeness, provide generic and/or species patterns based on palaeogeography and/or biofacies and an evaluation of extrinsic (*e.g.* relative sea level, climate changes and oceanographic changes) and intrinsic factors (*e.g.* key evolutionary innovations) affecting the radiation of the clade. Depth of coverage of course reflects the maturity of study of the clades, and particularly those with biostratigraphical utility. The remaining compilations effectively include an analysis of non-monophyletic groups, which if you take the stand that only monophyletic groups are real identities then the diversity plots are meaningless. I do not take this view, preferring to think of diversity as the changing number of species through time, not an ordered sequence of branching events. If higher taxa can be taken as a proxy for a given number of species (many argue not) and these taxa reflect sets of related niches in an ecosystem, then all that matters is that species are sufficiently similar to one another to be reasonably thought of as ecologically related; it is irrelevant whether these taxa are monophyletic. But it is difficult to ignore the existence of recent papers on the cladistical classification of echinoderms, corals, conodonts and molluscs as a starting point for global syntheses of diversity and palaeogeography.

At the outset the study of radiations, and mass extinctions for that matter, is dogged by the fundamental problem: faunal turnovers measured by origination and extinction are a species-scale phenomenon. Interrogating the fossil record at this level is an intractable problem, clouded by the vagaries of taxonomy and preservation potential. (Hoffman, 1989) has argued that the probabilities and therefore the rates of extinction and origination varied randomly through time and the overall pattern of changing global diversity amounted to the summation of a myriad number of individual and largely independent individual to species level events—a double random walk of speciation and extinction. This view is not sustained by the results from Project 410; there are clear, parallel, multi-group trends. There is also little doubt that the rise in the number of species in the marine environment in the late Cambrian to late Ordovician is real and obeys a simple logistic relationship. That is, the rate of increase fell as diversity increased, reaching a plateau at ~25% present day diversity.


The Great Ordovician Biodiversification Event

If time is short, and you can only read the chapters on clades with good fossil records, you will notice two fundamentally different diversity patterns:

1) Bryozoa, articulate brachiopods, echinoderms, corals, gastropods, bivalves, chitinozoa, ostracods and conodonts show a sustained increase in diversity until the late Caradoc or early Ashgill, independent of the timing of initiation. This was followed by a general decline through the later Ashgill and a varying impact of the end Ordovician mass extinction.
2) The planktonic groups exemplified by the acritarchs and graptolites reached peak diversity in the Arenig followed by a steady decline through the rest of the Ordovician.

Either the underlying mechanisms for radiation were different for plankton and benthos, or these groups responded differently to the same environmental cues. The fossil record of the terrestrial biosphere (trace fossils and spores) is too poor to deduce patterns beyond a gradual emergence through the Ordovician. Putative millipede tracks and the appearance of trilete spores in the Upper Ordovician suggest the existence of an incipient, low diversity, low complexity terrestrial ecosystem.

Multi-group parallels lend support to extrinsic factors being the cause of the radiation, for example changes in relative sea level, ocean chemistry and climate. These factors are all complexly inter-related and no single cause for the radiation should be sought. There is however no shortage of ecological explanations across the chapters, including habitat partitioning, trophic partitioning, increase in the number of guilds and escalation (probably best replaced by the more complex notions of multiple niche evolution). A correlation of productivity (*syn*. orogeny, (Connolly and Miller, 2002)) with diversity is evident only in the brachiopods. Intrinsic causes, such as the appearance of key evolutionary innovations, cannot be discounted but are difficult to test, requiring correlation of high resolution palaeo-environmental and diversity data, and certainly not with the data collected in this project.

Other published patterns and scenarios for diversification are present in some of the Ordovician data. The pattern of higher alpha diversity in nearshore environments and at low latitudes (Sepkoski Jr, 1991) is corroborated only by the trilobites and brachiopods which both show onshore originations followed by rapid offshore expansion. However, echinoderms show the reverse trend and bivalved molluscs originated in Gondwana and then expanded into low latitudes, first colonising the outer shelves of low latitude palaeocontinents. Plate tectonic partitioning of the marine ecosystem and the importance of island faunas as cradles of origination and refugia (hinted at by the brachiopods) are largely ignored.

IGCP 410 tried to discover non-random patterns in overall taxonomic turnover, to find common mechanisms that are statistically significant and can be used as explanations of evolutionary processes. The clear message from this book is that in groups with good fossil records, with resolved alpha taxonomy and deterministic palaeoecology, first order, non-random patterns can be demonstrated. As to discovering explanations, the how and why, and evolutionary mechanisms for radiations, this book does not provide the answers and there is much work still to be done. A synthesis of the patterns published in this book does hint at possible mechanisms. The Ordovician Radiation or, I think more correctly, the Ordovician Biodiversification, is characterised by the emergence of a more complex and more highly integrated marine ecosystem which extended from shelf to slope, and included ecologically diverse oceanic groups. At this point it is easy to become speculative and *ad hoc*, so I will.

Diversity peaks in planktonic groups may have led to radiation in the benthic fauna which started to include many new active suspension feeders with the ability to generate their own water currents. Changes in substrates led to an expansion in hard ground and reef communities. Simultaneously there was a rise in scavenging and predatory metazoans. This is a familiar scenario, also widely postulated for the Cambrian explosion. An additional feature of Ordovician shelf environments was the increase in the number of niches through time, the presumed result of trophic partitioning and other intrinsic factors operating at the individual and community level; these appear to have sustained the diversification. The jury is still out on the initial environmental and/or biological cues for the biodiversification. I would therefore suggest the study of radiations and mass extinctions have one thing in common; scenarios have been developed but too few hypotheses tested.

So should you buy this book? Would you buy Sepkoski (2002)? Ordovician workers will want this book on their shelves but, my feeling is this is a useful addition to your institutional library, you will use the information in teaching and I can see the scope for developing some interesting practicals on the nature of radiations. The compiled data are not accessible for research and this will of course retard progress on understanding radiations and in the follow up project IGCP 503, Ordovician palaeogeography and palaeoclimate.

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Howard A. Armstrong
Earth Systems Processes, Department of Earth Sciences, University of Durham, UK
<h.a.armstrong@durham.ac.uk>

High-Resolution Approaches in Stratigraphic Paleontology

Peter J. Harries (editor) (2003). Kluwer Academic Publications, Dordrecht.
ISBN 1402014430, £110 / $175/ €159 (Hardback) (CD-Rom included).

This book (volume 21) is one of a series in 'Topics in Geobiology', and comprises 13 chapters involving 21 authors. As the editor remarks in the preface, one of its main aims is to 'offer a broad perspective on both theoretical and practical issues related to high-resolution paleontologic studies', and for the most part, this book achieves its objective. It also sets out to highlight the increasing need for integrating a variety of approaches while at the same time realizing the limitations of palaeontological databases.

This volume includes twelve chapters, excluding the last chapter, which features details of the CD-Rom, used for the studies in chapters 2 and 3. However, in the contents list, confusion is caused by two chapters being given the same number 11. Most of the chapters are case studies involving fossil data collected as part of field-based projects. As all but one of the authors are based in the USA, the studies are focused entirely on North America and include one study each on Cambrian, Ordovician and Devonian faunas and seven on Cretaceous faunas. The other two chapters which begin the book are more theoretical case studies, including the opening chapter by Kowalewski and Bambach which is a critical assessment of the limits of palaeontological resolution, followed by a study involving biostratigraphy and computer-assisted correlations (Sadler and Cooper) which uses, in part, a Cambrian trilobite database.

Lower Cambrian trilobites from southern California are the main focus of the chapter by Webster *et al.* that combines data collected by the authors from measured sections with material in museum collections. This study successfully increased the biostratigraphic resolution and added to the species database. One of the main reasons behind this achievement was the use of computer algorithms which are objective and reproducible.

The trace fossil *Zoophycos* is the basis of a study by Savrda who was able to recognize that marine depositional processes and events were recorded by *Zoophycos* spreiten, unlike most trace fossil activity that results in destruction by intense bioturbation.

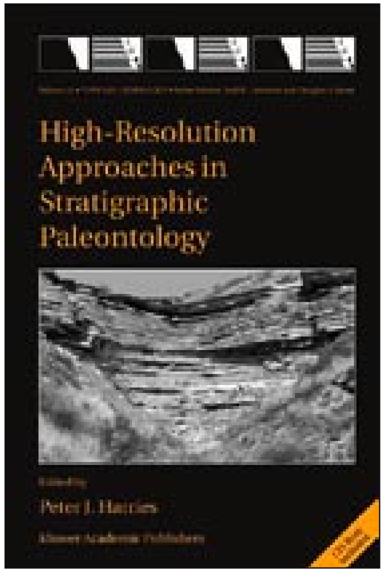
The next two chapters feature ammonites as the main fossil group. Landman et al. studied scaphitid ammonites from the Upper Cretaceous of North and South Dakota. This involved a detailed statistical analysis of the variation in size range and class of adult species through four assemblage zones. Their results show a geographic pattern of change that appears to be ecophenotypic, but stasis was the dominant feature during the evolutionary history of species examined. The paper by Yacobucci on Upper Cretaceous acanthoceratid ammonites on the other hand involved a much greater study area: the Western Interior Seaway (WIS). Statistical analysis of the variation in thickness ratio (width versus shell diameter) of eight species of one ammonite genus showed that neither facies nor regional differences were involved. However these factors may well have affected the shell shape.

Inoceramid bivalves from the WIS are used by Harries to test the relationship between sea level in the Cretaceous and species richness. Trends of species richness, origination and extinction were analysed utilising well-documented sea-level curves and temporal resolution provided by ammonite biostratigraphic schemes. Cross plots for the five major cyclothems showed that species richness is not solely determined by sea level at any given time, but a function of and response to ecologic, environmental and evolutionary factors that fluctuate through time.

Diversity patterns in non-marine Cretaceous vertebrates from the Western Interior Basin of North America are the basis of the study by Eaton and Kirkland. This is the first attempt at a meaningful compilation of data on sharks, fish, amphibians, reptiles and mammals from this period. It contains an extensive appendix (25 pages) for all occurrences of terrestrial vertebrates at order, family and genus level for the interval from the Barremian to Maastrichtian. This is very much a case of work in progress, but some tentative trends are suggested, with a notable increase in diversity through the Cretaceous and marked peaks in generic level at the end of the Albian and Campanian.

The study by Brett *et al.* on event beds and sedimentary cycles in Upper Ordovician rocks of Kentucky and Ohio best illustrates the importance of measuring sections at the centimetre scale. They were able to demonstrate that using high-resolution stratigraphy it was possible to correlate individual beds characterised by high concentrations of rare fossils, or ubiquitous fossil taxa marked by unusual morphologies. Even trace fossils and storm event beds could be correlated over tens of kilometres. This chapter contains many photographs of the important taxa and sedimentary features, but the vital cross-sections (figs. 13 and 14) summarizing the data lack a key to explain the symbols used as correlative markers.

The following chapter by Morrow and Sandberg on Upper Devonian conodonts from Utah and Nevada represents the integration of over 30 years of conodont biostratigraphic data with newer information on trangressive-regressive cycles and sequence stratigraphy. This chapter (by far the longest chapter in the book) consists of a detailed description and documentation of nine measured sections that contain summaries of important events. Focus is given particularly to the interpretation of the Frasnian-Fammenian boundary and event stratigraphy, set against a sound biostratigraphic framework provided by the conodonts. This chapter benefits from the presence of informative logs of sections, and outcrop photographs and photomicrographs.



A short chapter follows by Carpenter who has analysed the distribution of Cretaceous vertebrates from western Kansas. He documents the presence of Upper Cretaceous fish, reptiles and birds through seven biostratigraphic zones, defined using a combination of invertebrate macrofossils and vertebrates.

The final chapter is an unusual study by Kauffman of fossils recovered from limestone concretions from Cretaceous rocks of the Western Interior Basin. He has been able to recognize—from collecting concretions for over 40 years—34 palaeocommunities, comprising mostly molluscs ranging from freshwater to fully marine. What is also interesting and novel about this study is that by using refined radiometric dates recorded from bentonites interbedded with the strata containing the concretions, that the latter are considered to represent almost isochronous surfaces. This is the only chapter in the book that has colour photographs of outcrops, but unfortunately, their benefit is somewhat reduced by a lack of scale in all eight pictures.

In summary, I think this is a very useful book on stratigraphic palaeontology that should appeal to many palaeontologists because of the use of the different techniques employed and the wide variety of fossil groups analysed. It certainly is a must for those who still value the prime importance of gathering fossil data by detailed field work, measuring and sampling sections, and making critical observations. The book also highlights the increasing need for palaeontologists to collaborate with other specialists, or at least integrate data from other disciplines in developing new palaeobiological approaches used for investigating environmental, ecological and evolutionary changes and patterns. Perhaps the only disappointing aspect of the book is the price. It is not by any means cheap and is probably beyond most individuals' budget. However, do ensure that your library acquires a copy.

Ian D. Somerville
Department of Geology, University College Dublin, Dublin, Ireland
<Ian.somerville@ucd.ie>

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450 Millionen Jahre Beständigkeit in der Evolution endolithischer Mikroorganismen.

(Sitzungsberichte der wissenschaftlichen Gesellschaft an der Johann Wolfgang Goethe-Universität Frankfurt am Main, v. XLII, nr. 1: 3-42; 19 figs.)

Klaus Vogel and Ingrid Glaub (2004). Franz Steiner Verlag, Stuttgart.
ISBN 3-515-08461-4, €22 (Softbound).

Klaus Vogel, retired Professor of Paleontology at Frankfurt University, in Germany, launched a programme 16 years ago to study *microendoliths*. As the term may not be familiar to everybody, a few introductory remarks are warranted.

Microendoliths are borings in carbonate substrates, mostly shells. They should not be confused with the borings that can be studied with a pocket lens: the chains of chambers made by the sponge *Cliona*; the amphora-like drillings of pholad bivalves; the ones of acrothoracican barnacles shaped like an apple seed; the spreite burrows of the polychaete worm *Polydora*; or the filigree patterns of endolithic bryozoans. Microendoliths are microscopic, and a number of special techniques were prerequisite to study them.

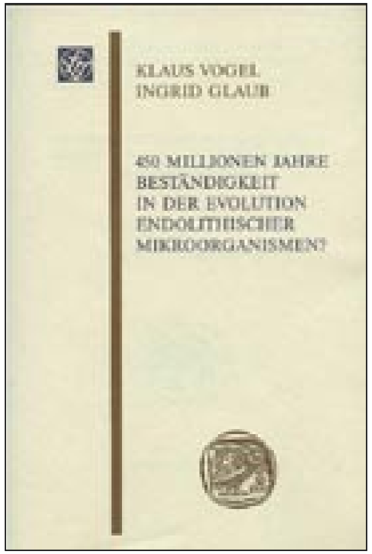
(1) *Casting* with resins that are liquid enough to fill the minute cavities and catalyse into a rigid material enduring acid dissolution of the calcareous substrate as well as preparation for SEM studies.

(2) The *scanning electron microscope* (SEM) allowing study and photography of the etched-out structures at the scale of microns.

(3) *Experimental* methods to study modern forms by the same method. Clear crystals of sparry calcite are suspended in natural environments at different water depths over controlled periods of time.

(4) Elaborate *morphological analysis* to distinguish highly variable bubbly or filamentous shapes that are controlled by general rules of growth rather than by rigid morphogenetic programmes.

Classification is another problem. By definition, these structures fall in the category of trace fossils. This means that they are labelled by Latin names different from those of the trace makers. Yet, there are important differences from traces produced in soft sediments. (1) While the latter reflect mechanical activities directed by behavioural programmes, microendoliths result from growth programmes. In this respect, they are more closely related to shells; only that growth steps correspond to overall dissolution, rather than localized accretion, of calcium carbonate. (2) As the morphological resolution of these trace fossils is also much higher than those in soft sediments, their external morphology corresponds directly to that of the trace maker. So the ichnological classification can, in principle, be concordant with the palaeozoological (or palaeobotanical) ones. As most taxa still exist, there is not even a discordance with the fossil record. (3) There is only one disadvantage compared to biogenic structures in soft sediments: microendoliths can be reworked from older layers, or transported into adjacent environments, together with their shelly substrates.



There is also an important general implication: the majority of the trace makers rely on photosynthesis. Thus, microborings provide potentially the most reliable proxy for palaeo-bathymetry, as long as those made by light-independent fungi and foraminifers can be singled-out. As shown by the authors, microendoliths made by red algae, green algae, and cyanobacteria extend to different water depths and can be used to subdivide the photic zone further, with the metric calibration changing with the luminosity (latitude) and clarity of the water column. This scheme was established in modern environments (Norway; Scotland; Mauretania; Bahamas; Great Barrier Reef). It has been successfully applied to ancient reef settings and basins of Middle Devonian, Permian, Middle Triassic, Upper Jurassic, and Upper Cretaceous age.

The present booklet by Klaus Vogel and his co-worker, Ingrid Glaub, is based on a public lecture, so it is not the comprehensive reference one might have hoped for. Instead, it carries a quite unexpected message: bacteria as the most ancient living fossils! Of course, one could argue that in these organisms speciation takes place at the level of their physiology rather than the poorly defined body morphology. But for practical purposes, some microendoliths found in Cambrian shells (or in the Precambrian, emplaced into oolite grains) are identical to ones living today. As it appears, geologic life spans were orders of magnitude higher than the few million years observed in animal (or plant) species.

A few interesting questions remain open. For instance, one would like to know to what extent these borers are host-specific. Do they prefer certain taxa or, more likely, certain kinds of shell mineralogy and microstructure? Also, is their yield high enough to serve as food for larger shell borers and shell-rasping gastropods or echinoids?

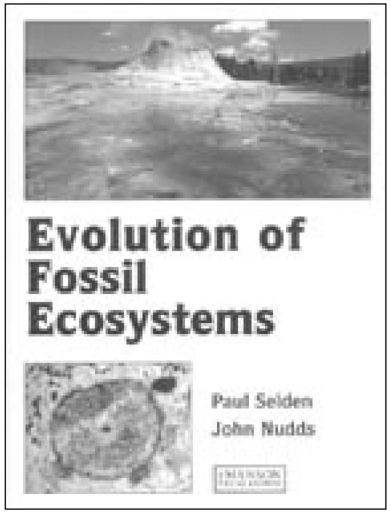
In any case, this is a piece of palaeontological literature that is well illustrated (including colour plates), very enjoyable to read (provided you know some German), and well worth its price!

Adolf Seilacher
Department of Geology and Geophysics, Yale University, New Haven, USA
<adolf.seilacher@yale.edu>

Evolution of fossil ecosystems

Paul Selden and John Nudds (2004). Manson Publishing Limited, London
ISBN: 1-84076-040-0, £39.95 (hardback);
ISBN: 1-84076-041-9, £19.95 (paperback).

Despite the title, this book is first and foremost an introduction to the palaeobiology of 15 exceptional faunas. The Ediacara, Burgess Shale, Soom Shale, Hunsrück Slate, Rhynie Chert, Mazon Creek, Grès à Voltzia and Holzmaden Shale biotas, the fauna from the Morrison Formation, the Solnhofen Limestone biota, the biotas from the Santana and Crato Formations, the Grube Messel biota, the fauna and flora encased in Baltic Amber and, finally, the fauna recovered from the Rancho La Brea tarpits are each reviewed in a similar manner: there are successive sections describing the 'Background,' 'History of discovery' and 'Stratigraphic setting and taphonomy' of the biota, a 'Description' of selected taxa, a consideration of the biota's 'Palaeoecology,' and to conclude, a 'Comparison' of it with others of similar age. The book itself concludes with an Appendix providing details on museums with collections of material from each biota and information on access to specific sites associated with each biota.



The authors explain the reasoning behind their choice of title in the preface: these faunas "scattered throughout the geological record … can provide a fairly complete picture of the evolution of ecosystems through time." Of course each fauna provides an invaluable insight into the structure of a specific ecosystem (although not, by any means, a complete one, a point that could, perhaps, have been emphasised more). Further, by providing, in the introductory Background section of each chapter, a summary of the major evolutionary innovations in the interval preceding each fauna some temporal dimension is added; more usefully, it places each individual biota in a wider geological context. Nevertheless, these faunas are too scattered—both in time and in the variety of different environments represented—to provide by themselves a continuous narrative of how ecosystems have evolved. Joining up the dots or 'windows' (to use the authors' phrase) provided by these and similar faunas involves the varied approaches and efforts of a much more diverse suite of biologists and palaeobiologists.

Although there are summaries of the entombment history and diagenesis of each individual biota, this text is not intended as a study of taphonomic processes. Thus, we have phrases such as "For a variety of reasons Plattenkalks often display exquisite preservation of soft tissues." The brevity of the introduction illustrates this—two pages, of which most of the second summarises the contents of, and draws links among, the succeeding chapters. The first page is used to distinguish between Konzentrat-, and Konservat-Lagerstätten; taphonomic processes (biostratinomy and diagenesis) are reviewed in a paragraph. Compounding this, the stratigraphic setting and taphonomy section for each biota emphasises the environmental and depositional conditions that favoured exceptional preservation (and is consistently reviewed well). The role of later, diagenetic, processes, including microbial activities, is, however, usually considered in less detail; there are, for example, no thin section or SEM photographs of, for example, the tissues preserved, or the minerals responsible. The only image in this vein is of musculature preserved within a Santana fish (image 201).

What about the choice of biotas? The inclusion of the biotas from the Morrison Formation and Rancho La Brea tarpits is an important contrast to the majority, the Konservat-Lagerstätten. There is little to quibble about with the selection of the latter; by and large, it is the 'usual suspects' that one would include in a book of this nature. Perhaps some mention of 'Orsten-type' Cambrian faunas as a source of information complementing that provided by Burgess Shale-type deposits, a chapter, or at least more detail, on the Chengjiang biota, and a chapter on the La Voulte-sur-Rhône biota (the fidelity of preservation of which is unparalleled in the fossil record) could have been included.

There can now be few exceptional faunas that have not had their geology, palaeontological content and taphonomy summarised for a wider audience. In fact most of the 14 faunas included here have been the subject of individual texts, and alternatively, or in addition, been reviewed in texts such as *Palaeobiology II* (edited by D.E.G. Briggs and P.R. Crowther, 2000) and *Exceptional Fossil Preservation* (edited by David J. Bottjer *et al.* 2003).

The obvious question is therefore: Is another book on exceptional faunas needed? The stimulus for this book was an undergraduate course taught by the two authors, and their recent collaboration on a new fossil gallery at Manchester University Museum. This is reflected in its scope, structure and target audience. And, yes, for the intended audience—the general reader, or as a text to complement an introductory undergraduate course—there is great mileage in this book. It's well written—engaging, easily read, with a very nice balance between general content (history of research) and specific detail (*e.g.* of the faunal elements). It includes introductions to individuals past and present who have been involved in the research on specific faunas and there are some great stories—exactly the sort of comment that adds a bit extra to any talk or lecture. Thus, for example, in an attempt to conceal locality information the discoverers of the Como Bluff locality within the Morrison Formation (William Edward Carlin and William Harlow Reed) identified themselves to Professor O.C. Marsh of Yale in their offer to sell him fossils under the pseudonyms Harlow and Edwards. All was going well until the cheque payable to Harlow and Edwards arrived, and couldn't be cashed, 'forcing them' to come out of the woodwork!!

Unusually, and although the chapters are numbered individually, the images are numbered sequentially throughout the book (the format would lend itself to production of a set of 35mm slides or digital images to complement the hard copy, a move that would enhance its usefulness as a textbook). Image quality is consistently excellent, particularly the numerous photographs of actual specimens: check out the images of the suite of specimens from the Crato Formation on page 115, or the reproduction of the radiograph of the starfish *Helianthaster rhenanus* from the Hunsrück Slate.

The selection of photographs reflects the wider geological, scenic and cultural aspects of many of the biotas—a nice touch. This includes images of relevant field sites and the more general landscape, as well as Recent analogues for some of the biotas (*e.g.* images of Yellowstone National Park in the chapter on the Rhynie Chert) and fossils (*e.g.* images of the plant *Psilotum nudum*, to which Rhynie Chert plants are compared). Field photographs include local collectors with their 'catch' of Santana fish (image 198), slabs of Crato Formation limestone (200) stacked up like, as I heard David Martill once describe them, album or CD covers in racks that you thumb through. There are even images of cave art (40).

Different scales are used in the images of the fossils; for example, reference can be made to the length of the animal (*e.g.* 226, total length 750mm including tail which is 450mm), part thereof (300mm long carapace of turtle), or the height of the image or fossil slab (*e.g.* 144). Very occasionally no scale is present (*e.g.* 201) or the scale bar included in the image conflicts with the value stated in the figure caption (*e.g.* 213). Many of the superb pen and ink reconstructions lack scales—not a problem when an actual specimen is also illustrated, but this is not always the case.

Line drawings of locality maps and stratigraphic sections are in colour. Some of these are just the wrong side of 'simplified,' *i.e.* they are at the point where useful data has been omitted; they have the feel of a visually attractive, 'clean,' image designed to be projected with some further comments or explanation to be provided orally. More labelling on the image or an extended figure caption would have been useful in some of them. A single example, the locality map and cross section of Grube Messel (image 219), illustrates the sort of quibble I have in mind. The only scale on the maps is on the inset, not the more detailed map of the area around Grube Messel. The Messel Formation is shown in both green and salmon pink. In some—but not all—cases, confusion can be resolved or deduced from the text; although it's not explicitly stated in the text, the colour difference in this case presumably separates the basal sands and gravels (green, based on the vertical sequence in the cross-section) from the succeeding oil shale facies.

The book could serve as an undergraduate-level teaching text on exceptional faunas, especially if it was supplemented by references providing more detail on the actual processes of fossilization that are involved. As a more general introduction to the subject of exceptional faunas, or just for anyone simply interested in the beauty of fossil material, this is an excellent book; it is much more than a pictorial guide to fossils, yet really does have that 'wow—look at that' factor.

And there's nothing wrong with that.

Patrick J. Orr
Department of Geology, University College Dublin, Dublin, Ireland
<Patrick.Orr@ucd.ie>

Post-graduate opportunities in Palaeontology

This year we have migrated the listing of palaeontology and related PhD projects, from *Palaeontology Newsletter*, to the Association's website <**www.palass.org**> so that, as a community, we can make it as comprehensive as possible, and disseminate it as widely as possible. This list, of projects that are planned to begin in October 2005, should be complete by the end of November so please be sure to check it out to identify the projects that most interest you or your students. Descriptions of palaeontology, and palaeontology-related, MSc courses remain listed below. Careers advice is also available from the Palaeontological Association website <**www.palass.org**> and includes a series of biographies from Palaeo-MSc students through to Professors of Palaeontology, Museum Curators, Science Publishers, and workers in both Show- and Oil-business, all of whom have made their way through a career path in palaeontology. Learn from these luminaries and get yourself a career!

M.Sc. in Palaeobiology: University of Bristol, Department of Earth Sciences

The M.Sc. in Palaeobiology offers a broad-based overview of modern approaches in palaeobiology. Students study nine out of 16 possible options, and topics range from taphonomy and palaeoecology to mammalian palaeobiology, dinosaurs to trace fossils, systematic methods to macroevolution. Then there is a six-month independent project, and students are offered a wide range of topics. The programme is designed for students with a BSc in either a biological or earth sciences subject, and conversion courses in evolution, basic palaeontology, and sedimentology are offered. Students also receive training in writing scientific papers, creating websites, applying for Ph.D.s and jobs (both in Britain and overseas).

So far, 60 students have graduated, and many have gone on to rewarding careers in palaeontology and related scientific areas. Full details of the programme, of former students, and how to apply are available at <**http://palaeo.gly.bris.ac.uk/opportunities/MSc.html**>. Application forms may be downloaded from the website, or they can be provided by <**shirley.sparks@bris.ac.uk**>.

M.Sc. Micropalaeontology: University College London

The science of Micropalaeontology studies the microscopic remains of animals, plants and protists belonging to biological groups mostly of simple organisation and less than 1mm in size. These organisms were extraordinarily abundant and diverse in the past and continue to be so in modern environments, in many cases forming the primary elements in marine, lacustrine and terrestrial organic productivity cycles and food chains. The production of these organisms is a basic component of the global biogeochemical system, intimately linked to present and past environmental change. In this way microfossils are keys to palaeoceanography and palaeoclimatology and to understanding the evolution of the biosphere. Our ability to use the pattern of evolution of microfossil groups during the last 400 million years as a means of ascribing relative ages to sedimentary rocks and reconstructing their environmental histories is of great value for understanding global sedimentary geology, and has especially important applications, for example, in the hydrocarbon industry.

The M.Sc. and Diploma course in Micropalaeontology was founded in 1959, was the first of its kind in Britain and was specifically designed to train professional micropalaeontologists. The importance of the subject for biostratigraphy and palaeoenvironmental interpretation is firmly established through its application to hydrocarbon exploration, and also as a key to understanding the history of the continental shelf and oceanic basins. A high proportion of graduates have entered the oil industry, either following the M.Sc. course or after further research. Close links are maintained with the hydrocarbon industry.

The course is broadly based and covers calcareous, organic-walled and siliceous microfossils. Great emphasis is placed on the biostratigraphy and spatial distribution of the organisms and their application to problems of zonation and correlation and to environmental analysis. All major post-Palaeozoic microfossil groups are covered in the M.Sc. curriculum. Individual and team project work forms an important part of the course.

The entry qualifications for the M.Sc. in Micropalaeontology are: at least a Lower Second Class Honours degree in Geology, although joint combinations with Geography, Biology and Oceanography may be acceptable. We welcome enquiries from graduates with experience in oil companies who wish to obtain further qualifications.

Further details and application forms are available from:

Professor A.R. Lord
Department of Geological Sciences, University College London, Gower Street, London
WC1E 6BT, UK. Tel: (44) 020 7679 7131; Fax: (44) 020 7388 7614
<micropal@ucl.ac.uk>

M.Sc. Advanced methods in taxonomy and biodiversity: Imperial College London

Imperial College of Science, Technology and Medicine and The Natural History Museum are jointly offering a Masters degree course in Advanced Methods in Taxonomy and Biodiversity.

The one-year full-time M.Sc. course provides essential skills for all concerned with taxonomy and biodiversity. The course is composed of ten taught modules followed by a four-month research project. The series of modules seeks to provide as wide as possible an overview of the theory and practice of modern taxonomy and systematics, with associated biodiversity studies. During their four-month research project, students can specialise in their chosen area.

The course is based at The Natural History Museum, London, one of the world's premier institutions for research on the diversity of the natural world. The collections include over 68 million specimens, 800,000 of which are type specimens, and the Museum houses a world class library covering all areas of taxonomy and systematics. The Museum is situated next to the main South Kensington campus of Imperial College, and there are close research and teaching links between the two establishments. Students will therefore be situated in the heart of London, and are able to make full use of the facilities at both institutions.

Students are trained to a high level of competence in systematics and a detailed understanding of the various uses and problems involved. The course provides methodological background, including quantitative skills, computer applications and practical skills in morphological and molecular techniques of taxonomy and systematics. The most up-to-date ideas and research in taxonomy and biodiversity are taught, to a large extent from primary literature. Hands-on training in conducting research in this area will be provided by project supervisors, with specialisation in the student's field of choice. After completing the course, students will be able to:

- apply a wide range of techniques to the study of systematics, including collections management, identification, key construction, taxonomic revision, phylogeny reconstruction and comparative methodologies;
- understand the diversity of living organisms in space and time, and be familiar with methods for measuring this diversity and monitoring changes due to both anthropogenic and natural factors, and in Earth history;
- select appropriate methods to solve taxonomic and biodiversity problems, and be able to acquire and analyze taxonomic data, including both traditional and molecular data;
- understand fully the conceptual basis of taxonomy and phylogenetics and in particular, cladistics, and to understand "biodiversity" within this framework;
- apply these concepts to issues of biodiversity and conservation management and research, to set priorities for sustainable development, environmental assessment and inventories; apply these concepts to other areas of biology such as parasitology and epidemiology.

Who is this course aimed at?

The course is aimed at anyone concerned with taxonomy and biodiversity. It is relevant to those involved with biodiversity assessments, conservation and sustainable development, from biomedical sciences to agriculture and fisheries, as well as to those intending to pursue academic careers in systematics and related fields.

Entry requirements

Applicants should normally either have or expect to gain at least a lower second class honours degree (or equivalent) in a biological or environmental subject (*e.g.* zoology, botany, microbiology, agriculture and veterinary science). Exceptionally students with different backgrounds or with related work experience will be considered.

Further details are available from:

Ms Amoret Brandt
Department of Entomology, Natural History Museum, London SW7 5BD, UK tel: +44 (0)20
7942 5036; fax:+44 (0)20 7942 5229
<a.brandt@nhm.ac.uk>

Royal Holloway, University of London: Department of Geology

MSc Geology by Research

This programme is offered to prospective students who wish to pursue research in a selected field of the Geological Sciences for a period of one calendar year full time or two calendar years part time and be awarded a Masters degree. Students will receive training in research skills, including data collection, data handling and analytical techniques as well as transferable and presentation skills. Students will take a course in a subject area closely related to the chosen field of research, selected from a menu of masters level courses offered by the department. The main outcome of the programme is a piece of independent research presented in the form of a dissertation. Upon completion of the programme students will have gained experience of research and presentation of material in the geological sciences which equips them to publish work in international scientific journals.

Prospective students should contact individual members of staff in the department in the first instance to discuss potential research projects. The research interests of staff are available on the department website <**http://www.gl.rhul.ac.uk/staff/acad.html**>.

University of Plymouth, School of Earth, Ocean & Environmental Sciences

M.Res. in Micropalaeontology

This programme in Micropalaeontology operates within a scheme involving a range of M-level subjects in the Earth, Marine, Environmental and Biological Sciences. In the first term a range of taught courses are offered including both subject-based topics and skills training. After this is completed satisfactorily students then pursue a major research project through from January to mid-September. This may be based on field samples collected by the student, samples provided by an industrial sponsor, samples requested from the Ocean Drilling Program or other samples in the collections of staff. Projects undertaken by students in the last academic year include estuarine foraminifera, sea level change in S.E.Italy, foraminifera of the Cambridge Greensand and the use of foraminifera and stable isotope stratigraphy in dating volcanic activity on Montserrat, Caribbean Sea. During this period of research students have to generate assessed reports and give a full seminar presentation on their research.

For further information contact the Course leader Prof Malcolm Hart <**mhart@plymouth.ac.uk**> or use the University website <**www.plymouth.ac.uk**>. Application forms for postgraduate study can be downloaded from this website. Some University bursaries may be available.

University of Plymouth, School of Earth, Ocean & Environmental Sciences

M.Sc./M.Res. Global Environmental Change

The M.Res. programme in Global Environmental Change follows the pattern outlined for the M.Res. in Micropalaeontology. Students following the M.Sc. pathway undertake a second term of subject-based courses, with examinations just after the Easter break. The research project for the M.Sc. students runs from Easter until mid-September and is assessed by interim reports, a seminar presentation and a final dissertation. Recent projects have involved investigation of climate change, sea level changes using foraminifera, palynological change in S.W.England and upland habitats in S.W.England.

For further information, contact Course Leader Dr Gregory Price <**gprice@plymouth.ac.uk**> or use the University website <**www.plymouth.ac.uk**>. Application forms for postgraduate study can be downloaded from this website. Some University bursaries may be available.

Discounts available to Palaeontological Association Members

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Individual US$75 (compared with the normal price of US$115). Please pay your subscription directly to the publishers.

Geobiology

£25 reduction on a personal subscription. Contact *Blackwells* Journal subscription department for further details.

Paleobiology

2004 subscription with back issues to date: $43 to ordinary members, $24 to student members, plus an additional $10 for an online subscription as well as the paper copy.

2005 subscription: $45 to ordinary members, $25 to student members, plus an additional $10 for an online subscription. Payment to the Paleontological Society's Subscription Office in the normal way (*not* to the Palaeontological Association). Download the form from **http://www.paleosoc.org/member.pdf**

Please mark the form "PalAss Member" and provide evidence of membership in the form of a confirmatory email from the Executive Officer, or the mailing label from a current issue of *Palaeontology*, which bears the PA member's name and membership status. It will be possible to subscribe and renew on-line by January, 2005.

Palaeontological Association Publications

Don't forget that all PalAss members are eligible for a 50% discount on back issues of the *Special Papers in Palaeontology* monograph series. Discounts are also available on PalAss field guides and issues of the *Fold-out fossils* series. See the Association website for details of available titles, discounts, and ordering.

Trilobites and Their Relatives

Special Papers in Palaeontology No 70, 397 pp. ISBN 0 901702 81 1. £80 (£40 to members)

Edited by Philip D. Lane, Derek Siveter and Richard A. Fortey

Contents

Introduction. *By* Richard A. Fortey, Philip D. Lane and Derek J. Siveter.

An Early Cambrian Phosphatocopid Crustacean With Three-Dimensionally Preserved Soft Parts From Shropshire, England. *By* David J. Siveter, Dieter Waloszek and Mark Williams.

Tagmata and Segment Specification in Trilobites. *By* Alessandro Minelli, Giuseppe Fusco and Nigel C. Hughes.

Phylogeny of Early Cambrian Trilobites. *By* Peter A. Jell.

Biogeography of the Trilobita During the Cambrian Radiation: Deducing Geological Processes From Trilobite Evolution. *By* Bruce S. Lieberman.

Ovatoryctocara Granulata: The Key To A Global Cambrian Stage Boundary and The Correlation of the Olenellid, Redlichiid and Paradoxidid Realms. *By* Terence P. Fletcher.

Ontogeny and Heterochrony in the Oryctoephalid Trilobite Arhricoephalus From The Cambrian of China. *By* Kenneth J. McNamara, Feng Yu and Zhou Zhiyi.

The Conocoryphid Biofacies: A Benthic Assemblage of Normal-Eyed and Blind Trilobites. *By* J. Javier Alvaro and Daniel Vizcaino.

Intraspecific Dimorphism in an Evolutionary Series of Paradoxidids from the Middle Cambrian of Murero, Spain. *By* Rodolfo Gozalo, Eladio Linan and M. Eugenia Dies.

Cryptic Behaviour in Trilobites. *By* Brian D. E. Chatterton, Desmond H. Collins and Rolf Ludvigsen.

The Late Cambrian Trilobite Irvingella from the Machari Formation, Korea. *By* Paul S. Hong, Jeong Gu Lee and Duck K. Choi.

Upper Cambrian Shumardiids from North-Western Hunan, China. *By* Shanchi Peng, Loren E. Babcock, Nigel C. Hughes and Huanling Lin.

Lower Ordovician Stratigraphy and Trilobite Faunas from the Southern Famatina Range, La Rioja, Argentina. *By* M. Franco Tortello and Susana B Esteban.

The Lower Ordovician Trilobite Krattaspis. *By* Helje Parnaste.

The Ontogeny of the Ordovician Trilobite Ovalocephalus and its Bearing on the Affinity and Evolution of the Genus. *By* Yuan Wenwei, Zhou Zhiyi, Derek J. Siveter and Zhou Zhiqlang.

Ordovician Trilobite Biodiversity Change in the Anglo-Welsh Sector of Avalonia. *By* Alan W. Owen and Tim McCormick.

Latest Llanvirn to Early Caradoc Trilobite Biofacies of the North-Western Marginal Area of the Yangtze Block, China. *By* Zhou Zhiyi, Zhou Zhiqiang, Derek J. Siveter and Yuan Wenwei.

Exuviation of Selected Bohemian Ordovician Trilobites. *By* Jana Bruthansova.

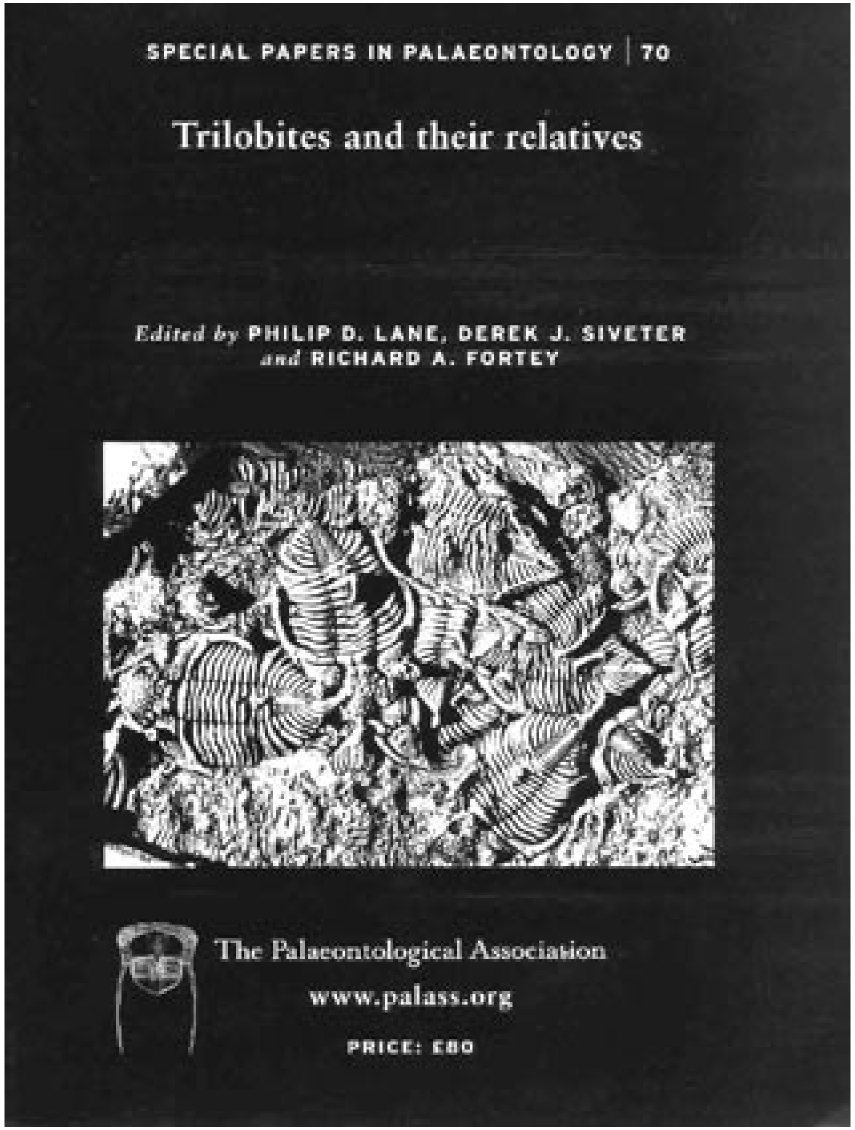
A Revision of Nephranomma Erben, 1952. *By* Andrew C. Sanford.

Making Phacops Come Alive. *By* David L. Bruton and Winfred Haas.

The Puzzling Eye of Phacops. *By* David L. Bruton and Winfred Haas.

Evolutionary and Biogeographical Implications of Phylogenetic Analysis of the Late Palaeozoic Trilobite Paladin. *By* David K. Brezinski.

The Stratigraphical Distribution and Extinctions of Permian Trilobites. *By* Robert M. Owens.



SPECIAL PAPERS IN PALAEONTOLOGY | 70

Trilobites and their relatives

Edited by PHILIP D. LANE, DEREK J. SIVETER
and RICHARD A. FORTEY

The Palaeontological Association
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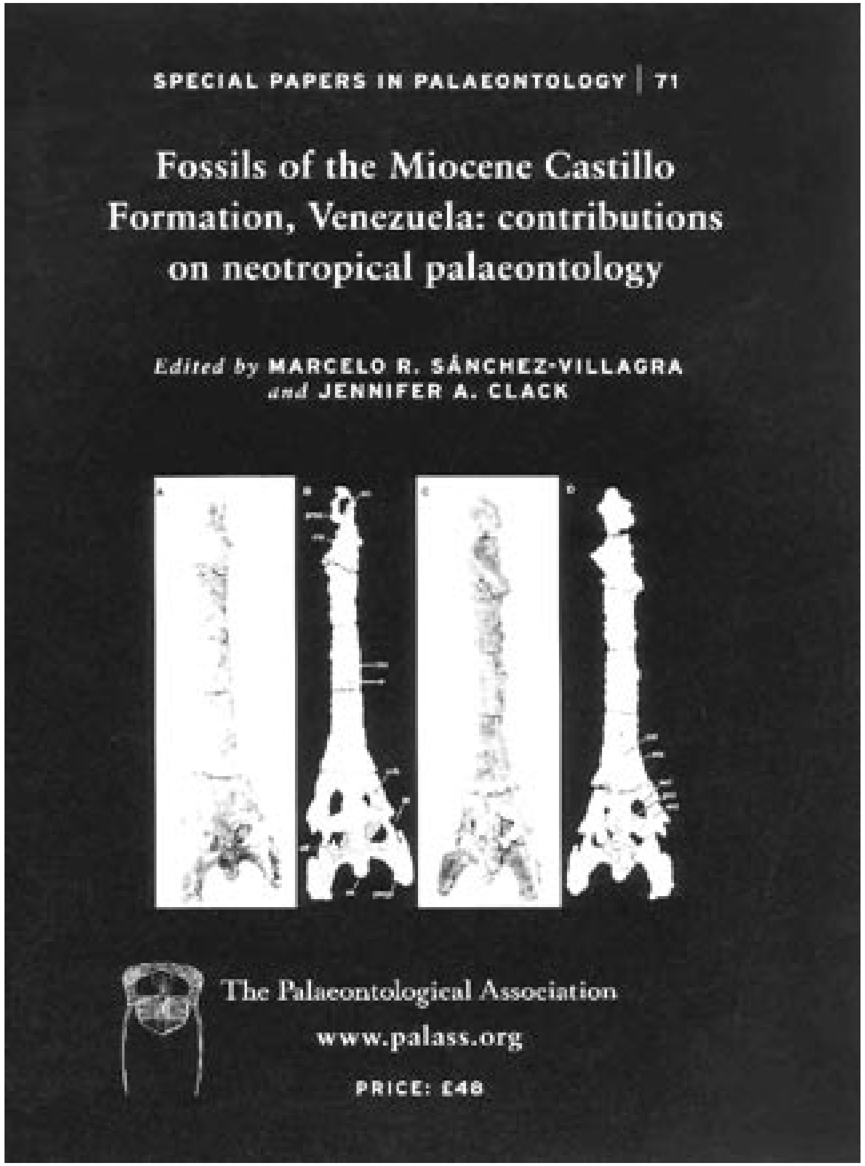
PRICE: £80

Fossils of the Miocene Castillo Formation, Venezuela: contributions on neotropical palaeontology

Special Papers in Palaeontology No. 71. 112 pp. ISBN 0 901702 82 X. £48 (£24 to members)

Edited by Marcelo R. Sánchez-Villagra and Jennifer A. Clack

Contents



SPECIAL PAPERS IN PALAEONTOLOGY | 71

Fossils of the Miocene Castillo Formation, Venezuela: contributions on neotropical palaeontology

Edited by MARCELO R. SÁNCHEZ-VILLAGRA *and* JENNIFER A. CLACK

The Palaeontological Association

www.palass.org

PRICE: £48

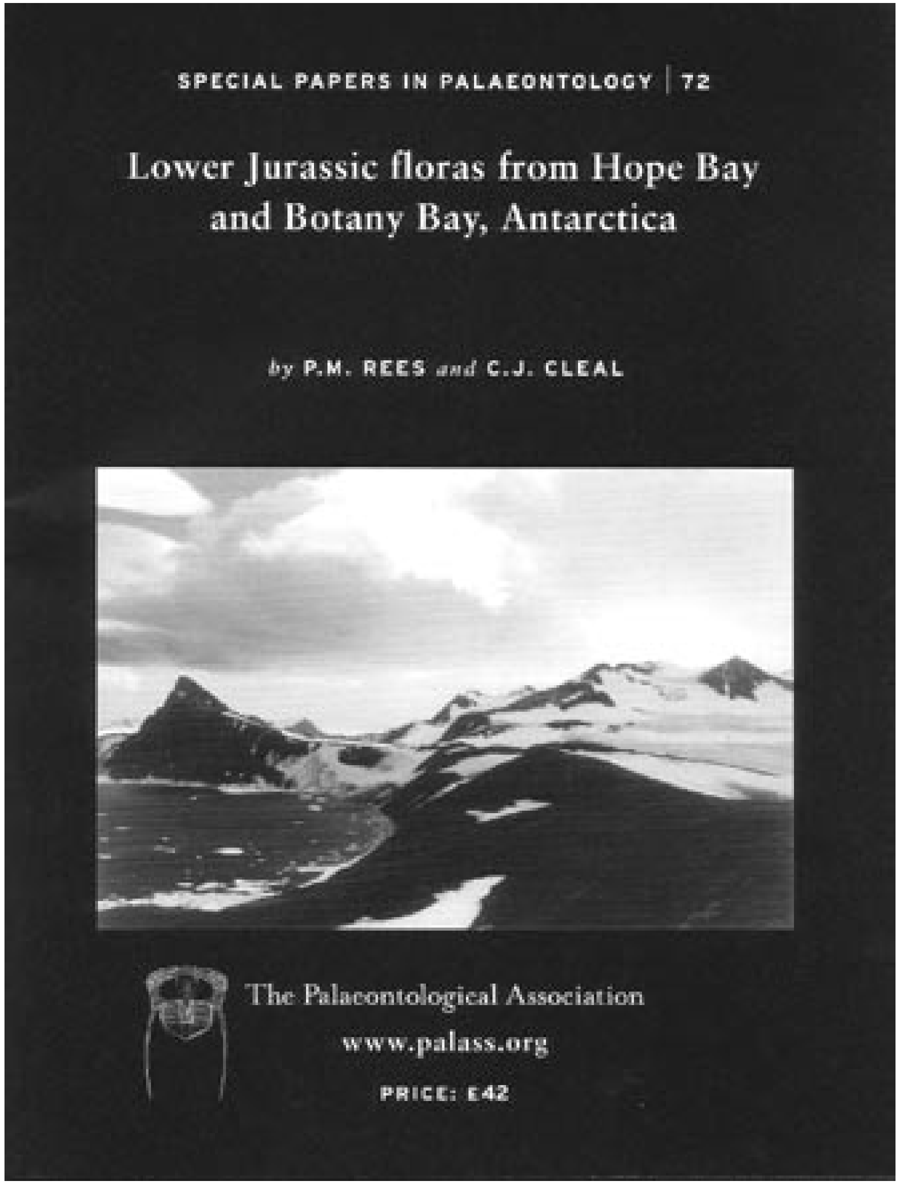
Lower Jurassic floras from Hope Bay and Botany Bay, Antarctica

Special Papers in Palaeontology No. 72. 90 pp. ISBN 0 901702 83 8.
£42 (£21 to members)

By P. M. Rees *and* C. J. Cleal

Abstract

Hope Bay and Botany Bay, Graham Land, Antarctica have yielded two of the most diverse floras known from the Jurassic. Because of its high diversity, as well as its early discovery and description (by T. G. Halle in 1913), the Hope Bay flora has served as a taxonomic standard for studies of other Mesozoic floras from Gondwana. This paper presents a major revision of the Hope Bay flora, based on extensive subsequent collections. A nearby flora from Botany Bay is described for the first time. Thirty-seven species are now recognised in the Hope Bay flora and 32 from Botany Bay. The floras are closely similar; 80 per cent of the Botany Bay species also occur at Hope Bay. They are shown here to be Early Jurassic, which contradicts the results of previous studies that suggested a Late Jurassic or earliest Cretaceous age. The revision of their age has special significance for our understanding of the Mesozoic geological history of the Antarctic Peninsula. It also highlights the need for reappraisal of a number of other Mesozoic Gondwanan floras that had been dated mainly on their close similarity to the Hope Bay flora. The taxonomic work has resulted in establishment of a new combination, *Taeniopteris taenioptteroides*, and emendation of the diagnoses of *Cladophlebis oblonga, Sphenopteris nordenskjoeldii, Sphenopteris pectin* and *Komlopteris indica*.



SPECIAL PAPERS IN PALAEONTOLOGY | 72

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Palaeontology

VOLUME 47 • PART 6

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The Palaeontological Association

48th Annual Meeting
17th–20th December 2004

University of Lille

ABSTRACTS

The Palaeontological Association

48th Annual Meeting
17th–20th December 2004

Laboratoire de Paléontologie et Paléogéographie du Paléozoïque (LP3), Université des Sciences et Technologies de Lille

On the following pages you will find the preliminary programme, schedule of events and abstracts (of the seminar talks, regular talks and posters) for the 48th Annual Meeting of the Palaeontological Association.

Following the suggestion of members, this year in Lille, as last year in Leicester, **no parallel sessions** are scheduled. All talks (except the seminar talks) are scheduled for 15 minutes, including discussion.

At the time of going to press more than **250 participants** are registered for the meeting, which will make the Lille meeting most probably the second largest Annual Meeting of the Association (the largest remains the 46th Meeting in Cambridge, 2002).

Confirmation of registration

We are currently in the process of preparing booking confirmation letters, that will be distributed by mid-November together with arrival and hotel information.

If you have not heard from us and wish to confirm your registration, a list of registered participants will soon be available on the website <**http://www.palass.org/**>.

If you wish to attend but have not yet registered, the booking form will be available at the website <**http://www.palass.org/**> until Friday 3rd December 2004. Accommodation, participation in the seminar, and excursions can no longer be booked, however, once the deadline has passed.

Registered participants should note that it will not be possible to refund registration and accommodation fees for bookings cancelled after Friday 3rd December 2004.

Venue, Accommodation and Travel

Detailed information will be sent to all registered participants before mid-November.

Lille is easily accessible from London by Eurostar high speed trains (appr. 1 hour 40 minutes). You can also come to Lille by using TGV high speed trains from Paris (1 hour) and Bruxelles (40 minutes), or other cities.

The seminar and icebreaker (Friday 17th) are in the city centre, the seminar will take place in the Musée des Beaux-Arts, the icebreaker in the Musée d'Histoire Naturelle.

The regular sessions, the Annual Address, Reception and Annual Meeting are taking place on the campus of the Université des Sciences et Technologies de Lille at Villeneuve d'Ascq, that can easily be reached by metro (underground train) in about 15 minutes from the city centre of Lille.

Sessions will take place in the Congress Centre MACC on the campus (five minutes' walk from the metro station «Cité Scientifique». Lunches, Reception and the Annual Dinner take place in the University restaurant «Charles Barrois», just next to the metro station «Cité Scientifique» (about eight minutes' walk from the MACC).

Accommodation is organised in different hotels (IBIS hotels or other). Most participants stay at Villeneuve d'Ascq, in hotels located at some 15 to 20 minutes' walking distance from the MACC. Some other participants stay in the city centre of Lille (transport to the MACC by metro). Precise information will be sent individually to all participants before mid-November.

Registration

A registration desk will be open for all participants who registered for the seminar in the afternoon of Friday 17th at the Beaux Arts Museum (1 pm to 5 pm). Registration will continue at the Natural History Museum (6 pm to 8 pm) the same day.

The registration desk will be placed in the entrance hall of the MACC on Saturday 18th and Sunday 19th.

Seminar

A seminar on «palaeobiogeography» is scheduled for the afternoon of Friday 17th from 2pm to 5pm. The seminar will highlight the importance of fossils for the reconstruction of palaeogeographical maps, and the impact of changing palaeogeography on the dynamics of biodiversity in the past.

Confirmed speakers are **F. Cecca** (Paris), **R.A. Fortey** (London), **P. Neige** (Dijon), **B. Rosen** (London) and **C.R. Scotese** (Arlington, Texas).

The lecture hall in the Beaux Arts Museum is limited to 200 seats. Attendance at the **seminar is free** to conference participants, but only if **booked in advance** in due time.

For programme, speakers and abstracts see subsequent pages.

See you in Lille !

Thomas Servais
on behalf on the organising committee:

Sophie Beckary

Alain Blieck

Philippe Courville (field trip coordinator Boulonnais)

Catherine Crônier

Thomas Servais (chair)

Jacques Verniers (field trip coordinator Brabant)

Schedule of events and timetable of oral presentations

FRIDAY 17th December

Registration for those attending the Seminar from 1 pm in the Musée des Beaux Arts, Lille.

Otherwise in the Musée d'Histoire Naturelle from 6 pm.

2:00 to 5:00 Seminar: *Palaeobiogeography*

Oral presentations in the Amphithéatre, Musée des Beaux Arts.

Palaeobiogeographic Units: history, applications, recommendations, methods and drawbacks
F. Cecca

Palaeontological evidence bearing on Lower Palaeozoic continental reconstructions
R.A. Fortey

Palaeobiogeography and the macroevolutionary theory
P. Neige

Is the biogeographical past a key to distribution patterns of the present? Progress on scleractinian corals, and the case history of the staghorn coral, Acropora
B. Rosen

Early Paleozoic Plate Tectonics, Paleogeography and Paleoclimate
C.R. Scotese

6:00 to 8:00 Icebreaker: Musée d'Histoire Naturelle

SATURDAY 18th December

Registration from 8am in the Congress Centre MACC, campus of the USTL, Villeneuve d'Ascq.

Oral presentations in the main lecture hall, MACC.

Poster presentations in the adjoining hall.

Book exhibitions in the entrance hall.

8:45 Welcome

9:00 Evolution of polymorphism in colonial animals: differentiation of the earliest avicularian polymorphs in the Cretaceous cheilostome bryozoan Wilbertopora
Paul D. Taylor, Alan H. Cheetham, Andrew N. Ostrovsky and JoAnn Sanner

9:15 Homology, shape and morphometric analysis of the conodont skeleton
David Jones, Mark Purnell, Peter von Bitter

9:30 Echinoderm Palaeoecology from fragments: reconstructing salinity and substrate controlled faunas in the British Middle Jurassic
Aaron W. Hunter

9:45 Biotic recovery in the aftermath of the Late Permian mass extinction event: new data from the oceanic seamounts of SW Japan
David Casenove, Richard J. Twitchett, and Tatsuo Oji

10:00 From flying reptile to marine turtle : the «pterodactyl» from the Chalk of Lezennes-lez-Lille
Eric Buffetaut

10:15 The evidence for and implications of an invertebrate diet in Jurassic pliosaurs (Reptilia: Sauropterygia)
Leslie F. Noè

10:30 Coffee and posters

11:00 A Silurian sea spider
Derek J. Siveter, Mark D. Sutton, Derek E. G. Briggs, David J. Siveter

11:15 Contrasting Late Miocene bryozoan faunas from the eastern Atlantic and western Mediterranean: implications for palaeoenvironmental reconstruction and the species concept in Bryozoa
Björn Berning

11:30 Eurypterid phylogeny and the origin of Arachnida
O. Erik Tetlie

11:45 The apparatus architecture of the prioniodinid conodont *Erismodus quadridactylus* (Stauffer) and its implications
Rosie Dhanda

12:00 Double-trouble in the Devonian – extinction and anoxia
David Bond

12:15 Exceptional Preservation in the Upper Carboniferous Coseley Lagerstätte
Laura Braznell

12:30 The first Danish dinosaur footprints!
Jesper Milàn

12:45 Lunch and posters

14:00 Exploring an Early Palaeozoic Tropical Archipelago on the Shores of Hudson Bay
Graham A. Young, Robert J. Elias, Godfrey S. Nowlan, David M. Rudkin, and Edward P. Dobrzanski

14:15 A new test of the role of CO_2 in the late Ordovician glaciation
Benjamin J. Fletcher, Charles H. Wellman and David J. Beerling

14:30 Nitrogen and carbon isotopes in conodonts: Evidence of trophic levels and nutrient flux in Palaeozoic oceans
Chris Nicholas, John Murray, Robbie Goodhue and Peter Ditchfield

14:45 The «Avins event», a remarkable highstand at the end of the Tournaisian. Its influence on the global distribution and on the evolution of the Viséan rugose corals
Edouard Poty

15:00 Terrestrial Gastropods and the Perils of Palaeoclimate Studies, or When Size Does Matter (sample size that is)!
Claire L. Pannell

15:15 Neogene climates near the South Pole: evidence from fossil plants and climate-vegetation models
Jane Francis, Alan Haywood, Allan Ashworth, Steven Roof, and David Cantrill

15:30 Tea and posters

16:00 A new genus of tetrapod from the Devonian of East Greenland
Jennifer A. Clack, Per E. Ahlberg, Henning Blom

16:15 The evergreen or deciduous habit of Cretaceous polar forests: Fossil data versus computer model predictions
Melise Harland

16:30 A null biogeographic model for quantifying the role of dispersal in shaping taxonomic richness and similarity patterns
Noel A. Heim and Steven M. Holland

16:45 A.G.M.

17:15 ***Annual Address: 'Palaeontologia de profundis'***
Stefan Bengtson

18:30 Members Reception (sponsored by Blackwell Publishing), University Restaurant Charles Barrois

19:30 Annual Dinner, University Restaurant Charles Barrois

followed by Open Bar

SUNDAY 19th December

Oral presentations in the main lecture hall, MACC.

9:00 Validating fossil bacteria: some cautionary tales from the Mid-Palaeozoic
D. Edwards, L. Axe and R.J. Parkes

9:15 How to make a Burgess Shale fossil: an experimental approach
Lucy Wilson

9:30 Tunnelling trilobites in Middle Ordovician _Thalassinoides_
Lesley Cherns, James R. Wheeley and Lars Karis

9:45 Might machaeridians be molluscs?
Liam Herringshaw, Alan Thomas and Paul Smith

10:00 Functional and Adaptive Implications of Cryptic Speciation in Planktic Foraminifera
Blair A. Steel, Michal Kucera and Kate F. Darling

10:15 Molluscan diversity in deteriorating climate regimes: The Plio-Pleistocene of the southern North Sea Basin
F.P. Wesselingh

10:30 Coffee and posters

11:00 Pollen abundance patterns: Neoecological insights for palaeoecology?
Guy J. Harrington

11:15 Towards the development of a Palaeo UV-B proxy from fossil land plants
B.H. Lomax, M.A. Sephton, T.V. Callaghan, C.H. Wellman and D.J. Beerling

11:30 How to get a date in the Devonian of Bolivia
Ian Troth, John Marshall and Andrew Racey

11:45 In search of the earliest seed plants
Christopher M. Berry, John E.A. Marshall, Alan R. Hemsley and Susan Hammond

12:00 A new Upper Permian flora from the Middle East with typical Triassic Gondwana elements
Hans Kerp, Abdallah Abu Hamad, Klaus Bandel, Birgit Niemann

12:15 Plant and vertebrate fossil-lagerstätten from the Albian-Cenomanian of Charente-Maritime (Western France)
Bernard Gomez, Didier Néraudeau, Romain Vullo, Blaise Videt, Vincent Perrichot, Véronique Daviero-Gomez, Frédéric Thévenard and Clément Coiffard

12:30 Assessing the Evidence for Extensive Wildfires at the Cretaceous-Tertiary Boundary
C.M. Belcher, M.E. Collinson, P. Finch and A.C. Scott

12:45 Lunch and posters

14:00 Influence of seawater saturation state on the Phanerozoic diversity of calcified marine algae and invertebrates
Robert Riding

14:15 The Galeropygidae: towards triumph or Disaster? A phylogeny of the basal irregular echinoids
Colin Barras

14:30 Graptogonophores, scopulae and _Dawsonia:_ putative reproductive organs reconsidered
Alex Page, Phil Wilby, Mark Williams and Jan Zalasiewicz

14:45 Ray-finned fishes evolution and breakup of Pangaea
Lionel Cavin and Peter L. Forey

15:00 The systematic position of the Late Jurassic alleged dinosaur Macelognathus (Crocodylomorpha: Sphenosuchia)
Ursula B. Göhlich, Luis M. Chiappe, James M. Clark and Hans-Dieter Sues

15:15 Mid-Miocene latitudinal environmental gradient in western Europe: mammals and vegetation compared
Loïc Costeur, Gonzalo Jimenez-Moreno

15:30 Tea and posters

16:00 Siliceous microfossils and biosiliceous sedimentation in the lowermost Cambrian of China
Andreas Braun, Chen Jun-Yuan, Dieter Waloszek and Andreas Maas

16:15 Inside the inside of a dendroid
Kate Saunders and Denis Bates

16:30 Functional morphology and light-gathering ability of podocopid ostracod eye
Gengo Tanaka

16:45 Discovery of Famennian and Early Carboniferous trilobite larvae: implications for the systematics and the evolutionary history of proetoids
Lerosey-Aubril Rudy

17:00 Substrate specificity of Auloporida (Tabulata) from the Devonian of the Holy Cross Mts., Poland
Mikolaj K. Zapalski

17:15 On convergent evolution in Nummulitidae with secondary chamberlets (Foraminiferida)
Willem Renema and Peter Lunt

17:30 Age assessment of Pleistocene and Holocene mammal bone
Christina Karla Reimann and Christian Ostertag-Henning

17:45 Announcement of prize winners and close

MONDAY 20th December

Field excursions (Boulonnais, Brabant)

Depart 8:00 am, return 5:00 pm approx.

Abstracts of seminar presentations

Palaeobiogeographic Units: history, applications, recommendations, methods and drawbacks

Fabrizio Cecca
Université "Pierre et Marie Curie", Paris VI, CNRS-UMR 5143 "Paléobiodiversité et Paléoenvironnements", Tour 56-46, 5ème étage, case 104, 4, place Jussieu, 75252 Paris Cedex 05, FRANCE <cecca@ccr.jussieu.fr>

Since the pioneering work of de Candolle (1820), who recognized 20 different botanical regions on the basis of the living floras, the practice of the definition of Province, Regions, Realms has been generalised to both Neo and Palaeobiogeography. As far as Mesozoic is concerned, Neumayr (1873) introduced the zoogeographic province, defined as a large area characterized by a common particular fauna and caused by geographic position (barriers, latitude, climate) but independent of facies. Uhlig (1911) introduced the more inclusive rank, the Realm and stressed the independence of facies. Thus, according to these original definitions, biogeographic units are based on endemism and should have an historical meaning. However, different definitions and concepts of biogeographic units have been proposed since.

There is no doubt that this notion has been extremely important in the history of biogeography because it highlights the importance of endemicity and the idea of area relationship. Provincial schemes are applied to palaeogeographic reconstructions and also to the study of evolutionary patterns, which imply the relation between diversity and endemism.

Biogeographical units (or biochorema) have been created and defined with the application of different criteria, both qualitative and quantitative. The recommendations recently proposed in the framework of the informal group "Friends of Paleobiogeography" are presented and discussed.

A short review of the most used analytical methods in biogeography is presented. Provincial schemes based on different organisms may lead to provincial patterns which reflect ecological responses of individual groups thus making their historical meaning unclear. Subjectivity, due to the use of endemic species arbitrarily selected as "provincial markers," is strongly discouraged. The quantitative treatment of similarity coefficients ("phenetics") is a far less subjective approach but it must be conceptually clarified and its limits stated as biogeographical units cannot be always used as proxies of endemism. The comparison of results obtained with different analytical techniques, from phenetics to cladistics, are recommended in biogeography.

Palaeontological evidence bearing on Lower Palaeozoic continental reconstructions

Richard A. Fortey
Department of Palaeontology, The Natural History Museum, Cromwell Rd, London SW7 5BD, U.K., and Dept of Zoology, Oxford University <raf@nhm.ac.uk>

Because of the difficulties in determining the disposition of continents in the Lower Palaeozoic, fossil evidence has played a crucial role in the definitions and position of palaeocontinents. The recognition of both Iapetus and Tornquist's was initially based largely on faunal evidence, often opposed at first by geologists from other disciplines. I shall describe something of the history of research on Lower Palaeozoic geography as deduced from fossil distributions. The original approach described 'faunal provinces' typified by widespread taxa. The recognition of benthic biofacies both rationalised and complicated the provincial picture. Integration of these data with plate tectonic models provided an initially satisfyingly simple picture of continental distributions, one that came to be progressively more complex as microcontinents and terranes were deduced to have had independent histories. Biofacies discrimination is a necessary prelude to interpreting the weight that can be placed on a single fauna. Various quantitative methods have been applied to continental reconstructions from faunal evidence—most show support for continental distributions arrived at from more subjective lines of evidence. Vicariance biogeographic methods are in their early days, largely because of the shortage of good phylogenetic analyses. Nonetheless, continental reconstructions are now sufficiently well-founded to plot range excursions of biota within them—for example, as evidence of a late Ordovician global warming that preceded the well-known glaciation.

Palaeobiogeography and the macroevolutionary theory

Pascal Neige
Centre des Sciences de la Terre & UMR CNRS 5561 Biogéosciences, Université de Bourgogne, 6 bd Gabriel, 21000 Dijon, France <Pascal.Neige@u-bourgogne.fr>

Eldredge and Gould launched one of the earliest pragmatic criticisms of the modern synthesis with the publication of their punctuated equilibrium theory. This may be seen as a liberating concept allowing the development of a macroevolutionary theory whose main object is to explore large-scale patterns and processes. Even if the micro/macroevolutionary split is still subject to much debate, palaeontologists now possess different tools and concepts to explore and interpret large-scale data. Among them is the concept of morphological disparity, which entails investigating biodiversity through its morphological component alone, and which complements the taxonomic diversity measurement, which is now widely used to study increase and decline of morphologies over time at the macroevolutionary scale.

Surprisingly, the biogeographic (or palaeobiogeographic) impact on disparity fluctuations has largely been ignored by authors. However, seminal studies report large differences in disparity measurements with respect to geographical units. Here, this geographical component of disparity is explored using two complementary examples: one on Recent cuttlefishes and the other on Jurassic ammonites. The first allows discussion of two distinctive geographical patterns (the East Indies and southern Africa) and the second, fluctuations in the diversity / disparity relationship through time and space.

Is the biogeographical past a key to distribution patterns of the present? Progress on scleractinian corals, and the case history of the staghorn coral, *Acropora*

Brian Rosen
Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD
<B.Rosen@nhm.ac.uk>

Over-fishing, pollution and global warming are all concurrent threats to the ecology and biodiversity of the marine environment. Their destructive effects on corals and coral reefs worldwide is now well known to science and the wider public. Biologists are increasingly asking what the response of organisms in the past can tell us about the future of biodiversity (*sensu lato*). Their methods (*e.g.* cladistic, phenetic, and molecular), however, either concentrate entirely on, or are unavoidably restricted to, living taxa. The complementary study of fossil data provides insights that living taxa on their own cannot reveal, *e.g.* through the study of the history of regional taxonomic pools.

During the Cenozoic, zooxanthellate corals (*cf.* 'reef corals'), the warmer the climate, the higher the diversity, but this was modulated by historical patterns of suitable habitat. For example, the highly diverse fauna of Europe and the Mediterranean during the Paleogene declined to zero during the Miocene as climate cooled and geotectonic events isolated it (yet this history and its significance are beyond detection by study of modern taxa alone). However, the quality of palaeobiogeographical coral data is extremely uneven across different regional pools (*e.g.* much better in the Caribbean Neogene, than the Indo-Pacific Neogene). Collaboration with Carden Wallace (Museum of Tropical Queensland) has made it possible to concentrate, instead, on one well-studied, species-rich genus, the staghorn coral, *Acropora*. Very early in its history, this was a common coral in the mid Eocene of southern England and northern France. Their palaeolatitude (*c.* 50ºN) is well beyond those of any zooxanthellate corals today (< *c.* 30ºN&S), suggesting that during such warm climatic times, zooxanthellate corals track warmer conditions into higher latitudes.

Understanding the effects of present global warming will increasingly dominate the scientific agenda, in step with social, economic and political agendas. In conclusion, I will suggest some implications for the future of palaeontology.

Early Paleozoic Plate Tectonics, Paleogeography and Paleoclimate

Christopher R. Scotese
PALEOMAP Project, Department of Earth and Environmental Sciences, University of Texas at Arlington, 500 Yates, Arlington, Texas, 76019 <chris@scotese.com>

Ten paleoreconstructions are presented, illustrating the plate tectonics, paleogeography and paleoclimate of the Latest Precambrian and Early Paleozoic. The time intervals chosen include two maps for the latest Precambrian (600 Ma and 570 Ma), maps for the Early and Late Cambrian, four maps for the Ordovician (early Tremadoc, early Arenig, Llandeilo/Caradoc, and Ashgill), as well as paleoreconstructions for the Early and Middle Silurian. The plate tectonic reconstructions show the probable location of active plate boundaries (subduction zones, island arcs and mid-ocean ridges). The paleogeographic maps illustrate the distribution of deep oceans, shallow shelves, lowlands and mountainous areas for each time interval. There are two versions of each paleogeographic map. One map shows the extent of maximum flooding during a period of high eustatic sea level. The second map shows the paleogeography during a time of minimum sea level corresponding to a major sequence boundary. In the final set of maps, climatically sensitive lithofacies such as evaporites, calcretes, bauxites, and tillites are plotted on the paleoreconstructions. Climatic zones are mapped based on the distribution of these climatically sensitive lithofacies.

Abstracts of oral presentations

The Galeropygidae: towards triumph or *Disaster*? A phylogeny of the basal irregular echinoids

Colin Barras
Department of Earth Sciences, School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT and Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD
<c.barras@nhm.ac.uk>

One of the most rapid and most important morphological diversifications of echinoids occurred during the late Early and Middle Jurassic. It was during this period that the major lines of irregular echinoid became established, leading on the one hand to the Cassiduloids and on the other, ultimately, to the Holasteroids and Spatangoids. These two groups are now morphologically highly differentiated, but precisely how this was achieved remains poorly understood. It is generally supposed that a small group of late Early-early Middle Jurassic irregulars, the Galeropygidae, are basal to both clades. While the Cassiduloid fossil record can be traced back with confidence to the Galeropygidae, thanks to an excellent fossil record of intermediaries, the origins of the Holasteroid-Spatangoid body plan is less well understood, and they have traditionally been linked to the Galeropygidae through a morphologically rather diverse Jurassic group, the disasteroids. There have been few previous attempts to produce a phylogeny documenting this critical period of divergence among the irregular echinoids, and none that take into consideration all of the pertinent taxa. Here, a comprehensive study of relevant material, coupled with new plating diagrams of many of these taxa, has been used to generate a cladistic analysis of the early irregular echinoid genera. This has confirmed the Galeropygidae as basal to both the Clypeidae and the collyritid-disasterid complex.

Assessing the Evidence for Extensive Wildfires at the Cretaceous-Tertiary Boundary

C. M. Belcher[1], M. E. Collinson[1], P. Finch[2] and A. C. Scott[1]
[1]*Dept of Geology, Royal Holloway University of London, Egham, Surrey, TW20 0EX* <c.belcher@gl.rhul.ac.uk>, <m.collinson@gl.rhul.ac.uk>, <a.scott@gl.rhul.ac.uk>

[2]*Centre of Chemical Sciences, Royal Holloway University of London, Egham, Surrey, TW20 0EX* <p.finch@rhul.ac.uk>

Models of the Cretaceous–Tertiary impact at Chicxulub have suggested that the thermal radiation released by the impact would have been sufficient to ignite extensive wildfires. Eight non-marine K–T sequences stretching across North America have been studied in order to test this hypothesis. Multiple palaeowildfire proxies (charcoal, soot and polyaromatic hydrocarbons (PAHs)) have been used in combination to assess the extent of any biomass burning. Quantitative data from three different measures of charcoal abundance reveal that the K–T boundary rocks contain significantly less charcoal than is typical of the Cretaceous background of this area. The Cretaceous sedimentary rocks contain between four and nine times (according to the measure used) more charcoal particles than the K–T sedimentary rocks. Furthermore non-charred plant remains are also abundant in the K–T rock layers. Re-assessment of the record of soot and PAHs reported in the K–T rocks suggests that the morphology of the soot and the signature of the PAHs is more consistent with them being sourced from the vaporization of hydrocarbon material rather than biomass burning. We conclude that there was no significant wildfire across North America as part of the K–T events and that the impact at Chicxulub did not deliver the high amounts of thermal radiation previously predicted.

Contrasting Late Miocene bryozoan faunas from the eastern Atlantic and western Mediterranean: implications for palaeoenvironmental reconstruction and the species concept in Bryozoa

Björn Berning
Geologisch-Paläontologisches Institut, Universität Hamburg, Bundesstr. 55, 20146 Hamburg, Germany <berning@geowiss.uni-hamburg.de>

A comparative morphological study on bryozoan faunas from the Late Miocene of the eastern Atlantic and western Mediterranean has shown that there exist considerable differences in morphology within species. The presence of a great number of Mediterranean species in the eastern Atlantic Guadalquivir Basin (SW Spain) rendered it possible to compare directly morphological variation between these two regions. Measurements of zooid size yielded a general trend towards the existence of smaller zooids in specimens from the eastern Atlantic. Although it is well known that environmental factors can generate within-colony variations in morphology (*e.g.* there is an inverse relationship between zooid size and temperature), genotypic differences have as yet been found to be predominant in producing between-colony variations. However, the present study indicates that the environment might play a greater role in producing intraspecific morphological variation than previously recognised. This is exemplified by the extant, erect, cheilostome *Myriapora truncata* (Pallas) which shows intracolonial, within-site and between-site variability in zooid size and branch diameter in both fossil and Recent assemblages. These findings suggest yet again that species discrimination purely based upon zooidal or colonial dimensions should be avoided in bryozoans. Furthermore, if the extrinsic controls on bryozoan morphology can be qualitatively and quantitatively ascertained, (palaeo)environmental information may be gained at various spatial and temporal scales.

In search of the earliest seed plants

Christopher M. Berry[1], John E. A. Marshall[2], Alan R. Hemsley[1] and Susan Hammond[1]
[1]*School of Earth, Ocean and Planetary Sciences, Cardiff University, Park Place, Cardiff CF10 3YE, UK* <chris.berry@earth.cf.ac.uk>

[2]*John Marshall, School of Ocean and Earth Science, University of Southampton, Southampton Oceanography Centre, European Way, Southampton, SO14 3ZH, UK* <jeam@soc.soton.ac.uk>

The appearance of seed plants in the Late Devonian is a critical episode in earth history. How seeds evolved is still an open question. Recently, in *Palaeontology*, Marshall and Hemsley described *Spermasporites allenii* from a Middle Devonian lake on Ella Ø, East Greenland. *S. allenii* is a seed megaspore bearing at its apex not only three smaller aborted spores of the original tetrad, but also a cluster of microspores. This suggested a new path to seed evolution, where the seed megaspore is most likely to be fertilized by microspores from within the same sporangium but also allows for fertilization by microspores from another sporangium or individual. In order to determine the taxonomic affinity of the seed-meagaspore bearing plant, CMB, JEAM, and AH mounted a NERC-funded expedition to Ella Ø (see poster) under the umbrella of CASP. Excavation of the layers in which the seed megaspores were concentrated yielded numerous partial specimens of the plant. Single megaspores are snugly contained in sporangia which are inserted erectly, singly and terminally on the end of an isodichotomous branching system. Association suggests that these were carried laterally on small sparsely dichotomously and trichotomously branching naked stems. This suggests morphology more similar to that of latest Devonian seed plants than to that of the contemporaneous advanced progymnosperm *Archaeopteris/Svalbardia* found elsewhere in the same lake, which may otherwise be an obvious candidate for ancestry of seed plants.

Double-trouble in the Devonian – extinction and anoxia

David Bond
School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK
<d.bond@earth.leeds.ac.uk>

The extinctions at the Frasnian-Famennian (Late Devonian) boundary constitute one of the “big-five” crises of the Phanerozoic. Many faunal studies have been compiled, but these have never been properly integrated. A lack of high-resolution faunal range data has hindered our understanding of the extinction dynamics. Amalgamation of the faunal data available in the literature, at conodont-zone level, together with the author’s own findings from a variety of marine sections in Europe and the United States, has allowed recognition of the nature and timing of the extinction. In particular, the tentaculitoids, a group of small, conical animals which were locally abundant during the Frasnian, provide a detailed record of the extinction timing.

A number of questions, crucial to our understanding of the extinction, will be explored: did the F–F extinction actually occur? If so, when, and how suddenly did it occur? How selective was the extinction? What was the significance of sea-level change during the extinction?

There are a number of competing extinction mechanisms. The faunal range data has been correlated with the record of globally widespread anoxia, supported by a variety of geochemical and sedimentological techniques. This provides strong evidence of a causal link between marine anoxia and the extinction.

Siliceous microfossils and biosiliceous sedimentation in the lowermost Cambrian of China

A. Braun[1], J.-Y. Chen[2], D. Waloszek[3] and A. Maas[3]
[1]*Institute of Palaeontology, University of Bonn, Nussallee 8, D-53115 Bonn, Germany*
<Braun@uni-bonn.de>
[2]*Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences, Nanjing 210008, China*
[3]*University of Ulm, Section for Biosystematic Documentation, Helmholtzstrasse 20, D-98081 Ulm, Germany*

Clay-rich and siliceous sedimentary rocks of lowermost Cambrian age on the Yangtze Platform, China contain a large amount of siliceous microfossils. Based on their high content of siliceous hard parts, these rocks are in fact biosiliceous sediments. In more clay-rich lithologies, diagenetic dissolution processes however caused a removal of siliceous hard parts and led to “pure mudstones” and “silicified claystones,” being apparently devoid of siliceous microfossils. Abundant preservation as Fe-hydroxide pseudomorphs and in early diagenetic concretions however indicate a high biosiliceous content of the original sediments. Rocks investigated belong to the lowermost Cambrian (*Anabarites trisulcatus – Protohertzina anabarica* assemblage zone) and come from black-chert sequences (Kuanshuanpu, S.-Shaanxi province, *cf*. Chen *et al*. 2004; Fengkoushao, Yunnan province) as well as sequences of black shales (Nuititang formation, Songtao section, E Guizhou province; Niutitang formation at Mengdong train station, Hunan province). Lighter coloured clay-rich lithologies of equal age in Guizhou (Taozichong section, *cf*. Wang *et al*. 1984) have similarly yielded abundant siliceous hardparts.

The significant contribution of biosiliceous particles to early Cambrian sedimentation on the Yangtze platform, as well as to other occurrences in Kazakhstan and Europe, implies that silica-biomineralizing organisms have played a significant role in the geochemical cycling of silica in the oceans by the beginning of the Phanerozoic. The high abundance of sponge spicules in the sediments indicates that sponges (Porifera) played a major ecological role in the early Cambrian environment of the investigated areas. This is supported by findings of complete sponges and spicule clusters on bedding planes of clay rich sediments and black shales.

Exceptional Preservation in the Upper Carboniferous Coseley Lagerstätte

Laura Braznell
The University of Birmingham, Edgbaston, Birmingham, B15 2TT <ljb855@bham.ac.uk>

The Late Carboniferous Coseley Lagerstätte of the West Midlands, UK, contains exceptionally preserved plant and animal fossils that occur as hard parts and mineralised soft tissues sealed within siderite nodules, which vary in size from 15–250 mm. The nodules are recovered from Westphalian B siltstones and mudstones that lie above the Thick Coal of the Coal Measure Group, and were abundant enough in these horizons to form commercial ironstone beds in the nineteenth century.

The Coseley fossils have been examined using various techniques, including scanning electron microscopy and electron microprobe analysis, that have revealed several distinctive phases of preservation. Soft tissues have been replicated by kaolinite and pyrite, voids have been extensively filled with sulphide minerals, and all of these phases are encased in siderite. The growth of clay minerals on the surface of decaying soft tissues could have been controlled either by purely inorganic processes or through bacterially mediated biofilms. This growth was accompanied by early framboidal pyrite formation and closely followed by void-filling sphalerite, galena and pyrite precipitation. Siderite formation occurred both during and shortly after soft tissue preservation, producing a nodule that inhibited compaction of the tissues.

From flying reptile to marine turtle: the « pterodactyl » from the Chalk of Lezennes-lez-Lille

Eric Buffetaut

CNRS, 16 cour du Liégat, 75013 Paris <Eric.Buffetaut@wanadoo.fr>

In 1874, Charles Barrois reported a pterodactyl tibia, from the White Chalk ("Craie blanche") which was then exploited in underground quarries at Lezennes (now in the suburbs of Lille). He referred it to *Pterodactylus giganteus*, a species from the English Chalk. Although no detailed description or illustration was provided, the occurrence of a pterodactyl in the Coniacian Lezennes Chalk was repeatedly mentioned in papers on local geology, as well as in lists of French pterosaurs.

A re-examination of the specimen (Musée d'Histoire Naturelle de Lille, MGL 4158) shows that it is an elongate, more or less cylindrical non-pneumatised bone with poorly differentiated articular ends, which bears no resemblance to pterosaur tibia, nor to any other element of a pterosaur skeleton.

Comparisons reveal that the so-called pterosaur tibia from Lezennes is in all likelihood a phalanx of a marine reptile. Among Late Cretaceous marine reptiles, plesiosaurs have proportionally much shorter phalanges. In mosasaurs, the phalanges are elongate but more hourglass-shaped than the specimen from Lezennes. The greatest resemblances seem to be with phalanges of marine turtles, which show a comparable degree of elongation and proximal and distal expansion. Incidentally, a turtle shell is known from the Lezennes Chalk.

Biotic recovery in the aftermath of the Late Permian mass extinction event: new data from the oceanic seamounts of SW Japan

David Casenove[1], Richard J. Twitchett[2], and Tatsuo Oji[3]

[1]*Université Claude Bernard Lyon 1, 43 Bd du 11 Novembre 1918, 69622 Villeurbanne cedex, France* <David.Casenove@ens-lyon.fr>

[2]*University of Tokyo, 7-3-1 Hongo, Tokyo, 113-0033, Japan, and University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK* <rtwitchett@plymouth.ac.uk>

[3]*University of Tokyo, 7-3-1 Hongo, Tokyo, 113-0033, Japan* <oji@eps.s.u-tokyo.ac.jp>

The Permian–Triassic interval witnessed the most severe mass extinction of the Phanerozoic. Despite its significance for the evolution of the marine biosphere, the subsequent recovery has attracted relatively little research effort. Recent work has demonstrated that the most rapid post-Permian recovery occurred in shallow, seamount settings of Neotethys (Twitchett *et al*., 2004, *Geology*, v. **32**, pp. 805–808). Is rapid recovery typical of all Early Triassic seamounts, or only those in Neotethys?

To address this question we undertook palaeoecological analyses of limestones of the Lower-Middle Triassic Taho Formation of SW Japan, which were deposited in an oceanic seamount setting in Panthalassa. The fauna comprises gastropods, bivalves, brachiopods, echinoderms, foraminifera, ostracods and serpulids. Firstly, the abundance of the different taxa, from thin sections and acetate peels, was assessed. Secondly, the palaeoecological parameters of dominance, evenness and diversity were calculated.

From the Griesbachian to the Anisian, dominance decreases slightly (from 1.0 to 0.8) as diversity increases (from 0.4 to 1.0). This contrasts with results from a shallow seamount in Neotethys, where high diversity and low dominance assemblages occur in the middle and late Griesbachian. The Taho Formation seamount limestones show no rapid recovery in the Griesbachian, but, instead, much slower recovery typical of shelf settings worldwide (*e.g.* western USA, northern Italy). Levels of ecological recovery recorded in the Griesbachian seamount limestones of Neotethys are not recorded in the Taho Formation limestones until the Anisian.

Ray-finned fishes evolution and breakup of Pangaea

Lionel Cavin and Peter L. Forey

The Natural History Museum, Dept. of Palaeontology, London SW7 5BD
<l.cavin@nhm.ac.uk>*,* <plf@nhm.ac.uk>

During the Late Jurassic and throughout the Cretaceous, Pangaea fragmented to northern and southern continents, which became separated by a Western arm of the Tethys Ocean. During the Cretaceous further fragmentation took place between South America and Africa to form the South Atlantic, and inland seas were beginning to form in North America and in North Africa. These geological events may have had great significance on fish evolution by allowing more available coastline with increased habitat diversification to be colonised. The fragmentation of land masses also isolated freshwater basins from each other, with their contained fish assemblages. It is usual in vicariance biogeography studies to look at terrestrial and freshwater organisms because it is thought that their distributions are more closely constrained and more easily definable. However, it is equally true that the distributions of most marine coastal fishes are also tightly constrained either by substrate or temperatures, or both.

In this study we test the congruence between the phylogenetic splitting of seven clades of ray-finned fishes—pycnodontiforms, vidalamins, osteoglossomorphs, aspidorhynchiforms, ichthyodectiforms, paraclupeids, chanoids—with the fragmentation of Pangaea. The pattern of form (phylogeny) matches the pattern of space for most of the clades, suggesting a causal relationship, but there are discrepancies between phylogenetic and fragmentation of geographical areas for a few clades and for two geographical areas. The discrepancies can be explained by the dispersal ability and/or ecological differences of the fishes, or by poorly determined phylogenies or depauperate taxon sampling.

We discuss the results in the light of Hunn and Upchurch's chronobiogeographical paradigm (2001).

HUNN, C.G. and UPCHURCH, P. 2001. The importance of time/space in diagnosing the causality of phylogenetic events: towards a "chronobiogeographical" paradigm. *Systematic biology*, **50**, 391–407.

Tunnelling trilobites in Middle Ordovician *Thalassinoides*

Lesley Cherns[1], James R. Wheeley[1] and Lars Karis[2]
[1]*School of Earth, Ocean and Planetary Sciences, Cardiff University, Cardiff, CF10 3YE, UK,* <Cherns@cardiff.ac.uk>, <Wheeleyjr@cardiff.ac.uk>
[2]*Geological Survey of Sweden, Villavägen 18, Uppsala, Box 670, SE-751 28, Uppsala, Sweden,* <Lars.Karis@sgu.se>

Articulated *Asaphus (A.) raniceps* body fossils are preserved within *Thalassinoides* branching burrow networks across an extensively exposed bedding surface of the Llanvirn Orthoceras Limestone in Jämtland, Sweden. Facultative tunnelling behaviour is interpreted for these trilobites, previously thought to be surficial dwellers. Diagenetic segregation of carbonate has enhanced burrows into a nodular semirelief 2D tier at a heterolithic limestone–black shale junction. Burrow interconnections are Y–T shaped, expanded at turning chambers. The diagenetic environment suggests originally shallow burrows where firmground transition layer carbonate mud enabled these trilobites to construct open domichnia. Vertical connection pipes to the palaeo-seafloor are not preserved so that depth of burrowing is unknown, and any original tiered 3D boxwork architecture, as reported for some early Palaeozoic *Thalassinoides*, is masked by the diagenetic nature of limestone beds. What was the advantage of an infaunal ethology to trilobites that were predators or scavengers? Tunnel networks would have provided protection from large carnivorous cephalopods at the top of the Ordovician food chain, while tunnel hydrodynamics likely aided breathing by drawing generally tranquil bottom waters across gill branches. The overlying black shale is the only physical evidence for the kill event, possibly anoxia, leading to preservation of the trilobites *in situ*. The intimate association of trilobites in *Thalassinoides* identifies this burrow geometry in the early Palaeozoic as arthropod prior to the decapod crustacean fossil record from the Devonian.

A new genus of tetrapod from the Devonian of East Greenland

Jennifer A. Clack[1], Per E. Ahlberg[2] and Henning Blom[1,2]
[1]*University Museum of Zoology, Cambridge, Downing St., Cambridge CB2 3EJ, UK* <j.a.clack@zoo.cam.ac.uk>
[2]*Department of Evolutionary Organismal Biology, Evolutionary Biology Centre, Uppsala University, Norbyvägen 18ASE-752 36, Uppsala, Sweden* <Per.Ahlberg@ebc.uu.se>, <Henning.Blom@ebc.uu.se>

A new genus and species of Devonian tetrapod has been identified from material collected in 1947 from the southern slope of Celsius Bjerg, Ymer Ø, East Greenland. The specimen preserves both lower jaws, partial palate, premaxillae and maxillae, with a natural mould of parts of the shoulder girdle. The new taxon shows many differences from both *Acanthostega* and *Ichthyostega*, though shows a closer resemblance to the latter. The dentition of *Ichthyostega* has also been reassessed in the light of fresh studies. Differences from *Ichthyostega* are most clearly seen in the dentition: tooth shape, number and proportions differ from that genus on all tooth-bearing bones. It also differs from *Ichthyostega* in skull ornamentation and lateral line expression. A cladistic analysis using characters of the palate, marginal bones, lower jaws and dentition shows that the specimen nests immediately below *Ichthyostega*, but above other Devonian tetrapods. Early and Late Carboniferous tetrapods stack robustly above these and suggest progressive modifications to the lower jaw associated with changes to feeding modes. Nine sites yielding Famennian tetrapods have now been recognised worldwide, producing a complement of at least 17 separate tetrapod taxa.

Mid-Miocene latitudinal environmental gradient in western Europe: mammals and vegetation compared

Loïc Costeur[1], Gonzalo Jimenez-Moreno[1,2]
[1]*UMR CNRS 5125, Université Claude Bernard Lyon 1, Bâtiment GEODE, 2 rue Dubois, 69622 Villeurbanne Cedex, France* <loic.costeur@univ-lyon1.fr>
[2]*Departamento de Estratigrafía y Paleontología, Universidad de Granada, Avda. Fuente Nueva S/N, 18002 Granada, Spain* <gonzaloj@ugr.es>

The middle Miocene (16 to 11 My) is a key period in the Cenozoic climatic evolution. It represents the last warmest episode of the Tertiary (Miocene Climatic Optimum) in a general cooling trend and development of major permanent Antarctic ice sheets (Zachos *et al*., 2001). In this context, terrestrial ecosystems evolved towards their present-day structure. We investigated how the western European middle Miocene vegetation and mammalian communities responded to this climatic evolution. We found that southwestern Europe (south and central Spain) was dominated by very arid environments and that progressively more closed and humid conditions were encountered going northward. The pollen grain contents of mega-mesothermic plants with higher water requirements increase and the mammalian communities body weight distributions progressively change from sub-desertic to closed and humid environments from central Spain to northeastern Germany. Thus a strong latitudinal environmental gradient already existed by mid-Miocene times and probably finds explanations in the global climatic and tectonic events that took place during this time-period.

The apparatus architecture of the prioniodinid conodont *Erismodus quadridactylus* (Stauffer) and its implications

Rosie Dhanda
School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK <RXD803@bham.ac.uk>

Of the three major orders of denticulate conodont, the Prioniodontida, the Prioniodinida and the Ozarkodinida, there is an abundance of architectural data available for the feeding apparatuses of prioniodontid and ozarkodinid conodonts. Conversely, the apparatus composition and architecture of prioniodinid conodonts is poorly understood due to the shortage of assemblage data. The apparatuses of prioniodinid conodonts generally comprise very fluid element shapes, making it difficult to reconstruct apparatus plans from discrete element collections.

An excellently preserved natural assemblage of the prioniodinid conodont *Erismodus quadridactylus* (Stauffer), found in core borehole rock in North Dakota, USA, offers some significant insights into the apparatus architecture of the genus *Erismodus*. In particular, the assemblage allows specific element morphotypes to be assigned to a fixed position within a constrained architectural template. The assemblage also reveals that certain element morphotypes, traditionally considered to reside within the main ramiform basket, lie elsewhere within the apparatus. Hence, this material allows for a near complete apparatus architecture to be constructed that is representative of basal prioniodinid conodonts. In addition the assemblage data provides a focal point for phylogenetic analysis of prioniodontid and prioniodinid relationships, and an insight into the evolution and diversity of conodont feeding mechanisms.

Validating fossil bacteria: some cautionary tales from the Mid-Palaeozoic

D. Edwards, L. Axe and R. J. Parkes

[1] *School of Earth, Ocean and Planetary Sciences, Cardiff University, Main Building, Park Place, Cardiff CF10 3YE, UK*

<EdwardsD2@cardiff.ac.uk>, <Axe@cardiff.ac.uk>, <J.Parkes@earth.cardiff.ac.uk>

Bacteria are very small, monotonously simple morphologically and very abundant throughout the biosphere. They may facilitate fossilization —but more frequently prevent it, *e.g.* destroying soft parts of plants and animals. Their own record is appalling, and its authenticity controversial. Just how does one identify a fossil bacterium? Spheres, rods and filaments of prokaryotic dimensions present on Silurian and Lower Devonian fossils offered the opportunity, courtesy of the NERC, to address this problem. We used SEM and TEM with elemental analyses, combined with experiments involving exposing fossil spores to an extant bacterial cocktail. We discovered that minerals, both naturally occurring and synthesised during extraction, are remarkably good at simulating coccoid and rod-shaped bacteria, even to the extent of producing tracks on spores. To our mortification, some mimicked tapetal residues associated with spore development. Biofilms contained more promising candidates for bacterial status, but when they first colonised the 'fossils' remains conjectural. Storage in hydrochloric acid immediately after collection was employed to avoid recent contamination, but water may have been seeping through those rocks for millions of years. These uncertainties have some relevance to those who seek to validate extra-terrestrial life. We, who now more fully appreciate what confronts them, wish them luck!

A new test of the role of CO_2 in the late Ordovician glaciation

Benjamin J. Fletcher, Charles H. Wellman and David J. Beerling

[1] *Department Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK*

<bop02bjf@sheffield.ac.uk>, <d.j.beerling@sheffield.ac.uk>, <c.wellman@sheffield.ac.uk>

Glaciation in the late Ordovician caused the second largest mass extinction in the Phanerozoic, with 26% of families made extinct. It is thought that atmospheric CO_2, a major control of climate, was very high during the Ordovician. There are currently two hypotheses vying to explain how such extensive glaciers formed under these conditions.

The productivity hypothesis suggests that increased phytoplankton growth drew down CO_2 during the Ordovician, leading to cooling. The weathering hypothesis suggests that after a lesser drop in CO_2, caused by silicate weathering, CO_2 rose as the land was covered in ice, but that the increase in albedo was enough to maintain the cold temperatures. However, a deadlock remains due to the lack of proxy measures of CO_2 over this period.

Based on laboratory growth experiments, we report that the stable carbon isotope composition of mosses and liverworts is very sensitive to atmospheric CO_2 levels. This finding indicates that fossil remains of Ordovician land plants can offer a means of reconstructing past CO_2 levels, with the exciting potential of resolving the role of CO_2 in the glacial event. Preliminary isotopic analysis of Ordovician mesofossils using an ion-microprobe mass spectrometer indicates high (10 x present) CO_2 levels before the glaciation when calibrated against modern plants.

Neogene climates near the South Pole: evidence from fossil plants and climate-vegetation models

Jane Francis[1], Alan Haywood[2], Allan Ashworth[3], Steven Roof[4], and David Cantrill[5]

[1]*Earth Sciences, University of Leeds, UK* <j.francis@earth.leeds.ac.uk>

[2]*British Antarctic Survey, Madingley Road, Cambridge, UK* <ahay@bas.ac.uk>

[3]*Department of Geosciences, North Dakota State University, Fargo, ND 58105-5517, USA,* <allan.ashworth@ndsu.nodak.edu>

[4]*Hampshire College, Amherst, MA.01002-3359, USA,* <sroof@hampshire.edu>

[5]*Swedish Museum of Natural History, Stockholm, Sweden,* <David.Cantrill@nrm.se>

Since the initiation of glaciation in the early Oligocene the Antarctic ice sheets have been an important driver of our global oceanic and atmospheric systems. The ice sheets have been considered as inherently stable, keeping Antarctica in a state of deep freeze. However, the discovery of fossil plants and insects interbedded with glacial tillites of the Sirius Group at 85°S indicates that the climate must have warmed dramatically during the Neogene and caused the ice sheets to retreat. New fossil discoveries indicate that tundra vegetation of *in situ* dwarf beeches, cushion plants and moss, with beetles and molluscs, colonised periglacial landscapes only 300 miles from the South Pole. Palaeoclimatic analysis of the fossils suggests that the mean annual temperature was ~–12°C, with short Summers of temperatures up to +5°C and long freezing winters. Although the age of the Sirius Group is debated, climate-vegetation models using a global Pliocene database predict comparable tundra conditions at this locality. This implies that the Antarctic ice sheets are not stable but may respond to future climate warming more dramatically than once thought.

The systematic position of the Late Jurassic alleged dinosaur *Macelognathus* (Crocodylomorpha: Sphenosuchia)

Ursula B. Göhlich[1], Luis M. Chiappe[2], James M. Clark[3] and Hans-Dieter Sues[4]

[1]*Université Claude Bernard – Lyon 1, UMR P.E.P.S., Bâtiment Géode, R2, #207, 2 rue Dubois, 69622 Villeurbanne Cedex, France* <u.goehlich@lrz.uni-muenchen.de>

[2]*Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007, USA* <chiappe@nhm.org>

[3]*Department of Biological Sciences, George Washington University, Washington, DC 20052, USA* <jclark@gwu.edu>

[4]*Department of Paleobiology, National Museum of Natural History, Washington, DC 20560, USA* <sues.hans@nmnh.si.edu>

Macelognathus vagans was described by O.C. Marsh in 1884 on the basis of a mandibular symphysis from the Upper Jurassic Morrison Formation of Wyoming, USA.

In the past, this taxon was often considered a dinosaur, but later was also tentatively referred to the Crocodylia. Its phylogenetic identity has until now been enigmatic and its determination was hampered by the fact that the taxon was represented only by a mandibular fragment.

Recently, some partial disarticulated skeletons, also from the Upper Jurassic Morrison Formation, but from a different locality, namely the Fruita Palaeontological Area, Colorado, have been studied and identified as sphenosuchians—an extinct sister-taxon of the Crocodyliformes (Crocodylomorpha). Two mandibles of this new material are morphologically identical with the holotype of *Macelognathus vagans*. On the basis of this new sphenosuchian material from the Fruita Paleontological Area it is possible for the first time to identify the enigmatic taxon *Macelognathus vagans* as a sphenosuchian crocodylomorph.

The new material of *Macelognathus vagans* augments our knowledge of the diversity of sphenosuchians and for the first time provides postcranial information of this taxon. In addition, the new material from the Upper Jurassic Morrison Formation of the Fruita Paleontological Area extends the known stratigraphic range of sphenosuchians and constitutes the youngest definitive occurrence of a sphenosuchian, previously known from the Late Triassic to the Middle or Late? Jurassic.

Plant and vertebrate fossil-*lagerstätten* from the Albian-Cenomanian of Charente-Maritime (Western France)

Bernard Gomez[1], Didier Néraudeau[1], Romain Vullo[1], Blaise Videt[1], Vincent Perrichot[1], Véronique Daviero-Gomez[2], Frédéric Thévenard[2] and Clément Coiffard[2]

[1]Géosciences Rennes - UMR CNRS 6118, Université Rennes 1, Campus de Beaulieu, bât. 15, 263, avenue du Général Leclerc, 35042 Rennes

[2]Paléobotanique, PEPS - UMR CNRS 5125, Université Claude Bernard Lyon 1, Bât Darwin A, 7 rue Dubois, 69622 Villeurbanne

Uppermost Albian and Lower Cenomanian limestones, sands and coaly clays were extensively deposited in the region Charente-Maritime of Western France. These fossil-*lagerstätten* are exposed locally at the lowermost parts of coastal cliffs and inland in sand quarries. They are of two types: (1) fossil-*lagerstätten* by preservation (*e.g.* plant beds at Puy-Puy), and (2) fossil-*lagerstätten* by concentration (*e.g.* sands bearing teeth and bones microremains at Les Renardières). T hey delivered very abundant and diverse palaeontological assemblages consisting of plants (leaf cuticles and wood of ferns, conifers, cycads and angiosperms), and vertebrates (bones and teeth of selachians, actinopterygians, turtles, crocodiles, snakes, pterosaurs, dinosaurs and mammals). From the palaeoenvironmental point of view, these settings represent transgressive deposits formed in an internal estuary and coastal lakes or lagoons, which were more or less continental (freshwater) or marine influenced. Interestingly, plants and vertebrates share palaeogeographical affinities with North America and North Africa.

The evergreen or deciduous habit of Cretaceous polar forests: Fossil data *versus* computer model predictions

Melise Harland

School of Earth Sciences, University of Leeds, Leeds, LS2 9JT, UK <melise@earth.leeds.ac.uk>

During the Cretaceous the polar regions were covered with dark dense forests. These forests would have significantly modified the climate both on polar and global scales, due to their low albedo and their effect on the land-surface heat budget and the hydrological cycle. The deciduous or evergreen habit of the conifers and the length of time they held their leaves would have played an important part in this feedback.

This project involves determination of the distribution of ancient polar forests and their deciduous or evergreen habit, to obtain data to be input into computer climate models. In previous studies the leaf habit of these trees has been determined by Nearest Living Relative analysis, a method that assumes the trees had the same leaf habit in the past as now. In this study, a new technique that quantitatively characterises the cell patterns within growth rings in fossil wood is used to determine how long the trees kept their leaves.

Analysis of Cretaceous fossil wood from the Arctic (Canadian Arctic and Svalbard) and the southern polar regions (Antarctica and Australia) indicates that the forests were composed of a mixture of both deciduous (*e.g. Laricioxylon)* and evergreen (*e.g. Protocedroxylon*, *Juniperoxylon*, *Piceoxylon, Araucariopitys*, *Cedroxylon*, *Glyptostroboxylon, Xenoxylon*) conifers in the northern polar regions but only evergreen conifers in southern high latitudes (*e.g. Podocarpoxylon*). The climate-vegetation models predict mixed deciduous and evergreen forests at both poles, which matches the fossil evidence for the north but not the southern polar region.

Pollen abundance patterns: Neoecological insights for palaeoecology?

Guy J. Harrington

School of Geography, Earth and Environmental Sciences, Aston Webb Building, The University of Birmingham, Birmingham, B15 2TT, UK <g.j.harrington@bham.ac.uk>

Pollen grains are usually counted in discrete samples of ≈300 specimens which, allowing for taphonomic filtering, provide proxy data on both parent floral composition and taxonomic diversity. However, there are no taxonomically independent (*i.e.* neutral) ways to determine environment and climate based on pollen data. I present an attempt to extract information from the modern pollen record that ignores the assumed systematic affinity of the pollen grains. My approach centres on the abundance distribution of pollen grains within counted samples. I posit that the abundance distributions will reflect plant community (biome) characteristics and especially pollination syndromes; samples should have increasing equitability with increasing latitude. The data set is constructed from 48 eastern North American localities which are isotaphonomically sampled along a latitudinal transect from the subtropics to the tundra. Pollen composition, taxonomic richness and pollen co-occurrence patterns change significantly between biomes. Evenness metrics (including Hurlbert's PIE) indicate that equitability shows only minor changes from one biome to another—all localities have positively skewed, leptokurtic abundance patterns and conform to a truncated log-normal distribution. Hence, sampled pollen equitability can not determine parent communities and has few, if any, predictive powers.

A null biogeographic model for quantifying the role of dispersal in shaping taxonomic richness and similarity patterns

Noel A. Heim and Steven M. Holland
Dept. of Geology, University of Georgia, Athens, GA 30602-2501, USA
<naheim@uga.edu>, <stratum@gly.uga.edu>

Diversity patterns in the fossil record are often interpreted as functions of only origination and extinction, while taxonomic dispersal among regions is rarely considered. We present a null biogeographic model of global diversity, that calculates taxonomic richness (S) and similarity (J), as measured by the Jaccard Coefficient. The model contains three regions, each initially containing a unique set of taxa. At each time step, each taxon is randomly allowed to go extinct, create a new taxon, disperse or remain unchanged. At the end of each time step, global S and mean global J are calculated. The probabilities for origination and extinction are set to be equal and the model was run with origination/extinction and dispersal probabilities that spanned over four orders of magnitude.

The model has two significant results. (1) If the probability of dispersal is sufficiently large relative to origination/extinction, regional and global richness increase exponentially. For non-negligible probabilities of origination, the combined effect of dispersal and origination exceeds the effect of extinction, causing the exponential increase in diversity. (2) If richness increases, global mean J will reach equilibrium (J_{eq}). When plotted against the ratio of dispersal probability to origination/extinction probability, J_{eq} follows a sigmoidal curve.

This null biogeographic model is useful for predicting dispersal probabilities in the fossil record when origination and extinction probabilities are known. Taxonomic dispersal among regions has the potential to play a significant role in shaping diversity trends, and should be considered when analysing Phanerozoic diversity trends.

Might machaeridians be molluscs?

Liam Herringshaw, Alan Thomas and Paul Smith
Palaeobiology Research Group, Lapworth Museum of Geology, School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK
<lgh865@hotmail.com>

Machaeridians were elongate, slug- or worm-like organisms with an external skeleton of imbricating calcite plates (sclerites). Known only from Palaeozoic marine environments, three groups are recognized—plumulitids, turrilepadids and lepidocoleids—but their zoological affinities are enigmatic. Withers (1926) recognized that they formed a monophyletic group, but was uncertain of their systematic position. He did note similarities between the optical properties of machaeridian sclerites and echinoderm ossicles, leading many later workers to interpret machaeridians as aberrant members of the Echinodermata. However, Bengtson (1978) showed this to be erroneous, and subsequent studies have suggested variously that machaeridians are most closely related to arthropods, annelids or molluscs. Using specimens from the Much Wenlock Limestone Formation (Silurian) of England, new information is presented here that indicates machaeridians are molluscs, probably the sister-group of Polyplacophora + Conchifera.

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Echinoderm Palaeoecology from fragments: reconstructing salinity and substrate controlled faunas in the British Middle Jurassic

Aaron W. Hunter
Research School of Earth Sciences, Birkbeck and UCL (University College London), Gower Street, Bloomsbury, London, WC1E 6BT, UK <aw.hunter@geology.bbk.ac.uk>

Research using bulk sampled sediments (of typically 10–40kg) from across the British Middle Jurassic (Bathonian), where the full spectrum of marine and marginal marine environments are represented, has demonstrated a distinct ecological zonation pattern in the crinoid groups characterised by at least two genera.

This research has been taken a stage further with its application to three more echinoderm groups (echinoids, asteroids and ophiuroids). Previously it was noted that lack of homology in the ossicles made identification beyond family level problematic; however, examination of complete specimens in museum collections has allowed the recognition of diagnostic ossicles that can identify tests, spines and marginal plates to generic level.

Results indicate a marked facies control on the distribution of groups influenced by factors including substrate and salinity. Groups such as echinoids inhabit ecosystems defined by facies belts; for example, *Hemipedina* inhabits normal marine settings, *Hemicidaris* is found in open shelf areas and *Acrosalenia* is found in lagoonal and restricted conditions. Such results are also mirrored in the asteroid and ophiuroid data.

This new data, combined with the previous findings on crinoid groups, has allowed the construction of a model for echinoderm palaeoecology across marginal marine environments. The application of this model to marine environments outside the British Jurassic, such as the Middle Jurassic of France and the Western interior, USA, has demonstrated that factors such as substrate and marine connection have a greater bias than geographical and stratigraphic controls.

Early eukaryotes in Paleoproterozoic and Mesoproterozoic oceans

Emmanuelle J. Javaux[1], Craig P. Marshall[2], Shuhai Xiao[3], Andrew H. Knoll[4] and Malcolm R.Walter[2]
[1]*Department of Astrophysics, Geophysics and Oceanography, University of Liège, Belgium.*
[2]*Australian Centre for Astrobiology, Department of Earth and Planetary Sciences, Macquarie University, Sydney, NSW 2109, Australia.*
[3]*Virginia Tech, VI, USA*
[4]*Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA.*

Biomarker molecular fossils in 2770 Ma shales suggest that the Eucarya diverged from other principal domains early in Earth history. Nonetheless, at present, the oldest fossils that can be assigned to an extant eukaryotic clade are filamentous red algae preserved in *ca.* 1200 Ma cherts from Arctic Canada. Between these records lies a rich assortment of potentially protistan microfossils. New microscopic study of late Paleoproterozoic shales from China (1800–1625 Ma Chuanlinggou Formation) and Australia (1650 Ma Mallapunyah Fm) permits the significant extension of the stratigraphic range of fossil evidence for early eukaryotes. Combined light microscopy, scanning electron microscopy, and transmission electron microscopy on fossils from the 1500–1400 Ma Roper Group, Australia, and broadly coeval rocks from China show that these intermediate assemblages do indeed include a moderate diversity of eukaryotic remains, although the observed diversity remains well below Neoproterozoic levels. In particular, preserved cell wall ultrastructure, observed using transmission electron microscopy (TEM), can help to bridge the current stratigraphic gap between the unambiguous eukaryotic morphologies of mid-Proterozoic assemblages and molecular biomarkers in much older rocks. Ongoing microchemical analyses (Micro-FTIR spectroscopy, Laser micro-Raman spectroscopy and Laser micro-pyrolysis-GC/MS) of individual microfossil walls may help us to place firmer constraints on phylogenetic interpretation.

Homology, shape and morphometric analysis of the conodont skeleton

David Jones[1], **Mark Purnell**[1] **and Peter von Bitter**[2]
[1]*Department of Geology, University of Leicester, University Road, Leicester, England LE1 7RH* <**doj2@le.ac.uk**>
[2]*Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, Canada M5S 2C6* <**peterv@rom.on.ca**>

Conodonts possess an exceptionally good fossil record and occupy a key phylogenetic position within the vertebrate clade. Consequently, they represent an invaluable tool for understanding both evolutionary patterns and the acquisition of vertebrate characters. Correct identification of homology is vital in exploiting this potential. However, as with most vertebrates, conodonts are rarely preserved as articulated skeletons, where homology can be determined directly from topological relationships. Traditionally homology has therefore been identified exclusively through qualitative description of the morphology of disarticulated elements. Yet hypotheses of homology based on articulated skeletons may contradict those derived from the morphology of isolated elements alone. Here, quantitative morphometric analysis of both skeletons and isolated elements is used to determine rigorously whether element morphology is an accurate guide to element homology.

A new Upper Permian flora from the Middle East with typical Triassic Gondwana elements

Hans Kerp[1], **Abdallah Abu Hamad**[1,2], **Klaus Bandel**[3] **and Birgit Niemann**[1]
[1]*Forschungsstelle für Paläobotanik, Westfälische Wilhelms-Universität Münster, Hindenburgplatz 57, 48143 Münster, Germany*
[2]*Natural Resources Authority, Geological Mapping Division, P.O. Box 7, Amman, 1118 Jordan*
[3]*Geologisch-Paläontologisches Institut, Universität Hamburg, Bundesstraße 55, 20146 Hamburg, Germany*

Several species of *Dicroidium* are described from the Um Irna Formation (Upper Permian) of the Dead Sea region, Jordan. Plant remains are preserved as compressions with excellent cuticles. It is the earliest unequivocal record of *Dicroidium*, a genus that is typical for the Triassic of Gondwana and the northernmost occurrence of this genus that apparently originated in the Late Permian in the palaeotropics. Middle and Late Permian floras from the Arabian Peninsula show a remarkable mixture of elements from different floral provinces, *i.e.* Euramerica, Cathaysia and Gondwana. The climatic amelioration that has been reported for the Early Triassic of the Gondwana apparently enabled *Dicroidium* to migrate southward and finally colonize the entire Gondwana region. *Dicrioidium* is one of the very few megaplant genera that was not affected by the biotic crisis at the Permian-Triassic transition.

Discovery of Famennian and Early Carboniferous trilobite larvae: implications for the systematics and the evolutionary history of proetoids

Rudy Lerosey-Aubril
Institut des Sciences de l'Evolution (UMR 5554, CNRS), Cc 064, University Montpellier II, Pl. E. Bataillon, 34095 Montpellier Cedex 05, France <**lerosey@isem.univ-montp2.fr**>

New silicified material from the Middle Famennian of Morocco, the Late Famennian of Germany, and the Early Carboniferous of France substantially increase our knowledge of proetoid larvae. Both anaprotaspides and metaprotaspides illustrate that proetoid trilobites possess a unique early ontogeny, remaining highly conservative from the Ordovician to the Early Carboniferous. Accordingly, they support the view that Proetida may be composed of two different clades. The new data also enable the evolution of anaprotaspis size in proetoids from the Ordovician to the Lower Carboniferous to be broadly depicted. In particular, two marked increases of larval sizes are recognised. The first one may have occurred around the Silurian/Devonian boundary, but its potential implication on proetoid evolutionary history is unknown. On the other hand, the substantial sizes reached by Late Famennian and Early Carboniferous anaprotaspides suggest the acquisition of an extended planktonic period in the early ontogeny of proetoids. The possible implications of this developmental strategy on the survivorship of these trilobites during the end Devonian Hangenberg biocrisis or, alternatively, on the colonization of deep water benthic habitats, are discussed.

Towards the development of a Palaeo UV-B proxy from fossil land plants

B. H. Lomax[1], **M. A. Sephton**[2], **T. V. Callaghan**[3,] **C. H. Wellman**[1] **and D. J. Beerling**[1]
[1]*Department of Animal and Plant Sciences, University of Sheffield* <**b.lomax@sheffield.ac.uk**>, <**c.wellman@sheffield.ac.uk**>, <**d.j.beerling@sheffield.ac.uk**>
[2]*Department of Earth Sciences, Open University* <**m.a.sephton@open.ac.uk**>
[3]*Department of Animal and Plant Sciences, University of Sheffield and Abisko Scientific Research Station SE-981 07 Abisko, Sweden* <**t.v.callaghan@sheffield.ac.uk**>

Changes in atmospheric oxygen, major volcanic eruptions and impact events have the potential to induce short- and long-term changes to the stratospheric ozone layer. However, detecting the interaction between these events and the expected increase in terrestrial UV-B flux has proved elusive.

Recent laboratory investigations suggest that the spores and pollen of land plants may respond to variations in the UV-B radiation by increasing investment in UV-B screening pigments. However, it is not known if this response is replicated in natural settings. Here, we report an increase in UV-B protecting pigments from the spores of plants growing in South Georgia (54° 20'S, 36° 40'W) and exposed to a progressive thinning of the Antarctic ozone hole since the 1950s. Our data records a strong three fold linear increase in the concentration of UV-B protecting pigments of *Lycopodium. magellanicum* spores in response to a 14% thinning of the ozone column.

Our results were obtained using high temperature FTIR analysis of sporopollenin, a decay-resistant biomacromolecule readily preserved in the fossil record. Therefore, this newly identified response of extant plants to modern day climate change offers the exciting possibility for the development of a potential tool to investigate palaeo changes in stratospheric ozone layer and UV-B flux.

The first Danish dinosaur footprints!

Jesper Milàn
Geological Institute, Østervoldgade 10, DK-1350 Copenhagen K., Denmark
<milan@geol.ku.dk>

Remains of dinosaurs from Denmark have hitherto consisted of two teeth, one complete dromaeosaur tooth, and a toothcrown with possible Titanosaurid affinities. Both teeth are of Lower Cretaceous (Berriasian/Ryazanian) age and found on the Baltic island Bornholm. In May 2004 two large sauropod footprints and a smaller, possibly thyreophorean footprint were found in the Middle Jurassic (Tithonian/Bathonian) Bagå Formation, which is exposed on the north-west coast of Bornholm in the Hasle Klinkefabrik clay pit. The sauropod tracks are pes imprints, 70 cm long and 45 cm wide, pentadactyl, with the impressions of digits I-III being the most prominent. The small track is 25 cm long and 19.5 cm wide, pentadactyl, with short clawed digits and symmetrical along the length axis. The Bagå Formation consists of alternating layers of clay and coal with thick cemented fluvial sandstone beds. During quarrying for clay, the hard sandstone beds were broken up and dumped on the beach in front of the clay pit. Palynological investigations of clay preserved between the footprint casts will determine the exact stratigraphic position of the blocks. These are the first dinosaur footprints found in Denmark, and the first sauropod footprints recorded from the Scandinavian area.

Nitrogen and carbon isotopes in conodonts: Evidence of trophic levels and nutrient flux in Palaeozoic oceans

Chris Nicholas[1], John Murray[2], Robbie Goodhue[3] and Peter Ditchfield[4]
[1]*Department of Geology, Trinity College Dublin, Dublin 2, Ireland* <nicholyj@tcd.ie>
[2]*School of Earth and Ocean Sciences, National University of Ireland, Galway, Ireland*
<murrayj@nuigalway.ie>
[3]*Department of Geology, Trinity College Dublin, Dublin 2, Ireland* <goodhuer@tcd.ie>
[4] *Research Laboratory for Archaeology, University of Oxford, 6 Keble Road, Oxford, OX1 3QT, U.K* <peter.ditchfield@archaeology-research.oxford.ac.uk>

Animals fractionate nitrogen and organic carbon isotopes during food digestion and preferentially excrete the lighter isotopes. New body tissues subsequently grown become about +3.4‰ more positive in δ^{15}N than their food and about +1‰ more enriched in δ^{13}C. This simple relationship between consumer and food means that the trophic level of organisms within the same ecosystem can be distinguished on the basis of their isotopic signature. This technique has been successfully applied to modelling trophic structure in present day and Neogene vertebrate ecosystems. But could original nitrogen and carbon isotopic ratios be preserved in much older fossil material?

Here we present the results of an initial attempt to investigate community structure in biotas where organisms are not only extinct but have no clear modern analogues. Conodont platform elements from two species, Gnathodus bilineatus and Gnathodus girtyi, display consistent and significantly different δ^{15}N and organic δ^{13}C signatures within the same sample. This isotopic discrepancy is consistent with data from modern marine organisms feeding at different trophic levels in the same ecosystem. These results not only extend the range of the nitrogen and carbon technique back a further 250 Ma than any previous studies, but they also raise the possibility of using fossil groups such as conodonts as tracers of nutrient flux in Palaeozoic oceans.

The evidence for and implications of an invertebrate diet in Jurassic pliosaurs (Reptilia: Sauropterygia)

Leslie F. Noè
The Sedgwick Museum, Department of Earth Sciences, The University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK <lnoe01@esc.cam.ac.uk>

The Callovian pliosaurs found in the Peterborough Member of the Oxford Clay Formation are relatively poorly understood. New reconstructions of the key taxa *Peloneustes*, *Liopleurodon* and *Simolestes* show divergent cranial, mandibular and dental specialisations. The cranial morphology of *Peloneustes* is elongate, narrow and low; in *Liopleurodon* the skull is shorter and wider, but still relatively depressed; but in *Simolestes* the cranium is short, and exceptionally wide and deep. Comparison to modern analogues indicates diet varied between the pliosaurian taxa, with *Peloneustes* a piscivore, *Liopleurodon* a predator on large hard-boned prey (thus confirming previous suggestions), but that *Simolestes* should be reinterpreted as predominantly consuming invertebrates, probably cephalopods. However, the consumption of invertebrates, which impart a high salt load on the consumer, has important physiological implications for reptiles, which are unable to produce urine stronger than the blood plasma; indeed it has been suggested that life in water is impossible for reptiles that cannot solve the problem of salt. It is therefore suggested that large salt-secreting glands were present in *Simolestes* due to its predominantly invertebrate diet, and present but smaller in other pliosaur genera. Due to the close packing of the tooth bases ('roots') and other organs in the skull, the salt glands of pliosaurs were probably located within the orbits, as seen in modern marine turtles.

Graptogonophores, scopulae and *Dawsonia*: putative reproductive organs reconsidered

Alex Page[1], Phil Wilby[2], Mark Williams[3] and Jan Zalasiewicz[1]

[1]*Department of Geology, University of Leicester, Leicester, LE1 7RH* <aap8@le.ac.uk>

[2]*British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG*

[3]*British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET*

Putatively vesicular structures on graptolites, for example scopulae, tend to attract interest and debate. For most of the nineteenth century scopulae were considered to be reproductive organs, similar to those of modern hydrozoans, and termed graptogonophores. Despite the increasing acceptance of a hemichordate affinity for graptolites in the twentieth century, the proposed reproductive function remained largely unchallenged, and latterly overlooked. Similarly, disarticulated sclerites from the problematic fossil *Dawsonia* have been regarded as scopulae broken from graptolites.

This work reassesses these structures: morphometric analysis demonstrates that the similarity between scopulae and *Dawsonia* is superficial. Moreover, comparison with isolated graptolites and vesicular graptolitic tissues shows that scopulae are best considered to be two-dimensional paddle-like appendages. Their two-dimensional nature indicates their function is more likely hydrodynamic than reproductive, leaving the term graptogonophore obsolete. Scopulae are only known in biserial graptolites but have arisen independently on several occasions, though in each instance their fossil occurrence is extremely rare. This may be consistent with modification to inhabit an infrequent and probably marginal habitat.

Terrestrial Gastropods and the Perils of Palaeoclimate Studies, or When Size Does Matter (sample size that is)!

Claire L. Pannell

Division of Earth Sciences, University of Glasgow Centre for Geoscience, Gregory Building, Lilybank Gardens, Glasgow, G12 8QQ, Scotland, UK <c.pannell@earthsci.gla.ac.uk>

Terrestrial gastropods have been widely used to investigate palaeoclimates by measuring the stable isotope signals of δ^{18} Oxygen and δ^{13} Carbon bound up within the shell carbonate. These signals can act as proxies for the local precipitation and/or relative humidity and the vegetation from which the snail obtained its moisture and food, and thus can be used to infer the wider climate at the time of shell formation. Results will be presented to illustrate that all land snail shells are not equal; some shells demonstrate wide within-shell variation, and within-species variation is just as great. It will be shown that inadequate homogenization of the shell or measurement of only part of a shell could lead to highly erroneous conclusions. Even where homogenization is possible, the large intraspecific variation found in Canarian land snail shells requires that researchers ensure a sufficiently large sample size that takes into account the natural variation present.

The « Avins event », a remarkable highstand at the end of the Tournaisian. Its influence on the global distribution and on the evolution of the Viséan rugose corals

E. Poty

Université de Liège, Belgium <e.poty@ulg.ac.be>

On the Namur-Dinant Basin platform (Belgium, north France), the top of the highstand system tract of the third-order sequence 4 corresponds to the Avins Member, a little lower than the Tournaisian-Visean boundary, which is situated in the lower part of the transgressive system tract of the sequence 5. The Avins Member is characterized by the appearance, among others, of *Palaeosmilia*, *Merlewoodia*, and *Amygdalophyllum*, which mark the base of the RC4b Subzone, and are the stock for typical Viséan genera and species.

It is remarkable that the Avins level can be traced throughout Eurasia, and as far as Australia. In some areas, the corresponding levels rest directly on an old basement and are the oldest Lower Carboniferous rocks recorded.

Such a very widespread coral assemblage is unusual for the Dinantian, during which most coral faunas are endemic, and shows that good connections between distant areas existed, confirming the very high sea level determined by sedimentological studies. The "Avins event" is followed by a strong fall in the sea level during which the common stock of corals gave rise by separate evolutions to endemic Lower Viséan coral assemblages, with basins becoming more or less isolated. The correlations between high-stand—widespread of fauna, and low-stand—endemism and evolution, can be extended to other radiations of corals during the Carboniferous.

Age assessment of Pleistocene and Holocene mammal bones

Christina Karla Reimann and Christian Ostertag-Henning

Geologisch-Paläontologisches Institut der Universität Münster, Corrensstr.24, 48149 Münster, <reimi@uni-muenster.de>

Palaeoenvironment, ecology and climate development reconstructions based on mammal bones need a palaeostratigraphic classification of the fossils. Too often this is not the case, especially with fossils from river currents out of highly reworked sediments.

A case study of about 5,000 mammal bones from a sandpit of a bayou of the River Ems, Münsterland, Germany, will help getting closer to that problem.

By the determination of achaeological troves from the mentioned sandpit the age of the fossils ranges from the Middle Palaeolithic up to the present day.

Because of their varying colours 16 different colour groups have been distinguished. Element analyses by REM indicate a possible influence of element inclusions on discolouration.

To look for more factors which could give a hint for the bones' age, thin sections have been investigated in terms of possible histological patterns.

Afterwards the age of the bones within the different colour groups was determined applying Amino-Acid-Racemization to check out a synchrony within the groups. If in fact the colour, microstructure or element-inclusions depend on the age of the bones, this would be a great tool for an easy age classification of fossils from one and the same location by only measuring the age of a few of the bones.

On convergent evolution in Nummulitidae with secondary chamberlets (Foraminiferida)

Willem Renema[1] and Peter Lunt[2]
[1]*Nationaal Natuurhistorisch Museum, P.O. box 9517, 2300 RA Leiden, the Netherlands*
<**Renema@naturalis.nl**>
[2]*Lundin Oil & Gas B.V., Plaza Great River, Jl. Rasuna Said Kav X-2 no 1, Jakarta 12950, Indonesia* <**plunt@mac.com**>

Recently molecular data have shown that extant nummulitid genera with secondary chamberlets are more closely related to *Operculina* than to each other. We discuss the palaeontological occurrence of nummulitds with secondary chamberlets and the implications for their phylogeny.

For the generic classification of Nummulitidae with secondary chamberlets we used the following characters:

1. Characters of the stolon system.
2. The presence and shape of secondary chamberlets in the first chambers.
3. The presence of lateral chamberlets (l.c.) and/or cubiculae. Cubiculae are shown to evolve into lateral chamberlets, with some specimens possessing cubiculae in the early whorls and l.c. in the latter.
4. The type of coiling (involute, maturo-evolute and evolute is regarded as less important. Not only is it not possible to use these characters in juveniles, but the presence of maturo-evolute specimens (*Heterostegina* cf. *depressa* of Tan Sin Hok, 1932) as intermediates between the *praecursor*- group and *Vlerkina* shows that this character state evolved more than once.
5. Additional characters can be found in the shape of the chamberlets (very narrow to as high as broad), the angle between the secondary and primary septa (rectangular *vs.* sharp angle).

Based on these characters we propose a simplified nomenclature for the groups included. *Heterostegina praecursor* and *H. bantamensis* will be included in *Cycloclypeus*, whilst *Tansinhokella* includes all Eocene species with lateral chamberlets or cubiculae and *Spiroclypeus* will include the Oligo-Miocene species.

Influence of seawater saturation state on the Phanerozoic diversity of calcified marine algae and invertebrates

Robert Riding
School of Earth, Ocean and Planetary Sciences, Cardiff University, Cardiff CF10 3YE, UK
<**riding@cardiff.ac.uk**>

Calcification in many marine algae and invertebrates is biologically induced rather than controlled. It can therefore be expected that secular variation in seawater saturation state for $CaCO_3$ minerals should have influenced the long-term history of organisms that biologically induce, rather than closely control, their calcification. Comparison of calculated seawater saturation state with patterns of marine calcified organisms during the Phanerozoic Eon suggests that the diversity of organisms with biologically induced calcification, such as chlorophytes, corals and sponges, increased during periods of elevated saturation state and declined when saturation state was reduced. In contrast, organisms with relatively controlled calcification, such as molluscs, brachiopods, bryozoans, and echinoderms, appear to have been relatively unaffected by saturation state. This indicates that $CaCO_3$ availability —governed by saturation state—has significantly influenced the diversity of organisms with biologically induced calcification. This effect involves many tropical marine algae and invertebrates, especially those that are most involved in reef building. Thus, despite its apparent abundance, $CaCO_3$ has been so widely employed in biomineralization by aquatic organisms during the past ~550 million years that it has constituted a limiting resource, partitioned between organisms that biologically control and biologically induce their calcification, with the surplus being inorganically precipitated.

Inside the inside of a dendroid

Kate Saunders and Denis Bates
Department of Earth Sciences, University of Oxford, Parks Road, Oxford OX1 3PR, UK
<**kate.saunders@earth ox.ac.uk**>

Desmograptus micronematodes Spencer, from the lower dendroid bed at Thornton quarry, Cook Co., Illinois, USA (middle Wenlock or lundgreni Biozone) is remarkably preserved in relief, outlined in pyrite. The internal details of the thecae, and of the stolon system, examined using the SEM, enabled us to reconstruct the growth of a stipe. Autothecae have a proximal portion, the stolotheca, partially within the parent autotheca, containing a stolon; a central portion which has a branching node of the stolon succeeded by the internal portions of its daughter autotheca and bitheca; and a distal portion which is an open cup. The stolons and stolonal nodes are formed of a dense crassal fabric, and are surrounded by a loose fabric of three-dimensional fibrils. The nodes have a complex structure of three boxes with proximal and distal nozzles. The base of a bitheca, and the base of each autothecal cup, has a central nozzle surrounded by a unique honeycomb fabric. Cortical and fusellar fibrils bear a surface structure of spiral ridges.

A Silurian sea spider

Derek J. Siveter[1,2], Mark D. Sutton[3], Derek E. G. Briggs[4], David J. Siveter[5]
[1]*Earth Sciences Department, University of Oxford, South Parks Road, Oxford OX1 3PS, UK*
[2]*Geological Collections, University Museum of Natural History, Oxford OX1 3PW, UK*
<**derek.siveter@earth.ox.ac.uk**>
[3]*Department of Earth Sciences, University of Oxford, South Parks Road, Oxford OX1 3PS, UK*
<**mark.sutton@earth.ox.ac.uk**>
[4]*Department of Geology & Geophysics, Yale University, P.O. Box 208109, New Haven, CT 06520-8109, USA* <**derek.briggs@yale.edu**>
[5]*Department of Geology, University of Leicester, Leicester LE1 7RH, UK* <**djs@leicester.ac.uk**>

The Herefordshire (Silurian) Konservat-Lagerstätte in England yields remarkable, three-dimensional, non-biomineralized fossils in carbonate concretions hosted in a volcaniclastic deposit. Pycnogonids (sea spiders) have an extremely sparse fossil record, and are known globally from just four species based on a few tens of specimens from two localities. A new, exceptionally-preserved sea spider from the Herefordshire deposit represents the oldest known adult by some 35 million years, the most completely known fossil species, and provides new insight into the early morphology of the Pycnogonida and its relationship to other arthropod groups. Cladistic analyses place the new species near the base of the pycnogonid crown group, implying that the latter had arisen by the Silurian. The morphology of this recently discovered form has been digitally reconstructed to produce a ‘virtual fossil’ in the round.

Functional and Adaptive Implications of Cryptic Speciation In Planktic Foraminifera

Blair A. Steel[1], Michal Kucera[1] and Kate F. Darling[2]
[1]*Department of Geology, Royal Holloway and Bedford New College, University of London, Egham, Surrey TW20 0EX, UK* <b.steel@gl.rhul.ac.uk>, <m.kucera@gl.rhul.ac.uk>
[2]*Grant Institute of Geology and Geophysics, University of Edinburgh, Edinburgh, United Kingdom, EH9 3JW* <Kate.Darling@glg.ed.ac.uk>

Cryptic species (genetically isolated and ecologically disparate sibling taxa) are seemingly common in the marine plankton, and both molecular clock and palaeontological methods suggest that some, if not many, of these diverged many millions of years ago. We have morphometrically analysed over 2,000 specimens of the common planktic foraminifers *Globigerinella siphonifera* and *Globigerinoides ruber*, extracted from well-dated ODP cores at two tropical sites (926A (Atlantic) and 806 (Pacific)). In both forms, DNA methods suggest the occurrence of deep (7–11 Ma) diverging cryptic species complexes and strong evidence of ecological specialisation—but with minimal concomitant morphological change. Our morphometric dataset (based on a suite of characteristics ranging from ultrastructural assays to multivariate analysis of whole-test form) suggests that the *Gl. siphonifera* sub-types are resolvable as fossils if the correct characters are extracted, but cryptic species of *Gs. ruber* appear to be almost entirely resistant to morphological division. In both cases, morphometric and/or molecular clock methods imply the long-term coexistence of ecologically discrete, but morphologically near-identical, reproductively isolated species. From a functional viewpoint, this finding is ambiguous; either very strong stabilising selection is acting to constrain morphological evolution (suggesting the adaptive primacy of test form), or the locus of selection is centred on other characters (implying that test form is of little or no adaptive significance). Resolving this paradox is of prime evolutionary importance, certainly amongst foraminifers, and potentially throughout the pelagic realm.

Functional morphology and light-gathering ability of podocopid ostracod eye

Gengo Tanaka
Faculty of Engineering, Kanazawa University, Kakuma, Kanazawa 920-1192, Japan
<Gengo@se-geomail.sci.shizuoka.ac.jp>

Optical features of lateral ocelli of the ostracod eye were examined in 29 species of the Podocopida using a theoretical morphological model. A cuticle lens–tapetum model was introduced for this purpose. The ray-tracing was simulated in each model, to assess light-gathering abilities of various forms of the eyes. The results of computer simulations and morphospace analyses indicate that the light-gathering ability is dominantly affected by thickness and curvature of outer surface of the lens. On the basis of a combination of form and light-gathering ability, four categories were recognised in the podocopid eye. The results of the phototactic experiment were concordant with estimated scores on the light-gathering ability using the theoretical model. The present study also indicates that the light-gathering ability is related to development of surface ornamentation on the valve.

Evolution of polymorphism in colonial animals: differentiation of the earliest avicularian polymorphs in the Cretaceous cheilostome bryozoan *Wilbertopora*

Paul D. Taylor[1], Alan H. Cheetham[2], Andrew N. Ostrovsky[3] and JoAnn Sanner[4]
[1]*Department of Palaeontology, The Natural History Museum, London SW7 5BD, England* <pdt@nhm.ac.uk>
[2]*Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, District of Columbia 20650 USA* <cheetham.alan@nmnh.si.edu>
[3]*Department of Invertebrate Zoology, Faculty of Biology and Soil Science, St. Petersburg State University, Universitetskaja nab. 7/9, 199034, St. Petersburg, Russia* <oan_univer@yahoo.com>
[4]*Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, District of Columbia 20650 USA* <sanner.joann@nmnh.si.edu>

In many colonial animals particular zooids perform different functions. This is usually reflected in their morphology, resulting in polymorphism. Darwin, during the voyage of the *Beagle*, observed the behaviour of non-feeding polymorphs called avicularia in cheilostome bryozoans. Avicularia are zooids with opercula enlarged to form mandibles or setae that are capable of functioning in defence and cleaning or, in rare instances, acting as locomotary appendages. Occurring in the majority of Recent and fossil cheilostomes, avicularia make their first appearance in the fossil record in the Cretaceous genus *Wilbertopora*. Scanning electron microscopy and morphometric studies of *W. mutabilis* Cheetham, 1954, from the Albian–Cenomanian of Texas and Oklahoma, have shown that this ‘species’ actually comprises eight different species distinguished most readily by their avicularia. Five of these species have well-differentiated avicularia resembling those found in many younger cheilostomes. However, in *W. mutabilis* s.s. and two new species, the avicularia are so similar to autozooids that they have been overlooked in the past. A series of morphological changes inferred from a cladistic analysis of the eight *Wilbertopora* species demonstrates the progressive differentiation of increasingly advanced avicularia.

Eurypterid phylogeny and the origin of Arachnida

O. Erik Tetlie
Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen’s Road, Bristol BS8 1RJ, UK <o.e.tetlie@bristol.ac.uk>

The monophyletic Palaeozoic chelicerate order Eurypterida, contains around 65 genera and is the subject of the first large-scale phylogenetic analysis of the group (201 morphological characters for the entire Chelicerata). Many eurypterids are known from fragmentary remains, and the 40 best-known genera are included in this analysis.

The analysis suggests that the two previous models that divide Eurypterida into two suborders—Pterygotina *vs.* Eurypterina (large *vs.* small chelicerae) and Eurypterina *vs.* Stylonurina (sixth appendage developed into swimming legs *vs.* walking legs)—renders one suborder paraphyletic. The suborder concept is therefore abandoned, but a number of superfamilies and families are recognised. The position of Eurypterida within Chelicerata (excluding Pantopoda) was also analysed and the result suggests Xiphosura is the most basal taxon in Chelicerata. Chasmataspidida are sister-group to Eurypterida + Arachnida. The monophyletic Arachnida has Scorpiones as its most basal taxon, followed by Haplocnemata (Solifugae + Pseudoscorpiones). The remaining higher taxa form a clade where Opiliones is basal, followed by the extinct Phalangiotarbida, Acaromorpha (Acari + Ricinulei), Palpigradi, Anthracomartida, Araneae, the extinct Haptopoda, Amblypygi, Thelyphonida and Schizomida.

How to get a date in the Devonian of Bolivia

Ian Troth[1], John Marshall[2] and Andrew Racey[3]
[1]*School of Ocean and Earth Science, Southampton Oceanography Centre, European Way, Southampton SO14 3ZH, UK* <it598@soc.soton.ac.uk>
[2]*School of Ocean and Earth Science, Southampton Oceanography Centre, European Way, Southampton SO14 3ZH, UK* <jeam@soc.soton.ac.uk>
[3]*BG Group, Thames Valley Park, Reading RG6 1PT, UK* <andrew.racey@bg-group.com>

During the Mid Palaeozoic Bolivia was part of the Malvinokaffric Province, a high-latitude southern hemisphere realm that had a highly endemic marine fauna. This makes dating and correlation with Euramerica by macrofossils difficult, but microfossils have proved more useful. A succession of microplankton 'events' has been recorded throughout the Devonian of Bolivia that comprise short-lived monospecific pulses of distinctive marine palynomorphs. Particular emphasis in this study has been placed on the *Evittia sommeri* event, dated by cosmopolitan chitinozoan and spore taxa as latest Emsian/early Eifelian. Sedimentology shows the *E. sommeri* event is associated with a major marine transgression that, based on the earliest Mid Devonian date, can be considered the Chotěc Event. This is the first time the Chotěc Event has been identified at high palaeolatitudes and its recognition has allowed a test of the Euramerican sea-level curve. Preliminary results of the Mid/Late Devonian in Bolivia show that the sea-level curve should be regarded with caution through this interval.

Molluscan diversity in deteriorating climate regimes: The Plio-Pleistocene of the southern North Sea Basin

F. P. Wesselingh
Curator, Naturalis, P.O. Box 9517, 2300 RA, Leiden, the Netherlands
<wesselingh@naturalis.nl>

After the catastrophic surge in the delta region of SW Netherlands in February 1953 an ambitious scheme of waterworks was erected, the deltaworks. The geological research preceding many of the new large infrastructural works resulted in a massive bore campaign. These so-called 'Deltadienst boreholes' cover SW Netherlands, and represent mainly Pliocene and Quaternary deposits, rich in fossil shells.

Ongoing research into the faunal successions provides a picture of molluscan diversity in the southern North Sea Basin during the Pliocene and Quaternary. In general a decline in species numbers is seen, with termophile and endemic groups most affected. However, immigration events, especially of Arctic–Pacific species, from the Middle Pliocene onwards, have greatly influenced the faunal development of the North Sea.

The deltadienst successions, together with new successions described from the Antwerp (Belgium) Pliocene, will lead to an improved molluscan biozonation for the southern margin of the North Sea Basin.

How to make a Burgess Shale fossil: an experimental approach

Lucy Wilson
Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK <law41@esc.cam.ac.uk>

The Burgess Shale fauna represents a taphonomic conundrum. A number of theories have been proposed to explain its preservation, ranging from a simple lack of bioturbation or increased anoxia to the heightened preservation potential by burial within sediments of particular physical or chemical properties, notably clay minerals. While several taphonomic experiments have been conducted with an aim to understand 'soft-part' decay and preservation, none have investigated the effect that different sediment properties have on taphonomy.

A series of experiments have thus been carried out looking at the preservation potential of four end-member sediment types. The results are certainly intriguing, and it appears that the non-smectite clay kaolinite has a preservation potential that far exceeds those of the other sediments, including montmorillonite. This reaffirms the idea that the presence of clay minerals may markedly enhance soft-part preservation, but suggests that the more reactive smectite clay minerals may not be responsible. This is supported by the suggestion that the premetamorphic sediment of the Burgess Shale was likely to have been an illite-smectite-kaolinite clay assemblage, with an absence of highly reactive species such as nontronite or Na-montmorillonite (Powell, 2003).

Exploring an Early Palaeozoic Tropical Archipelago on the Shores of Hudson Bay

Graham A. Young[1], Robert J. Elias[2], Godfrey S. Nowlan[3], David M. Rudkin[4] and Edward P. Dobrzanski[1]
[1]*Manitoba Museum, 190 Rupert Avenue, Winnipeg, MB, R3B 0N2, Canada*
<gyoung@cc.umanitoba.ca>
[2]*University of Manitoba, Winnipeg, MB, R3T 2N2, Canada* <eliasrj@ms.umanitoba.ca>
[3]*Geological Survey of Canada, 3303 – 33rd Street NW, Calgary, AB, T2L 2A7, Canada*
<GNowlan@NRCan.gc.ca>
[4]*Royal Ontario Museum, 100 Queen's Park, Toronto, ON, M5S 2C6, Canada*
<davidru@rom.on.ca>

A unique and spectacular Early Palaeozoic tropical archipelago is being unearthed near Churchill, Manitoba, Canada. Islands composed of Proterozoic quartzite are surrounded by shallow marine deposits of Late Ordovician and Early Silurian age. Field research since 1996 has revealed a total of 16 localities, representing shoreline and nearshore environments preserved both before and after the Late Ordovician mass extinction. The detailed data collected from surface outcrops were enhanced in 2003 by the extraction of drillcore from five sites, permitting three-dimensional interpretation.

Upper Ordovician (Richmondian) carbonates and sandstones were deposited in a variety of settings around quartzite islands: muddy bay, boulder beach, shallow-water sands, and a cove with restricted water circulation. They contain diverse biotas: trilobites, corals, brachiopods, cephalopods, gastropods, and conodonts. A claystone of undetermined age overlies the Ordovician rocks. Above this are Lower Silurian (lower Llandovery) deposits, consisting of poorly fossiliferous muddy dolostones overlain by coral-rich dolostones and by strata containing monospecific assemblages of the brachiopod *Virgiana decussata*. The unusual depositional settings represented by these rocks provide an excellent opportunity to improve our understanding of the Late Ordovician extinction and of Early Palaeozoic shallow marine ecosystems.

Data analysis and systematic description of the fossils are ongoing. Discoveries to date include: (1) records of environmental change through the extinction interval; (2) the largest known trilobite, *Isotelus rex*, and associated trace fossils; (3) unusual fossils including eurypterids and ophiuroids; and (4) diverse corals encrusting Ordovician shoreline boulders.

Substrate specificity of Auloporida (Tabulata) from the Devonian of the Holy Cross Mts., Poland

Mikołaj K. Zapalski
Laboratoire de Paléontologie stratigraphique, FLST & ISA, UMR 8014 & FR 1818 du CNRS,
13 rue de Toul, 59046 Lille cedex, France, and Warsaw University, Faculty of Geology,
Żwirki i Wigury 93, 02-089 Warszawa, Poland <m.zapalski@uw.edu.pl>

Brachiopods encrusted by various organisms (corals, bryozoans, crinoids) are common in the Devonian of Holy Cross Mts., Poland. Observations made on the material from the Skały Fm. (Upper Eifelian-Lower Givetian) of two sections—Grzegorzowice-Skały and Świętomarz-Śniadka (northern region of the Holy Cross Mts.)—allowed recognition of substrate specificity of auloporids (Tabulata).

Brachiopods were encrusted by *Aulopora* spp., *Aulocystis skalensis* (STASIŃSKA), *Aulocystis* sp. and *Pachyphragma* sp. (the latter one recognized in Europe for the first time).

Kyrtatrypa sp., a rare brachiopod in the Formation (under 5%), were the most often encrusted (63% of investigated specimens; N=31), while the most often occuring species, *Aulacella eifeliensis* (DE VERNEUIL) was nearly not encrusted. The majority of encrusted brachiopods were larger than 20 mm, while smaller brachiopods occur abundantly in the Formation. The substrate specificity has been caused mainly by the ornamentation of the host's shell, because in the Formation occur other big brachiopods with more delicate ribs (*e.g. Xystostrophia*). The position of corallites along the commissure of the brachiopod shell proves that auloporids often encrusted living hosts.

The epizoan probably used water currents produced by brachiopod's lophophore impoverishing the host's food composition; their relationship can therefore be described as scramble competition.

Abstracts of poster presentations

The rugose coral fauna from the Serpukhovian (Carboniferous) of the Ardengost Massif (Pyrenees, France) and its palaeobiogeographic implications

Markus Aretz[1], Laurent Barchy[2] and Emmanuel Chevalier[3]
[1]*Institut für Geologie und Mineralogie, Universität Köln, Zülpicher Str. 49a, 50674 Köln, Germany* <markus.aretz@uni-koeln.de>
[2] *Université de Liège, Unité de Paléontologie Animale, Allée du 6 Août, 4000 Liège, Belgium* <L.Barchy@ulg.ac.be>
[3] *Université de Liège, Unité de Paléontologie Animale, Allée du 6 Août, 4000 Liége, Belgium,* <E.Chevalier@ulg.ac.be>

The Ardengost Massif represents one of the rare occurrences of shallow-water carbonates from southern Armorica. Its microbial and bioclastic limestones of Serpukhovian age contain occasionally abundant coral faunas. Solitary forms dominate, but colonial forms are always present. The absence of non-dissepimented corals indicates non-stressed, shallow-water environments. Almost monospecific coral beds of *Kizilia*, *Dibunophyllum*, and *Palaeosmilia* are characteristic for the Serre de Castets section.

The overall generic composition indicates some interesting palaeobiogeo-graphic aspects for the European rugose coral province. It confirms the wide distribution of some classic Central European taxa, as *e.g. Dibunophyllum*, *Axophyllum*, *Palaeosmilia*, and *Diphyphyllum*. However, *Kizilia* and *Melanophyllum* indicate an overlap with the coral fauna of Russia and Ukraine. Therefore, migration from Russia into Europe followed two different paths: one north of Armorica into Central Europe indicated by *Nemistium*, and a second along the southern margin indicated by Kizilidae.

However, the composition of the coral fauna along a single path may vary considerably. Although almost similar in age and depositional realm, the closely spaced Ardengost and Montagne Noire coral faunas show remarkable compositional differences. Taxa very abundant in the Central Pyrenees—*e.g. Dibunophyllum*, *Koninckophyllum*—are almost unknown in the Montagne Noire and vice versa, *e.g.* certain Lithostrotionidae.

Morphology and Ultrastructure of a Lower Carboniferous Megaspore

Caroline Arioli[1], Bernard Lugardon[2], Thomas Servais[1], Charles. H. Wellman[3]
[1]*USTL, Sciences de la Terre, SN5, Laboratoire de Paléontologie et Paléogéographie du Paléozoïque, UMR 8014 du CNRS, 59655 Villeneuve d'Ascq Cedex, France*
<caroline_arioli@yahoo.fr>, <thomas.servais@univ-lille1.fr>
[2]*Laboratoire de Biologie Végétale, Université Paul Sabatier, 39 allée Jules-Guesde, 31000 Toulouse, France*
[3]*Department of Animal and Plant Sciences, Alfred Denny Building, Western Bank, Sheffield S10 2TN, UK* <c.wellman@sheffield.ac.uk>

The majority of Palaeozoic megaspores were produced by free-sporing, heterosporous, lycopsids. The Early Carboniferous was marked by an increase in the abundance and diversity of several megaspore genera, such as *Lagenicula*, that became dominant in the Upper Carboniferous. This rise in abundance/diversity probably reflects the development of forests dominated by large arborescent lycopsids. The study of the megaspore *Lagenicula variabilis* (Winslow, 1962) nov. comb. from the Lower Carboniferous of northeastern Ohio, U.S.A., utilizing LM, SEM and TEM analysis, has provided new information on its gross morphology, wall structure and wall ultrastructure. By comparing this spore with other fossil species of *Lagenicula* and the spores of extant lycopsids, it is possible to confirm its biological affinities with lycopsids. *In situ Lagenicula* (and related forms) from the Upper Carboniferous studies indicate that such megaspores derive from the Lepidocarpacea, that include many of the typical arborecent lycopsids that dominated the Euramerican Coal Measure forests. Although the specimens from the Lower Carboniferous of Ohio have not been recovered *in situ*, it seems likely that they derive from a similar source. This suggests that the arborescent lycopsids typical of the Upper Carboniferous were already present in the Lower Carboniferous, possibly forming forests in similar environments.

Euconodont histology, modularity and the development of complexity

Howard A. Armstrong
University of Durham, Department of Earth Sciences, South Road, Durham, UK.

Higher organisms are incredibly complex systems and one of the outstanding questions of modern biology is, how does such complexity evolve? Modularity, the combinational assembly of elementary building blocks, allows for the generation of complexity, particularly if the building blocks are duplicated and modified during evolution.

The vertebrate oral skeleton is an example of a modular system, comprising in various manifestations dentine, enamel and enameloid tissues. Tooth structures among gnathostomes comprise two configurations (Carlson 1990). At its most primitive, in Cambrian euconodonts, teeth are formed from dentine capped by enamel; a configuration also found enigmatically in clades crownwards of the amphibians. In the Chondrichthyes and Osteichthyes teeth are formed from dentine capped by enameloid. This pattern raises the obvious questions as to the origin of enameloid, and why are different combinations of tissues expressed at different times and in different clades?

Recent work on the histology of *Panderodus*, a coniform euconodont, thought to have had a nektonic or pelagic mode of life, indicates a tooth structure comprising dentine and enameloid. This clade arose in the Tremadoc (*deltifer* biozone) and it would therefore appear that the dentine–enamel configuration, found in most euconodonts, has evolutionary primacy. A hypothesis is offered in which enameloid was derived from a modification of the "enamel genetic module" as an adaptive response to different structural demands on teeth. From the Tremadoc, enamel and enameloid modules became available for expression in different adaptive situations.

CARLSON, S. J. 1990. Vertebrate dental structures. In: Carter, J. G. (ed.) *Skeletal Biomineralization: Patterns and Evolutionary Trends, Volume I*, 531–556. Van Nostrand Reinhold, New York.

Biodiversity variations around the Triassic/Jurassic boundary: example of vertebrate remains from paralic environments

Steven Barbe[1], Philippe Courville[2], Claire Derycke[1] and Catherine Crônier[1]
[1]USTL, Sciences de la Terre, SN5, Laboratoire de Paléontologie et Paléogéographie du Paléozoïque, UMR 8014 du CNRS, 59655 Villeneuve d'Ascq Cedex, France
<claire.derycke@univ-lille1.fr>
[2]Université de Rennes 1, Bât. 15, Géosciences Rennes, UMR 6118 du CNRS, 35042 Rennes Cedex, France <philippe.courville@univ-rennes1.fr>

Some new sections were studied in central and southern Burgundy (Eastern France), which exhibit continuous lithologic successions around the Triassic/Jurassic (T/J) boundary. Supposed to correspond to a major biological crisis, the T/J boundary is typically characterized in that area by siliciclastic facies, of proximal marine to paralic environments.

The Rhaetian typical facies is particularly enriched with vertebrate remains, mainly belonging to fishes (selachians and actinopterygians: *Acrodus substriatus*, *Hybodus cloacinus*, *H. minor*, *H. plicatilis*, *H. sublaevis*, *Lissodus minimus*, *Polyacrodus holwellensis*, *Pseudodalatias barnstonensis*, *Nemacanthus monilifer*, *Synechodus rhaeticus*, *Synechodus* sp., *Pseudocetorhinus pickfordi*, *Saurichthys longidens*, *Gyrolepis albertii*, *Birgeria acuminata*, *Colobodus* sp., *Sargodon tomicus*, *Lepidotes* sp., *Paralepidotus* sp., *Ceratodus kaupi*, *C.* sp.) or reptiles (*Ichtyosaurus* sp., *Rutiodon* sp.) and mammalian reptiles (*Pseudotriconodon* sp., *Gaumia* sp.).

The Hettangian part of the sections only yielded poor or absent vertebrate associations, despite the absence of obvious lithological/environmental changes around the T/J Boundary.

Is such an observation reflecting a general change in the vertebrate content around the T/J limit, resulting from a real biological crisis? Or is it not simply related to some local, changing environmental conditions? Or is it simply due to the taphonomic and preservation contexts?

Palaeoecology of Upper Eocene and Upper Oligocene larger foraminiferal and coralline algal dominated carbonates (north-eastern Italy)

Davide Bassi[1] and James H. Nebelsick[2]
[1] Dipart. delle Risorse Naturali e Culturali, University of Ferrara, Corso E. I d'Este 32, 44100 Ferrara, Italy <bsd@unife.it>
[2] Institute of Geosciences, University of Tübingen, Sigwartstr. 10, 72076 Tübingen, Germany
<nebelsick@uni-tuebingen.de>

During the Cainozoic, two main extinction events of marine benthic taxa took place in the Indo-Pacific area: a broad interval from the Middle Eocene to Lower Oligocene and a shorter interval during the Late Oligocene to earliest Miocene. During these periods, coralline red algae and larger foraminifera were important sediment producers while corals play a subordinate role in the northern margins of the Tethys. Priabonian (Late Eocene) and Chattian (Late Oligocene) coralline algal facies are identified in an extensive geographic area in north-eastern Italy including the Colli Berici, Monti Lessini area, the Piedmont Flexure, and Alpago area. These facies, found in both pure, shallow water carbonate as well as mixed siliciclastic-carbonate settings, are compared in terms of taxonomic diversity, coralline growth-forms, and taphonomic signatures. In the Priabonian the crustose coralline algal pavements are represented by a coralline crust bindstone and highly diversified nummulitid and orthophragminid foraminiferal fauna. Large rhodoliths occur commonly within this facies and are characteristically discoidal in shape. Chattian rhodolith pavements consist of a rudstone with a packstone matrix dominated by large spheroidal rhodoliths. These different biotic responses to ecological disturbances, probably due to increased rates of weathering and nutrient supply, associated with new trophic resources, promoted the flourishing of coralline algae rather than coral reefs.

Larval shell morphology, geographic range and abundance in a species-rich gastropod radiation (Turridae: Polystira): Recent perspectives on its 30my history

Karl Bates[1], Jonathan A. Todd[2] and Timothy A. Rawlings[3]
[1]Dept. Earth Sciences, University of Manchester, Manchester M13 9PL, UK
<tombates@totalise.co.uk>
[2]Dept. of Palaeontology, The Natural History Museum, London SW7 5BD, UK
<J.Todd@nhm.ac.uk>
[3]Dept. of Biological Sciences, Florida International University, Miami, FL 33199, USA
<rawlings@fiu.edu>

The turrid gastropod *Polystira* (Olig-Rec) is endemic to the subtropical/tropical Neotropics where it is among the most abundant and widely occurring marine molluscan genera (Recent and fossil) in 10–500m water depth. Accretionary growth leads gastropods to preserve their complete skeletal ontogeny, including the larval shell (protoconch) whose morphology reflects lifestyle. Analysis of protoconch morphology in *Polystira* show a bimodal distribution in form and individual morphospecies can be categorized as being either paucispiral (inferred non-planktotrophy) or multispiral (planktotrophic), the latter having greater dispersal potential.

Polystira represents a model marine invertebrate for examining the relationship between larval ecology and geographic range because it is; 1) exceptionally species-rich: 82 Recent Tropical Western Atlantic morphospecies; 2) well sampled: 770 mappable lots (>5,200 specimens), and 3) possible to map morphologies onto a robust molecular phylogenetic tree (16S, 28S, COI).

We have plotted the geographic ranges of each morphospecies within the TWA to test the extent to which inferred dispersal potential correlates with species distribution. Paucispiral taxa show uniformly restricted distributions as predicted by limited dispersal potential but perhaps surprisingly planktotrophic multispiral taxa appear to have more complex distributions including extremely wide and very narrow ranges.

The *Polystira* radiation demonstrates how patterns of abundance and distribution in Recent species have important consequences on our ability to estimate accurately macroevolutionary dynamics using the fossil record.

A rolling stone gathers no moss animals!?

Bjorn Berning[1], Julio Aguirre[2], Juan C. Braga[2], José M. Martín[2] and Christian Betzler[1,3]
[1]Geologisch-Paläontologisches Institut, Universität Hamburg, Bundesstr. 55, 20146 Hamburg, Germany, <berning@geowiss.uni-hamburg.de>
[2]Departamento de Estratigrafia y Paleontología, Universidad de Granada, Campus Fuentenueva, 18002 Granada, Spain
[3]Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK

Although bryozoans are well known to be part of the Recent rocky-shore boulder community, fossil assemblages are seldom recorded. Here we present a shallow-water bryozoan fauna with exceptional preservation from the Early Pliocene of the Carboneras Basin (Cabo de Gata, SE Spain). This small and shallow embayment of the Mediterranean Sea received, by means of intermittently shedding delta lobes, large amounts of coarse terrigenous material from the uplifting Sierra Cabrera to the north. These conglomerates host a diverse *barnamol* fossil assemblage dominated by large balanids, bivalves and bryozoans. The latter, of which some 35 species have been identified, are dominated by *Calpensia nobilis*, which frequently forms thick multilaminar crusts around the pebbles, and *Escharoides coccinea*. The excellent state of preservation of the pebble-encrusting fauna and the almost *in situ* conservation of most fossils imply an absence of strong turbulent currents, rapid burial and future exclusion from reworking. The considerable size reached by the encrusting barnacles and bryozoan colonies is further evidence for (occasionally perturbed) stability of the seafloor for several (tens of) years. Thus, although the proverb still holds true since these conglomerates were not rolling stones *sensu strictu*, this example shows that bryozoans can play an important role in contributing to the carbonate factory of shallow-water rocky shores.

In search of the earliest seed plants: a geological expedition to East Greenland

Christopher M. Berry[1], John E.A. Marshall[2] and Alan R. Hemsley[1]
[1]School of Earth, Ocean and Planetary Sciences, Cardiff University, Park Place, Cardiff CF10 3YE <chris.berry@earth.cf.ac.uk>
[2]John Marshall, School of Ocean and Earth Science, University of Southampton, Southampton Oceanography Centre, European Way, Southampton, SO14 3ZH, UK
<jeam@soc.soton.ac.uk>

Recently, in *Palaeontology*, Marshall and Hemsley described a seed-megaspore, *Spermasporites alleni*, from the Middle Devonian of Ella Ø, East Greenland. This seed-megaspore is highly unusual as it bears at its apex not only three smaller aborted spores of the original tetrad, but also a cluster of microspores. This suggested a new path to seed evolution. But the seed-megaspore has only been found as isolated specimens with no evidence as to their parent plants. In order to determine the taxonomic affinity of the seed-megaspore bearing plant, a NERC-funded expedition was mounted to Ella Ø under the umbrella of CASP. This poster describes the expedition and illustrates some of the palaeontological findings. It complements the scientific results which are being presented in a separate talk (Berry *et al*). A short video is also available on request.

Devonian Bryozoa from New Zealand

Françoise P. Bigey
Laboratoire de Micropaléontologie, Université P. & M. Curie, 4 place Jussieu, 75252 Paris Cedex 05, France <bigey@ccr.jussieu.fr>

As a whole Palaeozoic bryozoan fauna is scarce and poorly preserved in New Zealand. Some Devonian Bryozoa were described from two small areas of the South Island: Reefton and Baton River that belong to different structural units: Buller and Takaka terranes. The Reefton species were included into Cystoporata and Trepostomata. Recent collects yielded mainly Fenestrata, comparatively more abundant, but decalcification of the colonies prevents any determination at the specific level. The material was provided by the Lankey Limestone, Emsian in age. The Baton River species were almost exclusively attributed to Fenestrata. The shelly beds of the Baton River Formation are considered as Pragian/Emsian.

Low biodiversity of the Palaeozoic bryozoan fauna in New Zealand is confirmed with the Devonian forms. It differs widely from the nearest gondwanian domain, that is Australia, even though further studies have to be continued concerning the period. Therefore palaeobiogeographical links are not easy to establish.

Evolutionary patterns for *Normalograptus persculptus* (Elles and Wood, 1907)

Eddie Blackett[1], Jan Zalasiewicz[1], Mark Williams[2] and Barrie Rickards[3]
[1]*Department of Geology, Leicester University, Leicester LE1 7RH, UK*
<ejb1@le.ac.uk>, <jaz1@le.ac.uk>
[2]*British Antarctic Survey* <mwilli@bas.ac.uk>
[3]*Department od Earth Sciences, Cambridge University, Cambridge CB2 3EQ, UK*
<wageren@cambridge.ac.uk>

Assemblages of *Normalograptus persculptus* (Elles and Wood), collected through the LATEST Ordovician *persculptus* zone and EARLIEST Silurian *acuminatus* zone of Cerig Gwynion Quarry and the associated Prysg stream section and Ystraddfin sections of central Wales show: (1) a progressive delay in the insertion of the median septum, as originally identified by K.A. Davies IN 1929, representing a unidirectional microevolutionary trend within a lineage; (2) marked variability in morphology, particularly in rhabdosome dorso-ventral width, through time, producing alternate broader and narrower forms. New data indicate that these broad and narrow forms correspond to the species *Normalograptus persculptus* and *Normalograptus parvulus* (H. Lapworth), which are thus regarded as morphological end members within one variable species. We retain the name *N. persculptus* because of its historical stratigraphical importance, even though *N. parvulus* technically has priority.

A Welsh Ordovician Hunsrück?

Joseph P. Botting[1], Lucy Muir[2] and Talfan Barnie[3]
[1]*Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ* <joseph00@esc.cam.ac.uk>
[2]*Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD* <L.Muir@nhm.ac.uk>
[3]*Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, Ceredigion SY23 3DB*

Ordovician lagerstätten are extremely rare in comparison with the Cambrian, and known examples are severely restricted in the environment represented (Soom Shale) or the taxonomic range (Beecher's Trilobite Bed); the Arenig Fezouata Shale of Morocco yields more diverse organisms, but is at an early stage of investigation. This gives the impression, perhaps misleading, that the Burgess Shale-type communities are largely restricted to the Cambrian, despite some similar taxa in later deposits such as the Hunsrück Slate. The very recent discovery (Summer 2004) of a pyritised fauna in middle Ordovician black shales may help to resolve this issue. The associated, 'normal' fauna is dominantly graptolitic, with only very rare trilobite fragments; the pyritised components of the assemblage appear to be rapidly lost to weathering once exposed. Collections so far have been very restricted in view of the conservation needs of the material, and although soft tissue has not been definitively proven at the time of writing, the first fossils recovered strongly suggest exceptional preservation. The fauna already recovered is dominated by sponges and crinoids, but further organisms include a bivalved arthropod carapace, a partial asteroid (?), and apparently soft-bodied problematica, one of which is possibly a holothurian. The results of a more extensive investigation will be available by the time of the meeting.

The Ontogeny of the Phacopid trilobite Calyptaulax strasburgensis (Ulrich and Delo, 1940) from silicified Middle Ordovician material

Claire Brenner

2, South Drive, Wokingham, Berkshire, RG40 2DH <c.m.brenner@sms.ed.ac.uk>

The complete ontogeny of *Calyptaulax strasburgensis* is presented with both SEM images and diagrammatic reconstructions based on numerous silicified specimens of exceptional quality, originally collected by W.R.Evitt in the 1940s from Ordovician limestones of the Shenandoah Valley, Northern Virginia, USA. The exceptional state of preservation has allowed features on the smallest specimens to be preserved in sufficient detail for several noteworthy observations to be made. Photographic evidence is presented which shows common morphological features that confirm the link between minute (0.3mm diameter), presumably planktonic, bulbous protaspid larval forms with larger benthic protaspides. As recently as the latest *Treatise on Invertebrate Palaeontology* a discussion was had as to whether these bulbous forms represented a larval trilobite or an unidentified crustacean species. Changes in spinosity and tuberculation are documented throughout development and photographic evidence is presented to show the tubercles on the immature glabella are arranged in a spiral formation. Photographic evidence and discussion of the possible function of a unique bifurcating comb-like structure on the benthic protaspids is presented. A new related species is presented which is an intermediate, not fitting into the current generic classification of the Pterygometopids. The need for further work and a taxonomic revision is suggested.

Standing up on its own two (dozen) legs: A new trilobite-like arthropod from the Lower Cambrian Sirius Passet fauna and its functional morphology

Graham E. Budd[1], Martin Stein[1] and Sören Jensen[2]
[1]Uppsala University, Dept of Earth Sciences, Palaeobiology, Norbyvägen 22,
Uppsala SE 752 36 Sweden <graham.budd@pal.uu.se>, <martin.stein@geo.uu.se>
[2]Area de Paleontologia, Facultad de Ciencias, Universidad de Extremadura,
06071 Badajoz, Spain <soren@unex.es>

A large arthropod from the exceptionally-preserved Sirius Passet fauna (Lower Cambrian, Buen Formation, North Greenland) is described. Unusually for the Sirius Passet fauna, external morphology including limbs is well preserved, and internal anatomy less-well preserved, although a series of small gut diverticulae are known. The cephalic segmentation and overall layout of the body are similar to that of trilobites and their close relatives, and the limbs bear a remarkable resemblance to those of the relatively basal trilobites *Olenoides* and *Eoredlichia*. The plesiomorphic nature of this limb type (it is shared by naraoiids and other trilobite-like taxa) suggests that the remarkable success of the trilobites in the Early and Middle Cambrian did not come about primarily through modification of their limb type.

The functional morphology of all these taxa remains problematic, with basic disagreements in the literature concerning how the limbs were attached and oriented, and how they could have functioned to produce the characteristic arthropod trace fossils *Rusophycus* and *Cruziana*. We tackle these problems through the use of computer reconstruction and animation of the limbs of the new arthropod. The limbs of this, and by extension those of the trilobites, cannot have functioned like those of the extant *Limulus*, and indeed the suspicion must be that, unlike modern arthropods, trilobites truly did "stand on their legs, and not hang down from them"—to reverse Manton's crisp aphorism.

A multi-element radula-like structure from the Lower Cambrian Mahto Formation, Jasper National Park, Alberta, Canada

N. J. Butterfield
Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK

Organic-walled microfossils isolated from locally bioturbated shelf-facies mud/siltstone of the Lower Cambrian (mid *Bonnia-Ollenelus* zone) Mahto Fm., south central Canadian Rockies, include a diversity of articulated and disarticulated tooth-like structures with marked similarities to more recent molluscan radulae. Such assignment is supported by a conspicuously fibrous microstructure, presumably reflecting growth via microvilli. This style of construction, however, is not limited to radulae, or indeed molluscs, and the occurrence of organic-walled, microvillar, multi-element jaw structures in other lophotrochozoan phyla may eventually frustrate definitive taxonomic assignment of these fossils. As a radula, however, it supports (and is supported by) the interpretation of various early Cambrian SSF as crown-group molluscs. In any case, these structures clearly *worked* like a radula and document one of the earliest attempts to scrape out a living.

Late Ordovician Cool Water Bryozoan Mud Mounds From Libya

Caroline Buttler[1], Lesley Cherns[2] and Dominique Massa[3]
[1]Department of Geology, National Museum and Gallery Cardiff, Cathays Park,
Cardiff CF10 3NP, U.K. <caroline.buttler@nmgw.ac.uk>
[2]School of Earth, Ocean and Planetary Sciences, Cardiff University, Park Place,
Cardiff CF10 3YE, U.K <cherns@cardiff.ac.uk>
[3]6, Rue Jean-Jacques Rousseau, 92150, Suresnes, France

Upper Ordovician bryozoan mud mounds are identified from subsurface of the Jifarah Formation of Tripolitania, NW Libya. These limestones form part of a much wider, high latitude belt of cool water carbonates across several hundred kilometres through NE Spain, Morocco, Algeria and western Libya, which lay on the NW margin of Gondwanaland. In the mud mounds, the diverse, trepostome-dominated bryozoan assemblage includes delicate and robust branching, encrusting and nodular bryozoan growth forms, but mounds lack organic framework and microbial fabrics. Regional geophysical data suggest rapid thickness changes, where mud mounds in complexes up to 100m thick had some topographic relief over the surrounding muddy sea floor. The Jifarah limestones, which are overlain by glaciomarine shales, have been interpreted as developing during an early Ashgill period of warmer climates, when coral–stromatoporoid reefs formed at low latitudes in areas of Laurentia and Baltica. It is proposed here that analogues of the Jifarah bryozoan mounds are represented from upper slope environments of the Quaternary of the Great Australian Bight by cool-water bryozoan mud mounds, which apparently flourished during the last glacial lowstand. This comparison suggests that the Jifarah mounds may have developed in slope/outer ramp environments at an early Ashgill lowstand, and in cool climates.

Palaeoenvironments of the Montceau-les-Mines freshwater biota (Upper Carboniferous, France): new data from the flora preserved in nodules

Sylvain Charbonnier[1], Jean Vannier[1], Jean Galtier[2], Dominique Chabard[3] and Daniel Sotty[3]
[1]Université Claude-Bernard Lyon 1, UFR Sciences de la Terre, UMR 5125 PEPS,
Paléoenvironnements et Paléobiosphère, Bâtiment Géode, 2 rue Raphäel Dubois,
69622 Villeurbanne, France
<sylvain.charbonnier@univ-lyon1.fr>, <jean.vannier@univ-lyon1.fr>
[2]UMR 5120, CIRAD, Boulevard de la Lironde, TA 40 / PS2, 34398 Montpellier, France
<jean.galtier@cirad.fr>
[3]Muséum d'Histoire Naturelle d Autun, 12-14 rue Saint-Antoine, 71400 Autun, France

Recent faunal studies of the Montceau Lagerstätte have considerably improved our knowledge of this exceptional Upper Carboniferous freshwater biota. However, there is still a lack of information concerning its exact palaeoenvironmental setting (hydrology, relief, climate, ecological niches) and the aquatic ecosystem (*e.g.* trophic links) in which these animals were living. The sideritic nodules that yielded most of the fauna also contain a diverse and abundant flora. The composition of this flora is analyzed here and provides valuable information concerning the palaeoenvironment of the Montceau-les-Mines Lagerstätte. More than fifty species are recognized (*e.g.* *Annularia stellata*, *Pecopteris unita*, *Neuropteris cordata* are particularly abundant) that belong to groups typical of the Stephanian flora (lycophytes, sphenopsids, tree ferns and pteridosperms). Quantitative analyses indicate that arborescent sphenopsids and tree ferns were overwhelmingly dominant even though variations do exist between the floral composition of the different opencast mines studied at Montceau. At some localities, the flora may consist almost exclusively of pteridosperms or tree ferns. Taphonomical and sedimentological studies show that flora contained in nodules was autochtonous to parautochtonous. The three-dimensional preservation of plant remains indicate a rapid burial under presumably anoxic conditions. Nodules formed around plant remains through the precipitation of authigenic siderite, in the same way as in other Upper Carboniferous Lagerstätten such as Mazon Creek (USA), Coseley (UK) or Sosnowiec (Poland). A palaeoenvironmental reconstruction of the Montceau Lagerstätte is proposed, that displays a mosaic of environments (*e.g.* deltaic lacustrine, paludal to fluvial) colonized by plants in which a rich and diverse fauna (*e.g.* aquatic crustaceans, insects, amphibians, fishes) once flourished.

Spiny trilobites from the Devonian of Morocco

Brian D. E. Chatterton[1], Richard A. Fortey[2] and Claire J. T. Mellish[3]

[1]*Department of Earth and Atmospheric Sciences, University of Alberta*
<Brian.Chatterton@ualberta.ca>
[2] *Department of Palaeontology, Natural History Museum, London* <R.Fortey@nhm.ac.uk>
[3] *Department of Palaeontology, Natural History Museum, London* <C.Mellish@nhm.ac.uk>

Morocco has become one of the great sites for discovering new fossils. Notable among these are a range of spiny Devonian trilobites from the Anti-Atlas Mountains that exhibit some of the most bizarre adaptations of an already diverse group. At least five different families have produced morphologies unparalleled in the history of trilobites—or, indeed, the arthropods. These include the genus *Walliserops*, which carries a trident on the front of the cephalon, and another with an anterior 'spoon'. The functional explanations of these spines and projections have remained speculative but some have been postulated as defensive in nature. When some of these trilobites were enrolled the orientation of the spines would have presented predators with a particularly unappealing mouthful. One plausible functional explanation has been deduced for a structure associated with the eyes of a complete specimen of the phacopoid trilobite *Erbenochile* erbeni (Alberti). This trilobite has unique tower-like schizochroal eyes where the lenses are arranged in straight-sided columns and not in the usual spherical fashion. The palpebral lobe of each eye projects outwards over the visual surface so that light incident directly from above is prevented from reaching the lenses. This structure is thought to have acted as a visor or eyeshade.

Wagner's Parsimony analysis of Mid-Cretaceous European vegetation

Clément Coiffard[1], Bernard Gomez[2], Frédéric Thévenard[1], André Nel[3]

[1]*Paléobotanique, PEPS – UMR CNRS 5125, Université Claude Bernard Lyon 1, Bât Darwin A, 7 rue Dubois, 69622 Villeurbanne, France* <ccoiffar@ens-lyon.fr>
[2]*Géosciences Rennes – UMR CNRS 6118, Université Rennes 1, Campus de Beaulieu, bât. 15, 263, avenue du Général Leclerc, 35042 Rennes, France*
[3]*Laboratoire d'Entomologie et UMR 8569, Muséum National d'Histoire Naturelle, 45 rue Buffon, 75005, Paris, France*

The vegetation of Europe during the Mid-Cretaceous is poorly known (Kvaček, 2001, Uličný *et al.*, 1997). Nevertheless, numerous floristic lists have been published during the last century. A comparison of this database using the Wagner's Parsimony method (Coiffard *et al.*, 2004) results in the distinction of six plant associations.

Two associations are characterised by the dominance of gymnosperms *sensu lato* and represent estuary mouth and salt marsh deposits.

Three other associations are richer in pteridophytes, conifers and angiosperms, and correspond to levee, floodplain and probably swamp deposits.

The last association is characterised by three angiosperms, and characterises braided river deposits.

From the ecological and environmental points of view, gymnosperms *sensu lato* were still well-established in brackish, disturbed environments, while angiosperms dominated in freshwater, disturbed environments. This analysis provides important information for the understanding of the floristic turnover during the mid-Cretaceous times.

Xenomorphic growth in ostreids: an example from the middle Oxfordian of Burgundy (Dijon, France)

Yvan Coquinot[1] and Didier Marchand[2]

[1]*Laboratoire PBDS (Processus et Bilans des Domaines Sédimentaires), Université de Lille 1, Bât. SN5, 59655 Villeneuve d'Ascq, France* <yvan.coquinot@univ-lille1.fr>
[2]*Biogéosciences, Université de Bourgogne, 6 boulevard Gabriel, F-21000 Dijon, France*

Some attached marine molluscs rarely reflect the positive form of the substrate (xenomorphic sculpture) on the right (free) valve whereas the left one preserves the (negative) imprint of the substrate morphology. This phenomenon, called xenomorphism or previously designated as 'pseudomorphose' or 'mimetism', is observed more frequently in ostreids. Two xenomorph ostreids have been found in argillaceous limestones of the middle Oxfordian in the Dijon area (France). The attachment surfaces of both ostreids have preserved the imprint of an ammonite conch (*Perisphinctes* sp*)* while the right (upper, free) valve reflects perfectly its positive form. Any ammonite conch has been found in the same bed as the oysters, probably due to dissolution of the conch during diagenesis.

Image analysis indicates that the positive replica of the ammonite on the free ostreid valve is very accurate and preserves the most delicate morphological features. The ammonite conch is reflected by the young part of the free right valve. According to some authors, this could be explained by folding of the right mantle-edge parallel to the left one, both being influenced by the relief of the substrate, according to which the valves are secreted. Xenomorphism can be due to biological mechanisms, ecological factors or both.

Biodiversity *vs* Preservation: example of a trilobite association (Middle Ordovician, Massif Armoricain, France)

Philippe Courville [1], Catherine Crônier[2], Laurent Dubois[2] and Luc Miclot[3]
[1]*Université de Rennes 1, Bât. 15, Géosciences Rennes, UMR 6118 du CNRS, 35042 Rennes Cedex, France* <philippe.courville@univ-rennes1.fr>
[2]*USTL, Sciences de la Terre, SN5, Laboratoire de Paléontologie et Paleogéographie du Paléozoïque, UMR 8014 du CNRS, 59655 Villeneuve d'Ascq Cedex, France* <catherine.cronier@univ-lille1.fr>
[3]*218, rue Clos Pinard, 50110 Tourlaville, France*

Middle Ordovician (Darriwilian = 'Llandeilo *Auct.*' *pars.*) outcrops were recently discovered in the Massif Armoricain (Manche, western France). The clay 'Formation d'Urville' yields numerous well-preserved macrofossils, mainly trilobites: Illaenidae (*Illaenus giganteus*, *Cekovia perplexa*), Calymenidae (*Salterocoryphe salteri*, *Neseuretus tristani*, *Colpocoryphe rouaulti*), Homalonotidae (*Kerfornella brevicaudata*), Dalmanitidae (*Dalmanitina actua*, *D. philippoti*, *D. bossei*, *Eodalmanitina chillonensis*, *E. henryi*, *E. destombesi*, *E. macrophthalma*, *Crozonaspis morenensis*, *C. rouaulti*), Asaphidae (*Isabelinia* sp.), Cheiruridae (*Eccoptochile* sp.), Lichidae (*Uralichas* sp.), Odontopleuridae (*Selenopeltis* sp.), *etc*. Poorly known or even unknown larval stages were collected for most species.

The high diversity may partly be the result of faunal-mixing, in a calm, deep/distal depositional environment (clay deposit). Whole individuals or moults of Dalmanitidae and Illaenidae, with abundant larvas, are considered as the autochtonous trilobite association. Opposite, *Neseuretus* may characterize shallower, proximal environments: good individuals, moults or larvas are generally rarer, except for destroyed pieces of cranidia or isolated segments.

In fact, two kinds of preservation coexist: 1, generally well-preserved autochtonous elements, inside sediment. Allochtonous forms are rare in such a condition, and may profit by currents to arrive regularly. 2, Storm-controlled, rhythmic surface-accumulations of debris (mainly *Neseuretus*), related to the destruction of exotic, proximal communities.

Brachiopods and chips

Maggie Cusack[1] and John Craven[2]
[1]*Centre for Geosciences, Division of Earth Sciences, University of Glasgow* <M.Cusack@earthsci.gla.ac.uk>
[2]*School of Geosciences, Department of Geology and Geophysics, University of Edinburgh* <jcraven@staffmail.ed.ac.uk>

The juvenile shell of Discinoid brachiopods is mineralised by a single layered mosaic of siliceous tablets prior to the formation of the apatite shell. The rhombic tablets have a mean length, width and thickness of 1.3 µm, 0.7 µm and 100 nm respectively. The mosaic is bounded by a tablet-free ring of lamellae, separating it from the mature shell. The siliceous tablets are produced intracellularly within a vesicle and extruded onto the surface. Rhombic siliceous tablets and their imprints occur in extant *Discinisca*, *Discina* and *Pelagodiscus*. Imprints of siliceous tablets have also been found on juvenile shells of the late Devonian *Schizobolus* and the late Silurian *Opatrilkiella*.

The function of the siliceous tablets is unknown and very little is known about the formation of the tablets. Silicon isotope measurements have been used to determine the extent to which marine invertebrates fractionate silicon from seawater, shedding light on the much neglected silicon cycle in modern and ancient oceans. Preliminary silicon isotope measurements of the silicon chips of *Discinisca tenuis* suggest that brachiopods fractionate silicon to a lesser extent than do diatoms and siliceous sponges.

The ctenocystoids seen as stem-group hemichordates (not echinoderms) and their position within the deuterostomes

Patricio Dominguez[1] and Richard Jefferies[2]
[1]*Universidad Complutense de Madrid, Ciudad Universitaria, Madrid, Spain* <patricio@geo.ucm.esemail1@email.ac.uk>
[2]*The Natural History Museum, Cromwell Road, London, SW7 5BD* <r.jefferies@nhm.ac.uk>

Molecular methods show that the cladogram for the deuterostomes is: ((echinoderms + hemichordates) chordates).

The ctenocystoids (Cambrian – Ordovician) have a skeleton of monocrystalline calcite plates. Such a skeleton is diagnostic of echinoderms in the extant fauna, but not among fossils, since many Palaeozoic fossils with such a skeleton are not echinoderms but chordates. The cladogram therefore implies that the latest common ancestor of the deuterostomes would also have had a calcite skeleton and is therefore diagnostic, not of echinoderms, but of deuterostomes. For deciding the systematic position of a fossil within the deuterostomes, a calcite skeleton is irrelevant.

The ctenocystoids are probably hemichordates. This is suggested, in the first place, by their almost perfect bilateral symmetry and the presence of a posterior opening, probably a combined gill slit and anus, giving a general resemblance to an enteropneust hemichordate. Of particular interest is a still unpublished cylindrical ctenocystoid covered by a "fleece" of thin recurved spines. By annelid comparisons, these spines imply fossoriality, as in extant enteropneust hemichordates. If hemichordates, the ctenocystoids belong to the stem group, not to the crown group of the phylum, since they lack two important features (absence of calcite skeleton, presence of muscular protosome) which the latest common ancestor of extant hemichordates would have possessed.

In this light, we shall briefly discuss the systematic position of the other carpoid groups.

Lower Cretaceous swimming theropod trackway from La Virgen del Campo (La Rioja, Spain)

Rubén Ezquerra[1], Loïc Costeur[2], Peter M. Galton[3], Stefan Doublet[4] and Félix Pérez-Lorente[5]

[1]*Fundación Patrimonio Paleontológico de Enciso, calle Portillo, 3, E-26586 Enciso, La Rioja, España* <Ezquerrar@yahoo.fr>

[2]*UMR CNRS 5125, Université Claude Bernard Lyon 1, Bâtiment GEODE, 2 rue Dubois, 69622 Villeurbanne Cedex, France* <loic.costeur@univ-lyon1.fr>

[3]*College of Naturopathic Medicine, University of Bridgeport, Bridgeport, Connecticut, 06601 USA* <pgalton@juno.com>

[4]*UMR CNRS 5561, Biogéosciences, Centre des Sciences de la Terre, 6 boulevard Gabriel, 21000 Dijon, France* <stefan.doublet@u-bourgogne.fr>

[5]*Universidad de La Rioja, Edificio CT. Madre de Dios, 53, E-26006 Logroño, La Rioja, España* <felix.perez@dq.unirioja.es>

A major question concerning the behaviour of dinosaurs is whether or not they were able to swim. The Lower Cretaceous locality «La Virgen del Campo» (La Rioja, Spain) has yielded a new trackway that was made under water. The 15 m trackway consists of a series of 12 consecutive ichnites, each of which is a set of two or three long and slender well-impressed grooves. They are interpreted as being the result of scratches made on the sediment by the distal parts (claws or toe-tips) of digits II and III or II, III and IV. The long wispy sinuous scratching form of the footprints, and the variation in their length, clearly indicate their under water formation and thus the swimming ability of the trackmaker. The presence of NE–SW oriented ripple marks and the very marked S-shape of the right footprints points to the presence of a current at a 45 degree angle to the animal's direction. The peculiar form and digit marks associations (2 or 3) of the fooprints as well as the type of locomotion inferred from the tracks reveal that the trackmaker probably was a bipedal carnivorous dinosaur. This is the first definitive evidence for active swimming in a theropod dinosaur.

New insight into Palaeozoic charophytes using high-resolution X-ray Synchrotron microtomography

Monique Feist[1], Junying Liu[2] and Paul Tafforeau[3]

[1]*Institut des Sciences de l'Evolution, Université Montpellier II, place Bataillon, 34095 Montpellier, France* <mofeist@isem.univ-montp2.fr>

[2]*Institute of Geology, Academy of Geological Sciences, 26 Baiwanzhuang Road, 100037 Beijing, China* [3]*European Synchrotron Radiation Facility, 6 rue J. Horowitz, BP 220, 38043 Grenoble, France*

Recent findings on the nature of the fructification in Palaeozoic forms bring a new understanding of the early stages of charophyte evolution. Examination of Palaeozoic charophyte fructifications, using resources of high-resolution X-ray Synchrotron microtomography and microscopy, has revealed that most of them are provided with a utricle constituting a supplementary calcified cover around the gyrogonite. According to this new evidence, we assign all taxa with utricles to the Sycidiales. Indeed, they exhibit common features, such as a multilayered wall and an internal vesicle, but the different families can be distinguished by the diversity in orientation of external cells, complexity of the utricle wall and in the presence or absence of antheridia. The solidly packed structure of the utricle is regarded as an organ of protection of the zygote against dessication. We interpret the morphological similarities between Palaeozoic Sycidiales and Mesozoic Clavatoraceae, which both possess a utricle, as homoplasous rather than the expression of a true phylogenetic relationship. Our findings suggest that some Umbellids might correspond to utricles of charophytes.

Different modes of spine development in the pygidium of Devonian scutelluine trilobites

Raimund Feist

Institut des Sciences de l'Evolution, Université Montpellier II, 34095 Montpellier, France <rfeist@isem.univ-montp2.fr>

Styginid trilobites are characterized by their large pygidium with an entire margin. This general configuration is modified in specialized Early and Middle Devonian scutelluines where evolutionary trends towards spine development on the pygidial margins occur. Besides denticles and short spines, which are apparently unrelated to pleural segmentation, there are cases where segmental spines extend beyond the margin of the pygidium. Such modifications of the pygidium follow three different modes:

Thysanopeltella mode: size and shape remain unchanged, except that pleurae continue into free segmental spines.

Weberopeltis mode: overall size is maintained, but shape changes result from regression of interpleural fields leaving the pleural ribs as free spines.

Kolihapeltis mode: both size and shape are modified by lateral compression resulting in complete obsolescence of pleural fields.

Whereas in the first two modes spine development may occur iteratively, in the *Kolihapeltis* mode there is evidence of gradual evolution within a single lineage. New investigations of all forms with the *Kolihapeltis* mode shows shared characteristic traits of cephalic and thoracic sclerites. The acquisition of extremely reduced adaxial pleural fields in the thorax, along with the compressed pygidial configuration that differs from all other styginids, may be an adaptation to a mesopelagic life-style.

The ancestory of the Echiura. Early soft bodied preservation from the Cambrian of the Welsh Basin

William Fone

Staffordshire University, UK, ST18 0DG <W.Fone@Staffs.ac.uk>

The phylogenic positioning of the Echiura, Sedwick 1898, has been disputed many times. Members of this phylum share many homologus characters with Annelida. The argument for maintaining them within a phylum rests upon the lack of segmentation within the body cavity or other structures. Studies of the development of the nervous system of the extant *Bonellia viridis* suggest it is descended from a segmented ancestor (Hessing & Westheide, 2002, *J. Morphology*. **252**(**2**)). A fossil Echiuria recovered from the Welsh basin, near Harlech, is remarkably well preserved in three dimensions and demonstrates the presence of segmentation towards the anterior end. The existence of this fossil supports the proposal by Hessing & Westheide that the Echiuria should be included within the Annelida and also illustrates the presence of a lagerstätte of remarkable 3D softbody preservation.

Rates of fish evolution during the breakup of Pangaea

Peter Forey[1] and Lionel Cavin[2]
[1] *Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD, England* <plf@nhm.ac.uk>
[2] *Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD, England* <L.Cavin@nhm.ac.uk>

The rise of halecomorph and teleost fishes was co-incident with the breakup of Pangaea. During this time continents and seas became increasingly provincialised and the fishes responded, marine and freshwater alike. There were discernable and consistent patterns in the rates of morphological evolution of different fish groups, most of which showed intial bursts contemporaneous with the major continental reorganisations followed by decline in successive time bands. However, the nature of the changes was very different for different groups.

The Bjørkåsholmen Formation (Tremadoc): a homogenous distribution of trilobites throughout the Baltoscandian platform

Asa Frisk
Department of Earth Sciences, Palaeobiology, Uppsala University, Norbyvägen 22, SE-752 36 Uppsala, Sweden <asa.frisk@geo.uu.se>

The Lower Ordovician succession of Baltoscandia is initiated by extensive carbonate deposition forming the Tremadoc Bjørkåsholmen Formation, formerly the Ceratopyge Limestone, a distinctive unit corresponding to the trilobite zone of *Apatokephalus serratus*. The limestone succession has a broad regional distribution and its associated sediments were deposited across the Baltoscandian platform in a shallow water epicontinental sea. Similar depositional conditions are not known today. The unit is remarkable in its near homogenous facies, lithologic and faunal composition throughout the platform. This is clearly demonstrated in the present study, where sequences at Ottenby and Degerhamn on southern Öland, Sweden, were logged and compared for trilobite biostratigraphy. In both investigated localities the resulting trilobite abundance distributions are very consistent. The trilobite fauna from the Bjørkåsholmen Formation in the Oslo Region, Norway, and Öland are composed of the same typical Ceratopyge assemblage. Trilobite abundance data from both areas are nearly identical and demonstrate an upward declination of trilobite specimens. Comparison across the Baltoscandian platform between the westernmost occurrences in the Oslo Region and the easternmost outcrops on Öland therefore suggests widespread stable conditions of the Ceratopyge fauna during the sedimentation of the Bjørkåsholmen Formation.

Using Geometric Morphometics to Examine Lipotyphlan Relationships

Stefan N. Gabriel and P. David Polly
School of Biological Sciences, Queen Mary, University of London, Mile End Road, London E1 4NS, UK <s.n.gabriel@qmul.ac.uk>, <d.polly@qmul.ac.uk>

Morphologcial phylogenies coded with discrete characters reconstruct the 'Lipotyphla' as a monophyletic group. In constrast, molecular analyses divide the group into two—a rump Eulipotyphla, and the Tenrecoidea which are nested in Afrotheria. We have looked at this problem from a third perspective by using the continuous quantitative characters in a geometric morphometric analysis.

A dataset of 19 cranial landmarks on members of all extant 'lipotyphlan' families, plus the fossil taxa *Apternodus*, *Oligoryctes* and *Nesophontes*, had been previously collected in order to study functional relationships. A series of Maximum-Likelihood trees were constructed from these data. These consisted of an unrooted tree; trees rooted with erinaceids in order to reflect traditional morphological hypotheses of relationships; trees rooted with tenrecoids in order to reflect molecular hypotheses of relationships; and a tree rooted with the non-'lipotyphlan' taxon *Didelphis*.

The analysis failed to recover either the morphological or molecular hypotheses of relationships. Nevertheless, there was greater resolution at lower taxonomic levels. The Soricidae was recovered as a monophyletic group and the tenrecines Tenrec and Setifer grouped as sister taxa, although the other tenrecid in the analysis, Oryzorictes, grouped with the mole Talpa instead. This suggests that the strongest phylogenetic signal in the data was roughly at the level of families, but that only weak hierarchical structure existed for higher level groupings.

The evolution of the post-Palaeozoic Neoasteroidea

Andy Gale
University of Greenwich, Chatham ME4 4AW <ga14@gre.ac.uk>

The evolutionary relationships, and therefore the classification, of the monoplyletic post-Palaeozoic Neoasteroidea have been controversial, and recent molecular phylogenies have all provided highly divergent results. A morphological investigation of the skeletons of examples from 25 extant asteroid families, using progressive denudation of soft tissues and SEM imaging of 15 ossicle types, provides information for a new character set. Cladistic analysis of this database, using two Carboniferous and Permian outgroups, generated a single most parsimonious tree with an unexpected topology, implying that two of the widely recognised ordinal level neoasteroid groups are paraphyletic. This analysis supports the basal position of the Order Paxillosida, and the highly derived condition of the Forcipulatida (like the modern Asterias). Fossil taxa from the Jurassic and Cretaceous provide evidence of the evolutionary origins of many modern families, illustrated by the ancestry of the deep sea Pterasteridae. An entirely new classification of the Neoasteroidea is proposed. The new phylogeny has important implications for the origins of deep sea and tropical shallow marine asteroid families in particular.

New Early to Mid Ordovician trilobite faunas of Iran and their biogeographical significance

Mansoureh Ghobadi Pour
Department of Geology, University of Esfahan, Esfahan 81746, Iran
<m_ghobadipour@yahoo.com>

New, biogeographically important trilobite faunas have been discovered recently in two Lower to Middle Ordovician sections in Iran. The outer shelf Tremadoc to early Arenig trilobite assemblages of the Eastern Alborz are dominated by cosmopolitan or pan-Gondwanan genera, such as *Geragnostus*, *Asaphellus*, *Apatokephalus* and *Conophrys*, but also contain *Asaphopsis*, *Dactylocephalus* and *Psilocephalina* which suggest affinity to the faunas of South China. *Taihungshania* appears in the Eastern Alborz at about the same time as in Armorica and in the Turkish Taurides. The Tremadoc to Lower Arenig fauna from the Derenjal Mountains, Central Iran is of low diversity and includes such cosmopolitan taxa as *Shumardia* and *Proteuloma*. The upper Arenig to lower Llanvirn trilobite assemblage contains *Paraonychopyge*, *Nileus*, *Parabasilicus* and *Illaenus*. The youngest trilobite assemblage from the Derenjal Mountains is dated as upper Llanvirn to Early Caradoc. It contains *Neseuretinus*, *Ovalocephalus*, *Birmanites* and *Liomegalaspides*, as well as asaphids, cheirurids, lichids and trinucleids. It shows a close similarity to the contemporaneous trilobite faunas of Sibumasu, South China and South Uzbekistan. This study suggests that the Alborz was probably a separate microplate, situated between South China and the Turkish Taurides during the Early Ordovician. The palaeogeographical position of the Central Iranian plate is less certain, and it may have been a part of Gondwana at that time.

Exceptionally preserved Upper Silurian echinoderms from submarine channel deposits, Welsh Borderland

David J. Gladwell
Department of Geology, University of Leicester, UK <djg15@le.ac.uk>

The Upper Silurian submarine channel deposits at Leintwardine in the Welsh Borderland provide a unique palaeoenvironmental setting and contain a diverse range of predominantly fully articulated echinoderms, namely starfish, crinoids, echinoids and ophiocistioids, within so-called starfish beds. Some specimens are semi-articulated, for example starfish may have disarticulated arm portions, and the crinoids do not retain their distal holdfast structures. The starfish are the most abundant group and are ophiuroid-dominated. Crinoids are less common, whilst the echinoids and ophiocistioids are rarer still. Various biostratinomic and palaeoecological criteria are used to assess whether the biota was indigenous to the channels, as in some Recent submarine canyon settings. Echinoderm thanatocoenoses are generally not preserved and transportation is variable both between and within species. The echinoderms are interpreted to have been predominantly parautochthonous to allochthonous and may have been indigenous to the channel area including the immediately surrounding shelf. The relatively unbioturbated nature of the enclosing sediment may suggest that the channel facies was oxygen-restricted; complete bottom-water anoxia is unlikely, as rare surface bioturbation has been documented. The other major faunal groups of the channels, namely the arthropods and brachiopods, are also likely to have undergone transportation.

Unique microbiota from the Early Neoproterozoic of Yakutia (Eastern Siberia)

Elena Golubkova and Elena Raevskaya
Institute of Precambrian Geology and Geochronology RAN, Makarova embankment, 2, Saint-Petersburg, 199034, Russia

In the early 1980s a diverse and well preserved microphytofossil assemblage was discovered in a series of boreholes that crossed Precambrian strata in the Nepa-Botuoba anticlise (Yakutia), eastern Siberia. This assemblage was characterized by a high number of various acanthomorh acritarchs which were interpreted as being distinctive for the Early Cambrian (Rudavskaya, 1985, 1989). However, on the basis of subsequent taxonomical studies and of similarities with Australian microfossils from the Ediacaran Pertatataka Formation a Neoproterozoic (Vendian) age was suggested for the eastern Siberian assemblage (Moczydlowska *et al*. 1993).

In the present work the material from the Parshino Formation of the Nepa Horizon of Yakutia (boreholes Ozernaya-761, Zapadnaya-742 and Talakanskaya-841) has been reinvestigated, and a complete description of the exceptionally preserved Neoproterozoic microbiota is provided. The material includes distinctive taxa, such as *Ericiasphaera spjeldaesii* Vidal, *E. magna* (Zang) Zang *et al*., *Meghystrichosphaeridium densum* (Kolosova) Zang *et al*., *M. magnificum* Zang *et al*., *M. perfectum* (Kolosova) Zang *et al*., *'Tanarium' acuminatum* Kolosova, *'T.' conoideum* Kolosova, *'T.' tuberozum* Moczhydlowska *et al*., *Talakania obscura* Kolosova, *Obruchevella* sp., *Polytrichoides lineatus* Herman and others, which are common in the assemblages from the Chinese Doushantuo Formation and the Australian Pertatataka Formation. Numerous vase-, ring-, dumb-bell shaped problematical forms and multicellular algae also occur in the investigated microbiota. Its stratigraphical position can be correlated precisely in the Early Neoproterozoic.

Role of palaeo-environment in ammonite distribution: a Late Cretaceous example from Tunisia

Stijn Goolaerts[1], Christian Dupuis[2] and Etienne Steurbaut[3]
[1]*Departement Geologie Geografie KULeuven, Belgium* <stijn.goolaerts@geo.kuleuven.ac.be>
[2]*Faculté Polytechnique Mons, Belgium* <christian.dupuis@fpms.ac.be>
[3]*Royal Belgian Institute for Natural Sciences (KBIN-IRSNB), Belgium*
<etienne.steurbaut@natuurwetenschappen.be>

Tunisia yields many interesting Upper Cretaceous sections, including the GSSP for the K/P boundary at El Kef. In three areas, large quantities (>100 for each area) of ammonite specimens were collected from the Upper Maastrichtian part of the El Haria Formation. All three areas are situated in the same sedimentary basin, but in different palaeo-environmental settings, which allows us to investigate the role of the palaeo-environment (especially depth) in the distribution of the different suborders, families, genera and species.

In all three areas, the ammonite fauna is dominated by the Scaphitidae Gill genus *Indoscaphites* Forbes (Ancyloceratina Wiedmann). This dominance ranges from 45–75% over the three areas. Other Ancyloceratina Wiedmann like the Diplomoceratidae Spath compose up to 18.5%, the Desmocerataceae Zittel (Ammonitina Hyatt) up to 29%, and the Tetragonitaceae Hyatt up to 6% of the fauna. Phylloceratina Arkell are extremely rare (>1%).

Distinct abundance shifts of the different suborders, families, genera and species could be linked to the palaeo-environmental differences (depths) for the three areas. Scaphitidae appear to prefer a shallower habitat than Desmocerataceae and Tetragonitiaceae, providing an example of depth control in the distribution of Late Cretaceous ammonite species.

A new approach to studying microevolution in the fossil record

Bjarte Hannisdal
Department of the Geophysical Sciences, The University of Chicago 5734 S. Ellis Ave., Chicago, IL 60637, USA <bhannis@geosci.uchicago.edu>

We cannot measure microevolutionary rates or patterns directly in the fossil record, we can only measure morphological features on fossils preserved in stratigraphic sections (stratophenetic series). Analysis and interpretation of stratophenetic data depend on assumptions about the fossil organism and about the geological deposits yielding the fossils. Inference of evolutionary tempo and mode from fossil data thus depends on an underlying model, and the analysis of stratophenetic data is necessarily an inverse problem: given observed data, our knowledge of basin-fill and fossils, and a model mapping evolutionary to stratophenetic patterns, what is the most plausible evolutionary model supported by the available data? This involves a fundamental two-level problem: how do we fit unknown quantities to the data, and how many unknowns should we fit? Although theoretically analogous, the latter is more complicated in practice. In both cases, however, we seek quantitative measures of non-uniqueness, that is how much the model may vary while fitting the data. Here, I present a method that is designed to let the geological and palaeontological data justify our choice of evolutionary model and to quantify the associated uncertainty. Rather than a single 'best-fit' solution, a large number of solutions forms the basis for inference.

Diversity fluctuations in the Cenozoic brachiopod faunas of the greater Caribbean region

David A. T. Harper[1] and Roger W. Portell[2]
[1]Geological Museum, University of Copenhagen, ster Voldgade 5–7, DK-1350 Copenhagen K, Denmark <dharper@savik.geomus.ku.dk>
[2] Invertebrate Paleontology Division, Florida Museum of Natural History, PO Box 117800, University of Florida, Gainesville, Florida 32611-7800, USA <portell@flmnh.ufl.edu>

A compilation of new and existing brachiopod data from the Caribbean islands of Antigua, Barbados, Carriacou, Cuba, Curacao, Dominican Republic, Haiti, Jamaica, Puerto Rico, St. Bartholomew and Trinidad together with Costa Rica, Panama, Venezuela and SE USA has established some clear biotic patterns within the Cenozoic rocks of the Caribbean basin. The data for some 80 rhynchonelliformean species are of variable quantity and quality, nevertheless diversity apparently peaked during the Eocene and to a lesser extent during the Miocene; both events were dominated by terebratelloid and terebratulloid species. These diversity peaks are coincident with marked facies variations, particularly in deeper-water environments, across the basin and optimal climatic conditions. The more monotonous lithologies of the Oligocene have yielded few brachiopod taxa. Following a significant drop in diversity during the cooler climates of the late Miocene, diversity remained low during the Pliocene and Pleistocene. Throughout the Cenozoic cemented forms (thecideids) maintained a low but consistent background diversity at a range of depths; fluctuations are most marked amongst the larger pedunculate taxa.

Metazoan buildups on the Early Mid-Ordovician carbonate platform in NE Greenland: radiation of stromatoporoid mounds and substrates

David A. T. Harper[1], Svend Stouge[1] and Jorgen L. Christiansen[2]
[1]Geological Museum, University of Copenhagen, Oster Voldgade 5–7, DK-1350 Copenhagen K, Denmark <dharper@savik.geomus.ku.dk>, <svends@savik.geomus.ku.dk>
[2]Holbæk College of Education, Seminarieparken 2, DK-4300 Holb k, Denmark <jlc@holsem.dk>

The Albert Heim Bjerge region exposes the higher parts of the Ordovician succession of NE Greenland. The upper Cape Weber, Narwhale Sound and Heim Bjerge formations range in age from late Arenig to Lanvirn (Whiterock) and display a wide range of nearshore to midshelf carbonate environments with a locally abundant macrofauna of low diversity: cephalopods and gastropods are common at a few levels but the more typical members of the Paleozoic Evolutionary fauna, the brachiopods and trilobites, are rare, restricted mainly to deeper-water facies. Marked, however, is the sudden dominance of stromatoporoids in the inshore environments of the upper Cape Weber Formation, in contrast to the spectacular microbial mounds in the lower part of the succession. Within this early Whiterock interval a variety of growth strategies are developed, including both domical and laminar forms. This early stromatoporoid diversification provided a new carbonate factory, a variety of different substrates and a new and hitherto unfamiliar seascape during the early stages of the Ordovician radiation in NE Greenland.

Using Carboniferous palynomorphs to monitor temporal changes in vegetation

Kay Hawkins, Sarah J. Davies and Gary L. Mullins
Department of Geology, University of Leicester, Leicester LE1 7RH, UK
<kh62@leicester.ac.uk>, <sjd27@leicester.ac.uk>, <glm2@leicester.ac.uk>

A detailed palynological and sedimentological analysis has been undertaken through an 11m thick succession of fine-grained sediments from the Marsdenian Stage, Upper Carboniferous, exposed at Pule Hill, near Marsden, Lancashire, UK (Ordnance Survey grid reference: SE 0320 1000). This well-exposed section of predominantly marine sediments deposited in the Pennine Basin contains two, possibly three, 'marine bands': strata deposited during periods of sea level rise that contain a distinctive fossil assemblage important in local and regional correlation. Forty-seven samples were collected for palynological analysis and the occurrence of the marine macrofauna (goniatites and bivalves) was also noted. The distribution and abundance of the spores, pollen and marine microphytoplankton (possibly reworked) have been documented and the terrestrial palynomorphs have been assigned to their palaeobotanical and palaeoecological groupings. Statistical analyses will be carried out on these data to establish any significant trends within the section. The results of this research will be placed within a wider context through comparison with previous studies on similarly aged, near-shore, deltaic sediments that have yielded significant, systematic changes in the terrestrial palynomorph assemblages related to sea level fluctuation.

The Dennis Curry Collection at the Natural History Museum, London

Caroline A. Hensley
Department of Palaeontology, The Natural History Museum, Cromwell Road,
London SW7 5BD <C.Hensley@nhm.ac.uk>

Dennis Curry was a highly successful businessman becoming Chairman of the family business, Currys, in 1967. He was also a distinguished geologist, making his name in diverse fields and publishing widely. He won many medals and awards for his science and was appointed Visiting Professor of Marine Geology at University College, London, in 1971.

The Natural History Museum, London, first acquired some of Curry's material in 1961, with the majority of his collection arriving between 1998 and 2001. The collection is large (a conservative estimate of the number of molluscs alone stands at 90,000 specimens), and represents sixty years of prolific collecting. The majority of the collection falls into three categories: Mollusca, micropalaeontological, and sieved residues. Curry was a pioneer in sieving his samples and collecting the "total mollusc fauna" including the small species. There are also other macrofossils, including a small amount of vertebrate material. The collection comes mainly from south east England and the Paris Basin, but includes material from numerous other European countries and the rest of the world. The majority is of Palaeogene and Neogene age, and there are also a number of Chalk samples.

The size of the collection means that curatorial work is currently ongoing. This paper will serve as a snapshot into the scientific value and potential of a unique collection.

The ancestry of modern Priapulidae traced back to the Early Cambrian: new fossil evidence from China

Diying Huang[1, 2], Jean Vannier[2] and Junyuan Chen[1]
[1]*Nanjing Institute of Geology and Paleaontology, Chinese Academia of Sciences Nanjing,*
210008 <huangdiying@sina.com>, <chenjunyuan@163.com>
[2]*Université Claude Bernard Lyon 1, UFR Sciences de la Terre, UMR 5125 PEPS,*
Paléoenvironnements & Paléobiosphère, Bâtiment Géode, 2, rue Raphaël Dubois,
69622 Villeurbanne, France <jean.vannier@univ-lyon1.fr>

The small ecdysozoan phylum Priapulida consists of only 18 described living species in present-day marine environments. The family Priapulidae accommodates six living species distributed in three genera (*Priapulus*, *Acanthopriapulus*, *Priapulopsis*). Eleven species of conclusive priapulid worms are described from the Lower Cambrian Maotianshan Shale and reveal the high diversity of the group in the early stages of its evolutionary history. At least five species from the Maotianshan Shale are recognized as possible representatives of the extant family Priapulidae. They possess most of the diagnostic features of modern priapulids.

1, *Xiaoheiqingella*: Swollen introvert covered with 25 longitudinal scalid rows anteriorly, a circle of circumoral scalids present; neck as a contraction; annulated trunk evenly wide, without subdivisions; a caudal appendage rather thin and elongate.

2, *Yunnanpriapulus*: Swollen introvert covered with 25 longitudinal scalid rows anteriorly and with scattered scalids further back, a circle of circumoral scalids present; neck area relatively well defined; trunk divided into an anterior annulated section and a posterior swollen section armed with ring-papillae; a caudal appendage very short.

3, Double tailed "*Xiaoheiqingella*": Swollen introvert covered with 25 longitudinal scalid rows anteriorly and with small scattered scalids further back; neck as a contraction; annulated trunk with its posterior section slightly swollen and armed with ring-papillae; a pair of broad and elongate caudal appendages with tapering shape.

4, *Paratubiluchus bicaudatus*: Swollen introvert covered with 25 longitudinal scalid rows anteriorly; neck area as a contraction probably; trunk rather smooth, with no subdivisions; a pair of relatively short caudal appendages with tapering shape.

5, A new type: Swollen introvert covered with 25 longitudinal scalid rows anteriorly and with larger scattered scalids further back, a circle of circumoral scalids present; neck as a contraction; trunk rather smooth with ring-papillae posteriorly; two caudal appendages thin and elongate.

This set of fossil evidence (five different forms) shows that the body plan of modern Priapulidae was already established in the Early Cambrian. These remarkable fossils also bring detailed evidence of morphological stasis over extremely long periods of time (more than half a billion years).

The paleokarst of Ohain Sandpit. A geological site to protect

Benoit Hubert[1] and Gilles Jakubeck[2]
[1]*Laboratoire de Paléontologie stratigraphique FLST & ISA, UMR 8014 & FR 1818 du CNRS,*
13 rue de Toul, F 59046-Lille, France <benhubert@free.fr>
[2] *Parc Naturel Régional de l'Avesnois, Maison du Parc, 4 cour de l'Abbaye BP 3 ,*
59550 Maroilles, France <Gilles.Jakubeck@parc-naturel-Avesnois.com>

The sandpit of Ohain is located in the north of France, Avesnois. This geological site belongs to the south-western part of synclinorium of Dinant; we can see it in two different parts, as follows. The bottom of the quarry is composed of Eifelian reef limestone and shale, with many builders: stromatoporoids, tabulate and rugose corals associated with crinoids and some brachiopods. The surface of this limestone has been weathered and hill shaded in palaeokarst. In the dip between the plurimetric high "dome" created by phenomenon of karstification are deposited Ypresian sandstone, of which exploitation finished in the 1980s. This geological feature, uncommon in France, is similar to the large karst massives that we can observe in South China, Guangxi Province around Guilin city along the Lijiang river.

Actually this geological site is threatened with the creation of a rubbish dump. The aim of this work is to try with different partners: municipality, nature protection organisations, university …, to include the palaeokarst of Ohain sandpit into the France geological patrimony.

Redescription of Ishijima's types of coralline algal species (Corallinales, Rhodophyta)

Yasufumi Iriu[1] and Davide Bassi[2]

[1]*Institute of Geology and Paleontolology, Graduate School of Science, Tohoku University, Aobayama, Sendai 980-8578 Japan* <iryu@dges.tohoku.ac.jp>

[2] *Dipart. delle Risorse Naturali e Culturali, University of Ferrara, Corso E. I d'Este 32, 44100 Ferrara, Italy* <bsd@unife.it>

The taxonomy of living species of coralline red algae (Corallinales, Rhodophyta) has undergone marked changes since 1960. The group is now treated as a separate order of Rhodophyta and it is considered to represent a major evolutionary line within the red algae. Concepts of families, subfamilies, genera, and species have changed as a result of extensive new information. These developments have significant implications for the taxonomy of fossil coralline red algae.

From 1935 to 1979 W. Ishijima published several papers on the taxonomy of fossil calcareous algae of diverse ages from the large geographic area including Japan, Philippines, Malaysia, and Indonesia. Among many other taxa, Ishijima described fourteen new species which he attributed to the Corallinaceae (Corallinales, Rhodophyta). The study of this collection highlights the importance of re-documentation of type material of fossil taxa defined decades ago with descriptions and illustrations focused on characters different from those considered diagnostic in modern taxonomy. Re-examination of the species types from a modern perspective of coralline algal taxonomy shows that all the species have been validly published. Among them, five species are confirmed to be valid, six species are assigned to different genera, one species is re-named, and two species are of uncertain circumscription within the Corallinaceae as their recognisable features do not warrant confidently delimiting the genera.

Taxonomy, biostratigraphy and ecostratigraphy of Ordovician (Arenigian) megistaspid trilobites from Western Russia

Kristian G. Jakobsen and Arne T. Nielsen

Geological Museum, University of Copenhagen, Denmark

<KGJ@savik.geomus.ku.dk>, <Arnet@savik.geomus.ku.dk>

Approximately seven thousand trilobites have been sampled bed-by-bed in the Putilovo quarry and Lynna River section east of St. Petersburg, Russia. Here the middle to upper Arenigian carbonate succession spans the upper part of the Billingen, Volkhov and most of the Kunda stages. The large trilobite material has been registered, facilitating a preliminary biofacies investigation and recognition of biozones. The aim of the present study is to undertake a taxonomic revision of the stratigraphically important megistaspid group, which is represented by several hundreds of specimens belonging to the subgenera *Megistaspis*, *Paramegistaspis*, *Rhinoferus* and *Megistaspidella*. The chronostratigraphic zonation of the Billingen and Volkhov stages of Scandinavia is based on the distribution of megistaspids, but the eastern Baltic faunas are rather different and provide only few ties for correlation across Baltoscandia. However, at local level a very detailed correlation can be based on megistaspids. Correlation between Putilovo quarry and the Lynna River section, located 70 kilometres further east, indicates that the latter section is thicker but stratigraphically less complete. An important faunal shift from dominance of *Rhinoferus* to dominance of *Megistaspidella* occurs in the upper part of the Volkhov Stage. The distribution of *Megistaspis* and *Paramegistaspis* indicates that the representatives of these taxa preferred somewhat deeper water environments by comparison with representatives of *Rhinoferus* and *Megistaspidella*.

Kangerlussuaq and the latest Cretaceous ammonite faunas of East Greenland

Simon R. A. Kelly[1], W. Jim Kennedy[2] and Andrew G. Whitham[1]

[1]*CASP, University of Cambridge, West Building, 181a Huntingdon Road, Cambridge CB3 0DH, UK* <simon.kelly@casp.cam.ac.uk>

[2]*Geological Collections, Oxford University Museum of Natural History, Oxford OX1 3PW, UK* <jim.kennedy@earth.ox.ac.uk>

Hitherto the latest described Cretaceous ammonite fauna from eastern Greenland was D.T. Donovan's Campanian *Scaphites greenlandicus* assemblage from Traill Ø and Geographical Society Ø. Further collections by CASP also show better preserved but slightly older Campanian with *Scaphites ikorfatensis* and *Pseudophyllites skoui*. However, in the Kangerlussuaq Basin, south Blosseville Kyst, the late Jake Hancock first indicated the presence of the Maastrichtian, by an unfigured record attributed to *Pachydiscus gollevillensis* which was collected by Jack Soper. New collections from the basin by CASP and GEUS (Geological Survey of Denmark and Greenland) demonstrate the presence of rich Maastrichtian ammonite faunas. Most abundant is the heteromorph *Diplomoceras cylindraceum*, which reaches over 600 mm length. Other taxa recognised include *Neophylloceras groenlandicum*, *Anagaudryceras politissimum*, *A.* cf. *lueneburgense*, *Saghalinites wrighti*, *Pachydiscus (Pachydiscus)* sp., *Baculites sp.*, *Acanthoscaphites tridens*, and *Hoploscaphites angmartussutensis*, many taxa similar to those described by Tove Birkelund from West Greenland. Dinoflagellate associations indicate the presence of both Early and Late Maastrichtian. The importance of these new collections is their use with other molluscs, palynology and micropalaeontology to provide a new detailed integrated Cretaceous biostratigraphy for eastern Greenland. CASP and GEUS are currently collaborating in preparing a detailed Kangerlussuaq Basin memoir, including lithostratigraphy and biostratigraphy. The Kangerlussuaq Basin together with the Traill Ø to Hold with Hope region are of major importance to the hydrocarbon exploration industry in the northern North Atlantic region, containing the only onshore exposures of Late Cretaceous sedimentary rocks.

A new systematic subdivision for the Class Palaeoscolecida Conway Morris and Robison, 1986

Petr Kraft[1] and Oliver Lehnert[2]

[1]*Charles University Prague, Institute of Geology and Palaeontology, Albertov 6, 128 43, Prague 2, Czech Republic*

[2]*Université des Sciences et Technologies de Lille (USTL), Paléontologie LP3 & UMR 8014, SN5, 59655 Villeneuve d'Ascq Cedex, France*

We try to provide some insights into the phylogeny of the Palaeoscolecida. A review of body fossils, isolated material and published information leads to a systematic subdivision based on a biological approach and allows us to recognize certain evolutionary steps. Palaeoscolecidan cuticle possessed up to three sclerite types which can be found isolated.

Our phylogenetic concept is based on the relationships of tubercles (plates) and platelets relative to their position to the epidermal layer. We distinguish four different families. Tubercles and platelets are regularly arranged in the family Palaeoscolecidae. Their sclerites were partly embedded within the epidermis, sitting at the outermost epidermal layer; only their upper central and sculptured part was uncovered. At the lateral-basal part of hadimopanellid tubercles "microwrinkles" display the cover of a soft-tissue. Utahphoshidae split off the Palaeoscolecidae and bear similar *Hadimopanella*-like plates, but the amalgamated tubercles form extended conical structures without platelets between the rounded tubercles. In the Verrucotuberculidae sclerite morphologies and irregular platelet arrangements relative to the plates are unique. Basal portions of plates and platelets were above the surface bearing the microplates which was covered by epithelial cells. The Plasmuscolecidae have only larger plates and microplates which were fully uncovered and arranged in two parallel rows per annullum.

Difficulty in identifying mass extinctions among tetrapods (Late Permian Early Jurassic)

Graeme T. Lloyd and Michael J. Benton[1]

[1]*Department of Earth Sciences, University of Bristol, Queens Road, Bristol BS8 1RJ*
<mike.benton@bristol.ac.uk>

The Late Permian to Early Jurassic transition is the most important in tetrapod history, and incorporates two or three posited extinctions; at the end-Permian, end-Carnian (possibly) and end-Triassic. However, because of small sample sizes, these events are hard to establish when the data are inspected closely. Two datasets, one of 814 genera and the other of 208 families, were compiled from the literature and each taxon assigned to categories of body size, diet, habitat and geographic range. Traditional metrics of diversity, extinction and origination failed to produce convincing evidence of mass extinction. However, where stage-crossing taxa alone were considered the two major events (end-Permian and end-Triassic) become more prominent (the postulated end-Carnian event could not be delineated). Chi-square tests compared survivorship and pre- and post-extinction faunas, although the former were plagued by low sample sizes. The most significant ecological changes are associated with the end-Permian event. Jablonski's model of alternating macroevolutionary regimes is weakly supported, but not contradicted. Similarly differences between extinction events seem to support their contingency.

Further analysis of the datasets included, 1) Pearson chi-square tests of variable independence, 2) measures of endemism using Jacquard's coefficient of similarity, and 3) comparisons between the two datasets. These results suggest that, 1) the selected 'characters' are mostly redundant due to significant levels of association, 2) faunas became more endemic throughout the Triassic (prior to Pangean breakup), and 3) neither genus- nor family-level data is the ideal taxonomic rank in tetrapod macroevolution. Although this study has mostly negative ramifications for future research a possibly rewarding line of enquiry is suggested.

Soft tissue preservation in Mesozoic gastropods: Image capture and 3D reconstruction

E. J. Lönnkvist[1] and M. J. Barker[2]

[1]*University of Portsmouth, School of Earth and Environmental Sciences, Burnaby Building, Burnaby Road, PO1 3QL* <eep20046@port.ac.uk>
[2]*University of Portsmouth, School of Earth and Environmental Sciences, Burnaby Building, Burnaby Road, PO1 3QL* <mike.barker@port.ac.uk>

Only rarely is molluscan soft tissue preserved during fossilisation. However, Jurassic–Cretaceous nerineoidean gastropods possess a complex internal morphology in which the body cavity is constricted by a series of folds of shelly material. The soft tissue comprises a number of lobes constrained and defined by the characteristic internal morphology. Post-mortem this internal morphology facilitated fine sediment ingress in association with soft tissue decay. The sediment enveloped and supported the ducts of the presumed digestive gland/gonad in the body during lithification and diagenesis. In axial section these duct systems are now preserved as distinctive calcite "dots" within the lobes of what was the labile soft tissue in the spire. In three dimensions, it comprises helically coiled calcite rods.

A selection of nerineoidean gastropods preserved in fine sediment (mostly peloidal micrites) were ground axially producing serial sections at 500µm intervals. These were then digitally photographed. Using 'Corel Draw 9.0' the calcite "dots" were selected according to their position in the lobes of the soft tissue and copied onto a blank image. Each resulting image was imported into 'Discreet 3D Studio Max 5.1' in the corresponding position of the original fossil. The "dots" acted as 3D coordinates which were connected in a helical fashion to make a 3D reconstruction of the duct systems in each specimen.

This method of data analysis has revealed that nerineoidean gastropods possessed at least five individual duct systems presumed to be the preserved duct systems of the digestive gland/gonad.

Oelandocaris oelandica, the possible earliest stem-lineage crustacean

Andreas Maas[1], Martin Stein[2] and Dieter Waloszek[1]

[1]*Section for Biosystematic Documentation, University of Ulm, Helmhotzstrasse 20, D-89081 Ulm, Germany*
<andreas.maas@biologie.uni-ulm.de>, <dieter.waloszek@biologie.uni-ulm.de>
[2]*Uppsala University, Department of Earth Sciences, Palaeobiology, Norbyvägen 22, S-75236 Uppsala, Sweden* <martin.stein@geo.uu.se>

Oelandocaris oelandica Müller, 1983 was originally described from a single limb-less fragment found in 'Orsten' limestones of Upper Cambrian age from the Isle of Öland, Sweden. It has been affiliated with the Crustacea on the basis of its general design, particularly the shallow head shield with a frontal rostrum but short lateral and no posterior extensions. Six additional specimens with preserved appendages discovered subsequently permit a detailed reconstruction of this approximately one millimetre long arthropod. The most significant features of *Oelandocaris* are: a shallow long hypostome with a pair of lobes anteriorly; a huge antennula subdivided into three long, spine-bearing outgrowths; two subsequent limbs differing from the series of posterior limbs in having segmented exopods. The three anterior appendages were likely involved in food gathering and intake, while the six posterior limbs may have served mainly for swimming. The hypostome with exposed mouth, lack of a labrum and lack of fine setulation in the mouth area suggest a position of *Oelandocaris* in the stem lineage of Crustacea. The characteristic proximal endite, one of the autapomorphies of Crustacea, is developed only in the third limb. *Oelandocaris* may, hence, be regarded as the earliest representative of stem-lineage crustaceans. The striking similarities to the anterior three appendages of the co-existing *Agnostus pisiformis* (Wahlenberg, 1818) raises again the question if the specialisation of these appendages characterize an early phase in the evolution of Crustacea, which would bring the agnostids closer to the crustaceans.

A new tool for the Gardener of Ediacara

Breandán Anraoi MacGabhann[1], John Murray[2] and Chris Nicholas[3]

[1]*University of Dublin, Trinity College, Dublin 2, Ireland* <macgabhhb@tcd.ie>

[2]*Department of Earth and Ocean Sciences, National University of Ireland, Galway* <john.murray@nuigalway.ie>

[3]*University of Dublin, Trinity College, Dublin 2, Ireland* <nicholyj@tcd.ie>

A major problem in the analysis of extinct non-skeletalised taxa is the lack of life-orientation and taphonomic data. Such information may be obtained through analogue modelling of scaled replicas. Here, a method is proposed for the construction of density compensated, liquid-filled, silicone rubber scale models of creatures which originally lacked true mineralised skeletons. This method was used to model a previously proposed reconstruction for *Ediacaria booleyi*, an enigmatic Cambrian discoidal fossil, of reputed Ediacaran affinity, from Co. Wexford. The reconstruction was modelled initially in self-hardening clay. Once hardened, both surfaces were then cast in clay, creating a two-part external mould, to which the fine ornament was added. A smaller clay insert was constructed, matching the profile of the external mould, so that the model could be created with a hollow interior. RTV 420 Silicone was then poured into each of the half-moulds and the inserts pushed into place. Once set, the silicone was peeled from the mould and the two counterparts joined with a strong adhesive. A particular strength to this approach lies in the fact that the density of the creature being modelled can be finely adjusted by filling the hollow interior with varying proportions of oil and water.

Preliminary comparative analysis of large and small European neogene mammals: two different diversity dynamics

Olivier Maridet, Loïc Costeur and Serge Legendre

UMR CNRS 5125, Université Claude Bernard Lyon 1, Bâtiment GEODE, 2 rue Dubois, 69622 Villeurbanne Cedex, France <loic.costeur@univ-lyon1.fr>

The mammalian fossil record is very rich for the European Neogene. A database of more than 1,600 localities that yielded large and small mammals has been built in order to understand better the evolution of mammals' biodiversity, biogeography and communities structure. Throughout the Neogene, important environmental and climatic fluctuations are documented but the link between them and the diverse changes recognized in the faunas stays unclear. The dynamics of extant large and small mammals' biodiversity exhibits different reactions to the various environmental constraints. Bearing this in mind, our preliminary palaeoecological approach compares the dynamics of Neogene large (ungulates) and small (rodents and lagomorphs) mammals' biodiversity at the regional scale. This spatial scale has proven to be ecologically relevant and enables a reliable estimation of the palaeobiodiversity thanks to the good fossil record available (*i.e.* several localities in each region).

The analyses undertaken involve for both groups of mammals:

- Basic diversity estimators (familial and species richness)
- Equitability measurements (species richness within families and Pielou's index)
- Palaeobiogeography computations (relationships between regions at the continental scale: Raup and Crick similarity index, 1979)

RAUP, D.M. and CRICK, R.E., 1979. Measurement of faunal similarity in paleontology. *Journal of Paleontology*, **53**, 1213–1227.

Unravelling fish swimming trails: a review of the ichnogenus *Undichna*

Nicholas J. Minter and Simon J. Braddy

Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK <N.J.Minter@bris.ac.uk>, <S.J.Braddy@bris.ac.uk>

Fish swimming trails, assigned to the ichnogenus *Undichna* currently comprise 13 ichnospecies, each consisting of various combinations of sinusoidal waves of differing complexity. Indeed, some of the more complex ichnospecies are made up of elements of the simpler forms. Such ichnospecies could therefore represent undertrails of the more complex forms. Potential taphoseries relationships (*i.e.* preservational variants that reflect, for example, undertrails) between the various ichnospecies are proposed, however, the naming of such simpler ichnospecies is valid if they represent a recurrent morphology. Suggested systematic revisions reduce the number of ichnospecies in *Undichna* to eight. *U. radnicensis*, a highly variable ichnospecies, is a synonym of *U. britannica*, based on material from China that demonstrates they can intergrade. *U. tricosta* and *U. prava* are based upon limited material. *U. tricosta* falls within the minimum diagnosis of *U. simplicitas*, whilst *U. prava* is a partial *U. tricosta;* both are regarded as subjective junior synonyms of *U. simplicitas*. *U. gosiutensis* is based upon a single specimen and is regarded as a junior subjective synonym of *U. quina*. *U. westerbergensis*, attributed to a crossopterygian fish and demonstrating that they used tetrapod-like gaits, is regarded as synonymous with Lunichnium rotterodium, which was originally erected for an amphibian swimming trackway.

Devonian stromatoporoids, tabulate corals and brachiopods from the Northeast Thailand

Bruno Mistiaen[1], Mikołaj K. Zapalski[1-2], Denise Brice[1], Henri Fontaine[3], Sirot Salyapongse[4] and V. Suteethorn[4]
[1]*Laboratoire de Paléontologie stratigraphique FLST & ISA, UMR 8014 & FR 1818 du CNRS, 13 rue de Toul F 59046 Lille Cedex, France*
<denise.brice@fls.fupl.asso.fr>, <bruno.mistiaen@fls.fupl.asso.fr>
[2]*Warsaw University, Faculty of Geology. Żwirki i Wigury 93, 02-089 Warszawa, Poland*
<m.zapalski@uw.edu.pl>
[3]*8 allée de la Chapelle, F92140 Clamart, France* <henri-fontaine@wanadoo.fr>
[4]*Department of Geological Resources, Ministry of Natural Resources, Rama VI Road, Bangkok 10400, Thailand*

In 1928 Bourret observed isolated Devonian deposits for the first time in Thailand. Devonian rocks are exposed both in Northeastern and Western Thailand, but only Northeastern Thailand outcrops provided rich fossiliferous limestone facies. Material collected by Fontaine, Salyapongse and others in several isolated localities is here investigated. In spite of bad preservation and dispersed outcrops, precise determination is sometimes questionable but the fauna appears to be highly diversified. Biostratigraphic consequences and some palaeobiogeographical affinities are attempted.

Stromatoporoids are numerous and well diversified. Dendroid forms are the most representative, with several species of *Amphipora*, *Stachyodes* and some *Vacuustroma*, a genus known until now only from the Devonian of Vietnam and France (Boulonnais). Other recognized genera are *Hermatostroma*, *Clathrocoilona*, *Salairella*, and probably also *Atelodictyon*, *Coenostroma* and *Hermatoporella*.

Tabulate corals are also numerous with predominance of branching forms. Preliminary study allowed recognition of genera *Favosites*, *Echyropora*, *Alveolites*, *Crassialveolites*, *Caliapora*, and various indetermined thamnoporids and auloporids.

Brachiopods belong probably to genera *Macropotamorhynchus* (rhynchonellid usually present in Lower Carboniferous), and Devonian *Desquamatia* (atrypid), *Athyris*, Meristelloides (athyrids), *Reticulariopsis* (spiriferid).

The stratigraphic range of the investigated fauna is estimated from the Middle Devonian (Givetian) up to locally the Lower Carboniferous.

The domination of dendroid stromatoporoids and branching tabulates indicate a rather calm depositional environment. However, some localities provided debris-like samples, which may indicate a slightly higher energetic environment than the previous one.

Some data on the Upper Devonian succession of the Shaogun quarries, North Guangdong, South China

Bruno Mistiaen[1], Denise Brice[1], Jean-Pierre Nicollin[1] and Hu Bin[2]
[1]*Laboratoire de Paléontologie stratigraphique FLST & ISA, UMR 8014 & FR 1818 du CNRS, 13 rue de Toul F59046 Lille Cedex, France* <denise.brice@fls.fupl.asso.fr>, <bruno.mistiaen@fls.fupl.asso.fr>, <jean-pierre.nicollin@fls.fupl.asso.fr>
[2]*Jiaozuo Institute of Technology. Jiaozuo 454000 Henan, P.R. China* <hub@jzit.edu.cn>

Devono-carboniferous limestones are exploited in quarries near Shaoguan (South China, North Guangdong). These quarries were visited during fieldwork, in August 2002. Some new observations are presented.

In this area, two formations, Shetianquiao and Xikuanshan Fm, are exposed.

The lower (Shetianquiao) formation consists of thick-bedded metric grey dark limestone, sometimes argillaceous and bioclastic, with thinner shale beds.

The upper (Xikuanshan) formation consists also of thick-bedded (0.5 – 2 m) limestone but grey-yellow, micritic and lithographic, with frequent laminations, some oncolitic and bioclastic beds. Fossil traces are frequent, indicating near shore or tidal environments.

Classically, the Frasnian–Famennain boundary is placed at the limit between the two formations, but in this section, this boundary is faulted.

The two formations are poorly fossiliferous but some bioclastic beds provided fossils. The Shetianquiao Fm. has yielded remains of brachiopods (atrypids), associated with rugose (Disphyllid) and tabulate (Syringoporids) corals presumed Frasnian in age. The Xikuanshan Fm. has yielded rare other brachiopods (*Cyrtospirifer* e.g. *brodi* and *Nayunella*) giving a Famennian age.

Near the top of the Shetianquiao Fm., a 0.65 m thick dark shaly bed constitutes a guide level. According to its situation, it could correspond to the Kellwasser event. Samples collected just below and above this level contain Amphiporids. Comparisons are proposed with the Xichun section in Guangxi.

The Ediacaran phytoplankton and cyanobacteria diversity – a recovery after the Snowball Earth glaciations

Malgorzata Moczydlowska
Uppsala University, Department of Earth Sciences, Palaeobiology, Norbyvägen 22, 752 36 Uppsala, Sweden <malgo.vidal@pal.uu.se>

Global radiations of phytoplankton (algal acritarchs) and benthic cyanobacteria are recognized in the Ediacaran Period, preceding the appearance of bilaterian metazoans. The Ediacaran large ornamented acritarchs are morphologically innovative and complex and are known from Australia, China and Siberia, showing a worldwide distribution in a relatively short time interval of *ca*. 20 Ma. The radiation of more than fifty species of acritarchs at *ca*. 570 Ma occurred while the Earth experienced severe climatic and environmental changes in the aftermath of the Snowball Earth glaciations and marine anoxia. The records of cyanobacteria are fragmentary and stratigraphically discontinuous, but the occurrence of certain diagnostic species pre- and post-dates the global glaciations. The Ediacaran diversification may be interpreted as a recovery of marine microbiota after a major extinction caused by the global glaciations. However, the evidence of some persisting taxa, both of planktonic acritarchs and benthic cyanobacteria, speaks against the radical version of the Snowball Earth hypothesis assuming that oceanic photosynthesis and bioproductivity in the ocean collapsed for millions of years because of the ice cover blocking out sunlight.

Late Frasnian Atrypida (Brachiopoda) from the Ardenne shelf (southern Belgium)

Bernard Mottequin
Département de Paléontologie, Institut royal des Sciences naturelles de Belgique,
rue Vautier, 29, 1000 Bruxelles, Belgium <Bernard.Mottequin@sciencesnaturelles.be>

In southern Belgium, the atrypid brachiopods were decimated well below the Frasnian–Famennian boundary (Upper Devonian). Within the Late Frasnian formations of the Ardenne shelf, the following genera and subgenera have been recognized: *Costatrypa, Desquamatia (Desquamatia), D. (Seratrypa?), Pseudoatrypa, Radiatrypa, Spinatrypa (Spinatrypa), Spinatrypina (Spinatrypina?), Spinatrypina (Exatrypa), Waiotrypa,* and *Iowatrypa*. Their representatives are particularly abundant in the reefal environments. Godefroid & Helsen (1998) noted that their extinctions were linked to diachronous regional facies changes. Indeed, their demise occurred first within the Lower *Palmatolepis rhenana* conodont Zone (top of the Neuville Formation) on the southern flank of the Dinant Synclinorium, and in the Upper *P. rhenana* Zone (top of the Les Valisettes Formation) in the case of the Philippeville Massif. In these areas, the last atrypids have been collected just below the dark limestone bed(s) marking the base of the essentially shaly Matagne Formation expressing hypoxic bottom conditions during sedimentation. Additional data from the northern border of the Dinant Synclinorium and from the Vesdre Nappe showed that the atrypids vanished within the Lambermont Formation (Upper *P. rhenana* Zone), below a level of dark shales formerly included in the Matagne Formation by some authors. In the famous Hony section (northern border of the Dinant Synclinorium), the last occurrence of atrypids is ±9 m below the first Famennian limestone bed of the Early *P. triangularis* Zone.

GODEFROID, J. & HELSEN, S., 1998. The last Frasnian Atrypida (Brachiopoda) in southern Belgium. *Acta Palaeontologica Polonica*, **43**, 241–272.

Biodiversity and paleogeography of Middle Jurassic ammonites (Upper Aalenian to Middle Bathonian)

Sébastien Moyne, Pascal Neige, Jacques Thierry and Didier Marchand
Centre des Sciences de la Terre & UMR CNRS 5561 Biogéosciences, Université de Bourgogne,
6 Bd Gabriel, 21000 Dijon, France <sebastien.moyne@u-bourgogne.fr>

The break up of the Pangea takes place in the Jurassic; the palaeoceanographic consequences are the opening of seaways, particularly at the place of the future Atlantic and Indian oceanic areas. Near the end of the Aalenian, the Ammonitina sub-order undergoes a strong faunal turnover. The last Hammatocerataceae, a well known and diversified Liassic superfamily, gives birth to three distinct superfamilies which will dominate among others till the end of the Jurassic: Stephanocerataceae, Perisphinctaceae and Haplocerataceae. The analysis of the worldwide corresponding radiation of these three major taxa puts in light differences and similarities between the biogeographic provinces usually recognised.

The counting of the species of each subfamily within the several palaeobiogeographic provinces emphasises faunal similarities in terms of total biodiversity between the several provinces. The North-Western Tethyan provinces share strong similarities between them and with the provinces of the South-West Tethyan margin. The Circum-Pacific provinces gather themselves, underlining their great faunal similarities.

The total time variation of the diversity is expressed by the counting of species in each biozone from the Late Aalenian to the Middle Bathonian. The primary and global signal of the diversity evolution obtained is then independently related to each palaeobiogeographic province. The comparison between the two signals shows the differences of the time evolution of the diversity in the several provinces. The maximum of diversity are often diachronous in the several listed provinces: Early Bajocian in North America; Late Bajocian on the North-West European platforms.

Finally, the palaeogeographic distribution of each ammonite subfamily is used to emphasise the evidence of the several seaways that would exist between the several provinces. The maps which has been constructed for the considered ammonite taxa show that peculiar seaways like the « Hispanic corridor » (Caribbean Tethys), the « South Gondwana » (South Pacific Sea) and the « North Laurasia » (Boreal Sea) bypasses could have been used by ammonites to invade several provinces.

Sponging off the poriferans: complex Ordovician ecosystems reliant on spicule-rich sediments

Lucy A. Muir[1], Joseph P. Botting[2], Sarah Long[1] and Richard Fortey[1]
[1]*Department of Palaeontology, The Natural History Museum, Cromwell Road,*
London SW7 5BD <L.Muir@nhm.ac.uk>, <S.Long@nhm.ac.uk>, <R.Fortey@nhm.ac.uk>
[2]*Department of Earth Sciences, Downing Street, Cambridge CB2 3EQ*
<joseph00@esc.cam.ac.uk>

For understanding the history of life, the development of complex shallow-water ecosystems during the Ordovician is one of the most critical areas in Palaeozoic palaeontology. Siliciclastic sediments often have a very intermittent record in shallow water, with poorly preserved and mixed fossil assemblages, and little lateral continuity. A study of the ecological patterns in well-preserved, shallow-water Llanvirn siliciclastics from the Builth Inlier volcanic island complex, central Wales, has revealed that the distribution of diverse communities is closely linked to the presence of abundant sponges. The gregarious hexactinellids *Brevicirrus*, and especially *Pyritonema*, modified the sediment by producing vast quantities of relatively large spicules (hexactines in *Brevicirrus*, monaxons in *Pyritonema*). These authigenic particles are often larger than the background sediment particles, and would have significantly stabilised the substrate; a similar phenomenon is known in modern polar deep sea floors. In some cases, bryozoans grew immediately around isolated spicules, and a variety of similar interactions are also preserved among other organisms. Further sediment-stabilising strategies followed, including monospecific crinoid thickets and substrate-encrusting bryozoans. The abundant faunas sometimes resulted in local bioclastic limestones. The development of complex Ordovician shallow-water communities, possibly including the later coral-stromatoporoid carbonate community, was facilitated by the onshore migration of spicular sponges during the Lower Ordovician. The rise of the dominantly sessile, suspension-feeding Palaeozoic Evolutionary Fauna would have been difficult to achieve before this occurred.

Exploring the Radiolarian biotic response to the Late Cenomanian Oceanic Anoxic Event (OAE-2) in the tropical Atlantic (offshore Surinam)

Benjamin Musavu-Moussavou and Taniel Danelian
Micropaléontologie, Université Paris VI, UMR 5143, C. 104, 4 place Jussieu, 75005 Paris, France <musavu@ccr.jussieu.fr>, <danelian@ccr.jussieu.fr>

OAEs reflect relatively short periods of environmental perturbations which affected ocean chemistry and productivity, through changes in global climate. Improved understanding of the ecological disruption induced by OAEs to pelagic ecosystems may be obtained by studies of the biodiversity and abundance of planktonic organisms, especially those capable of generating biogenic sediments.

Radiolaria occur rather frequently throughout the Late Cenomanian-earliest Turonian part of finely laminated black shales drilled recently on Demerara Rise (ODP Leg 207) and they are often well-preserved. The observed faunas are of a remarkably low diversity, with a maximum of 14 species per sample and about 40 species in total for the entire Late Cenomanian interval. Assemblages are equally represented by Nassellarians and "Spumellarians". The presence of six species unknown in time-equivalent diversified Tethyan assemblages is worth noting.

Unlike the sedimentary record of some Tethyan basins, radiolarian abundance not only fails to pick during the OAE-2 event, but with the exception of its initial phase, Radiolaria appear to be entirely absent in this interval. The biogenic silica record of Demerara poses many challenges to biogeochemical models suggested for the OAE-2, involving either volcanically-induced iron fertilisation of oceans or improved recycling of phosphorus following widespread anoxia.

Biotic response of Radiolaria during climax of Permian/Triassic Oceanic Anoxic Event

Benjamin Musavu-Moussavou[1], Nutthawut Wonganan[2], Qinghua Shang[3] and Martial Caridroit[2]
[1]*Université Pierre et Marie Curie (Paris6), Département de Géologie Sédimentaire-CNRS-UMR 5143, FR-32, 4 place Jussieu, 75252 Cedex 05, France* <bmusavu@ccr.jussieu.fr>
[2]*Université des Sciences et Technologie de Lille, Laboratoire de Paléontologie et Paléogéographie du Paléozoïque-CNRS-UMR 8014-59655 Villeneuve d'Ascq cedex France*
[3]*Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences, Nanjing 210008, China*

According to the studies of deep and distal oceanic sedimentary facies, *e.g.* radiolarites in Japan, the Permo-Triassic time is significantly characterized by the presence of the longest oceanic anoxic event in the Phanerozoic, around P/T boundary. This remarkable event began in Late Permian and persisted into Triassic, with the climax during early/middle Changshingian to late Induan (*e.g.* Kajiwara *et al.*, 1994; Isozaki 1997). In such series, the observed radiolarian biodiversity suggests a rapid change of fauna after the boundary, with obviously observed extremely low faunal diversity in most of the lowest Triassic strata. The origin of this change is still debated; many possibilities can be proposed: a real low diversity, or poor faunal preservation related to sedimentary facies change and/or to oceanic water chemistry change, or the absence of radiolarians in the deposit environment, *etc.*?

The present study is mainly based on two fundamental possibilities: the environment, during this period, generated biomass extinction and/or only the increase of faunal diversity since late Early Triassic time when sufficiently oxygenated oceanic water has been recovered. Comparisons of radiolarian fauna between distal oceanic series (radiolarites) from Thailand and Japan and platform series (shallow siliceous deposits) from South China, focused on Late Permian and Early Triassic radiolarian assemblages, give an attempt to answer this question. Geochemical and physical analyses of these sediments are being studied in order to understand or at least to compare these different palaeoenvironmental rock facies.

Isozaki, Y.(1997) "Permo-Triassic Boundary Superanoxia and Stratified Superocean: Records from Lost Deep Sea". *Science*, **276**, 235–238.

Kajiwara, Y., Yamakita, S., Ishida, K., Ishiga, H., & Imai, A., (1994) "Development of largely anoxic stratified ocean and its temporary massive mixing at the Permian/Triassic boundary supported by the sulfur isotopic record". *Palaegeography, Palaeoclimatology, Palaeoceanography*, **111**, 367–379.

Devonian pelagic bivalves – forgotten and misunderstood

Judith Nagel[1], Michael Amler[2] and R. Thomas Becker[1]
[1]*Westfälische Wilhelms-Universität Münster, Geologisch-Paläontologisches Institut Münster, Correnssstr.24, 48145 Münster, Germany* <nageju@uni-muenster.de>
[2]*Institut für Geologie und Paläontologie, Philipps-Universität Marburg, Hans-Meerwein-Strasse, 35032 Marburg, Germany* <amler@staff.uni-marburg.de>

The Devonian pelagic facies (Bohemian or Hercynian facies) is rich in peculiar bivalves. Despite their great quantity in several different horizons, neither their life habits nor their correct stratigraphic range are well understood. Additionally, no systematic concept is available for classification and phylogenetic development.

Our current knowledge dates back to Münster (1840), Barrande (1881) and Clarke (1904) who erected most of the taxa from the Bohemian and the Laurussian region. But apart from the introduction of names, no details of the internal morphology or species concepts have been presented yet. Since that time, relationships between both the pelagic Bohemian and the nearshore Rhenish faunas also remain virtually unknown.

A characteristic example for these bivalves is the genus *Loxopteria*, erected for three species in the Late Devonian cephalopod limestones from Germany. Members of Loxopteria occur in the eastern North American Late Devonian and seem to be present in the Devonian of Bohemia. Morphological characteristics include strongly inequivalve shells with prosogyrate umbos and its bauplan seems to be analogous to species related to *Exogyra* and *Pseudomonotis*. Without bivalved specimens, correlation of right and left valves remains almost impossible. This feature, however, has caused nomenclatural confusion as left and right valves have often been regarded as separate taxa. Fortunately, several well-preserved specimens offer many details of external and internal morphology including soft tissue attachment. It is expected to get more information on possible life habits of these bivalves in the near future.

Barrande, J. (1881): Système silurien du centre de la Bohême. v. 6: published by the author and editor, Prague, Paris.

Clarke, J.M., (1904): Naples fauna in western New York, Pt. 2: N.Y. State Museum, Mem.6, Albany.

Münster, G., Graf zu; (1840): Die Versteinerungen des Übergangskalkes mit Clymenien und Orthoceratiten von Oberfranken: Beitr. Petrefactenkd., 3: 33–121, Bayreuth.

Revision and stratigraphical importance of "Spirifer julii" Dehée, 1928, a typical spiriferid species from Uppermost Devonian

Jean-Pierre Nicollin
Laboratoire de Paléontologie stratigraphique FLST & ISA, UMR 8014 & FR 1818 du CNRS, 13 rue de Toul F 59046 Lille Cedex, France <jean-pierre.nicollin@fls.fupl.asso.fr>

In 1929, Dehée created the new species "*Spirifer julii*" to design specimens collected in the "zone d'Etroeungt" of Avesnois by Gosselet, 1880 and called after Dehée by error, "*Spirifer distans*" Sowerby, 1840. Since then, this species has been found in Upper Devonian of many places in the world. In this paper, we revise "*Spirifer julii*":

- with re-examination of type material kept in the Musée Gosselet, Lille France,
- with study of new material collected in the type locality and stratum typicum in Avesnois,
- with examination of material of different collections coming from neighbouring Belgian and German areas.

This revision led us to adopt, for the moment, the generic assignment of *Sphenospira* Cooper, 1954 to *julii*, already given by some authors. We have effectively observed the presence of remains of frills (one of the characteristics of the genus) in some specimens. However, none of the specimens we have studied shows the delthyrial covering (stegidium) given as another important feature of *Sphenospira* by Cooper. We suggest it could be a problem of preservation.

Finally, we examine critically the citations of *Sphenospira julii* in Uppermost Devonian of varied countries (western Europe, ex USSR territories, North Africa), to show its stratigraphical importance as brachiopod marker.

Major changes in the early ontogeny of molluscs across the Cambrian/Ordovician boundary

Alexander Nützel[1] and Oliver Lehnert[2]
[1]*Institut für Paläontologie, Universität Erlangen, Löwenichstr. 28, D-91054 Erlangen, Germany* <nuetzel@pal.uni-erlangen.de>
[2]*Université des Sciences et Technologies de Lille (USTL), Sciences de la Terre, SN5, Paléontologie LP3 & UMR 8014 du CNRS, 59655 Villeneuve d'Ascq Cedex, France*

Minute mollusc steinkerns are abundant in Early Paleozoic small shelly assemblages. These steinkerns represent casts of mollusc protoconchs or early juveniles. Generally, such casts are useless for taxonomic or systematic purposes. However, the size of these natural casts reflects the size of the hatching animal and the amount of yolk within the egg. Therefore, such steinkern faunas can reflect the ontogenetic development of molluscs. Size and shape of mollusc protoconchs from small shelly assemblages across the Cambrian/Ordovician boundary indicate a major evolutionary change in ontogenetic strategies. During the Cambrian, characteristic limpet shaped or coiled molluscs (e.g. *Pelagiella*, *Aldanella*, *Anarbarella*, *Latouchella*) have relatively large, undifferentiated initial parts which indicate non planktotrophic (lecitotrophic or direct) ontogeny. In the Early Ordovician, various forms of gastropod larval shells appear for the first time. The size of the initial part of many of these larval shells suggests planktotrophy. The gastropod protoconchs display a high number of different shapes and many of them are indeed openly coiled. The greater variation of gastropod protoconch morphology reflects the tremendous Ordovician radiation of the Gastropoda and the size indicates that planktotrophy has been acquired at the same time.

Phylogeny of early Caenogastropoda: Formation of a superclade

Alexander Nützel
Institut für Paläontologie, Löwenichstr. 28, 91054 Erlangen, Germany
<nuetzel@pal.uni-erlangen.de>

The Caenogastropoda are one of the most diverse metazoan groups. Anatomical characters form a robust argument for the monophyly of the crown-group caenogastropods. However, the systematic placement of Palaeozoic members is more problematic. New protoconch data suggest that planktotrophic larval shells are shared with the Naticopsidae, a diverse Palaeozoic group which is assigned to the Neritaemorpha. This and the lack of nacre obstruct a clear differentiation between fossil neritaemorphs and caenogastropods. A sister-group relationship seems to be possible which would be in conflict with analyses based on anatomical characters. Openly coiled protoconchs are present in possible Palaeozoic stem-groups of the caenogastropods. This feature was increasingly abandoned during the Palaeozoic and is absent in the Mesozoic. This macroevolutionary loss of openly coiled larval shells in various clades shows that this character cannot be used as an apomorphy. The presence of slits in several Palaeozoic caenogastropods sheds light on the evolution of the mantle cavity. However, a previously suggested relationship to pleurotomarioideans is not supported by protoconch and shell structure data. Ongoing phylogenetic analyses of the Late Palaeozoic and Early Mesozoic caenogastropods show a poor resolution (basal multifurcations) but several clades can be recognized and possible links with Recent gastropods are suggested.

Cathodoluminescence-spectroscopy of extant and fossil brachiopod shells

Niall Paterson[1], Jennifer England[1], Maggie Cusack[1], Martin Lee[1], Paul Edwards[2] and Robert Martin[2]
[1]*Centre for Geosciences, Division of Earth Sciences, University of Glasgow*
<0105240p@student.gla.ac.uk>
[2]*Department of Physics, University of Strathclyde* <paul.edwards@strath.ac.uk>

Cathodoluminescence (CL)-microscopy is used for qualitative assessment of diagenetic alteration of fossil shells. CL-spectroscopy provides quantitative analyses. Combined with microprobe elemental analysis, CL-spectroscopy can determine which elements are contributing to luminescence. CL-spectroscopy is, therefore, an extremely powerful tool with which to assess alteration of fossils. CL-microscopy and CL-spectroscopy are applied to extant and fossil brachiopod shells. A detailed assessment of the conditions required for a linear CL response is determined using extant shells before applying CL-spectroscopy to fossils. In CL-microscopy, no luminescence is detected from *Terebratulina retusa* while *Novocrania anomala* emits orange-red luminescence as does *Crania quadrata* (Carboniferous) and *Crania craniolaris* (Cretaceous). In CL-spectroscopy, a 20nA current, applied as a 5µm diameter beam, results in extant *T. retusa* generating almost five times as much luminescence as *N. anomala*. While CL-microscopy displays orange luminescence from both *Crania quadrata* and *Crania craniolaris,* CL-spectroscopy reveals that *Crania quadrata* emits luminescence at 560 nm (yellow) and *Crania quadrata* at 406 nm (blue).

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Originations and Extinctions of Pennsylvanian Brachiopods: Response to palaeogeographic and climatic changes

Alberto Perez-Huerta
Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403-1272, USA
<aperezhu@darkwing.uoregon.edu>

Originations and extinctions of brachiopod faunas have been reported across the Mid-Carboniferous boundary and within the Pennsylvanian in response to paleogeographic and climatic changes during the Late Palaeozoic. Previous studies were mainly based on analyses of global databases and, therefore, little is known about how the palaeoenvironmental changes affect the faunas regionally. Using a newly compiled 30 Myr record of Pennsylvanian brachiopods from the Great Basin (USA) the following matters are addressed: 1) Examination of species-level origination and extinction patterns; 2) The importance of changing palaeogeography in brachiopod origination events; 3) Causes of long-term extinction of brachiopod faunas.

The results show an extinction event at the Desmoinesian-Missourian boundary and three origination events: at the Mid-Carboniferous boundary, the Missourian-Virgilian boundary, and in the Desmoinesian. The extinction event at the end of the Desmoinesian is related to a warming episode. The appearance of new brachiopod faunas is likely related to migration in response to oceanic currents. The oceanic currents developed during the Pennsylvanian as a result of palaeogeographic changes that accompanied the formation of Pangea toward the end of the Palaeozoic. These extinctions and originations represent long-term biotic responses to climatic and paleogeographic changes during the Pennsylvanian.

Silurian midwater communities dominated by ostracods: evidence from fossil assemblages in France and Bohemia

Vincent Perrier[1], Jean Vannier[1], David J. Siveter[2], Jiri Kriz[3] and Stepan Manda[3]
[1]*Université Claude-Bernard Lyon 1, UFR Sciences de la Terre, UMR 5125 PEPS, Paléoenvironnements et Paléobiosphère, Bâtiment Géode, 2 rue Raphäel Dubois, 69622 Villeurbanne, France* <vincent.perrier@univ-lyon1.fr>, <jean.vannier@univ-lyon1.fr>
[2]*Department of Geology, Bennett Building, University of Leicester, University Road, Leicester LE1 7RH, UK* <djs@le.ac.uk>
[3]*Czech Geological Survey, P.O.B. 85, Praha 011, 118 21, Czech Republic*

Much of our information about Palaeozoic marine life is known from shallow water benthic assemblages typically dominated by arthropods (*e.g.* trilobites, podocope and palaeocope ostracods), molluscs and brachiopods. By contrast, information concerning midwater communities is sparse and fragmentary. In recent years, the study of particular depositional environments such as deeper water black shales has yielded information on possible pelagic inhabitants of the water column, in addition to the ubiquitous planktonic graptolites. This is the case for Cambrian bradoriids (Vannier *et al.* in progress), Early Ordovician phyllocarid crustaceans and Late Silurian myodocope ostracods. Nevertheless, the assumed pelagic Silurian ostracod faunas of Europe (*e.g.* Great-Britain, France, Sardinia, Bohemia) and Morocco lack detailed studies.

The preliminary results presented here concern two myodocope-dominated assemblages from "black-shale" type deposits: one in Brittany (La Cultais, Armorican Massif, France; Late Wenlock, *Colonograptus ludensis* Biozone); the other from Bohemia (Holy Hill near Lounín, Prague Basin, Bohemia; Mid Ludlow, *Monograptus fritschi linearis* Biozone). At both localities, myodocopes occur with graptolites, nektobenthic cephalopods, phyllocarids and bivalves (epibenthic, nektonic or adapted to oxygen deficient waters). Bottom conditions (disoxyic to anoxic) were unsuitable for benthic faunas. At La Cultais, the most common myodocopes (size from *ca.* 5 to 15 mm) are *Bolbozoe bohemica*, *Bolbozoe anomala*, and cypridinids. At Holy Hill, *Bolbozoe bohemica*, cypridinid and *Entomis migrans* (ostracods with a finger-print ornament) are dominant. These ostracods had a non-mineralized, light carapace and external ornament (*e.g.* reticulated, corrugated, finger-print) typical of some present-day pelagic crustaceans (*e.g.* halocypridid myodocope ostracods). They were clearly adapted to a free-swimming lifestyle. The composition of modern midwater communities is strongly influenced by environmental parameters (sea temperature, bathymetry, light, food availability). Similarly, some of the differences observed between the French and the Czech assemblages may result from environmental factors. For example, *Entomis migrans* is frequent at Holy Hill and in more proximal settings of the Bohemian Basin (calcareous rocks with abundant bivalves, trilobites and gastropods) but is absent at La Cultais. This would suggest that *Entomis* may have been epipelagic whereas bolbozoids had ecological preferences for deeper (colder) water masses.

The systematics of the trilobite family Lichidae Hawle & Corda, 1847

J. R. Pollitt[1], M. A. Wills[1] and R. A. Fortey[2]
[1]*The Department of Biology & Biochemistry, The University of Bath, Claverton Down, Bath BA2 7AY* <bspjrp@bath.ac.uk>, <bssmaw@bath.ac.uk>
[2]*The Natural History Museum, Cromwell Road, London SW7 5BD* <r.fortey@nhm.ac.uk>

The first cladistic and Bayesian analyses of the trilobite family Lichidae Hawle & Corda, 1847 are presented. Thirty lichid genera and five lichakephalid outgroup taxa were coded for forty-nine characters using published descriptions. Two methods of phylogenetic inference were adopted: (1) the more traditional maximum-parsimony approach (MP); and (2) the newer Bayesian approach (BI). The majority-rule consensus trees from the MP and BI analyses were topologically similar, but differed principally in the deeper branches (the relationships between major clades). The Lichidae is monophyletic with respect to the Lichakephalidae in both analyses. The Trochurinae (Holloway & Thomas 1988) is well supported by both analyses. Other groups are also supported (*i.e.* Tetralichinae, Echinolichinae and Platylichinae); two, however, are not (*i.e.* Homolichinae, Lichinae). The level of homoplasy found in the dataset (CI=0.4778) is comparable to that found in similar-sized trilobite datasets.

Deep-oceanic conodonts: are they different?

Carine Randon[1], Nutthawut Wonganan[1,2] and Martial Caridroit[1]
[1]*UMR-CNRS 8014 (LP3), UFR des Sciences de la Terre, Université des Sciences et technologies de Lille, France* <carine.randon@ed.univ-lille1.fr>
[1]*Department of Geological Sciences, Chiang Mai University*

In northern Thailand, radiolarites deposited from Devonian to Triassic times. These continuous, siliceous and biogenic sediments are the witness of an oceanic realm that must have been opened between the Shan-Thai and the Indochina continental terranes and whose size must have been rather large and deep to avoid important detritic and/or carbonaceous sedimentation (at least several hundred of kilometres as the present Red Sea, and several thousands of kilometres during Carboniferous and Permian). Many conodonts were found from these radiolarites and so they are one rare witness of a deep-oceanic conodont fauna. The study focuses on Upper Devonian–Lower Carboniferous conodonts. This oceanic fauna has several features. The elements found are similar to the ones from pelagic limestones (deposited on the continental slope). But they seem to be smaller than the ones from limestones. Are conodont animals from the oceanic environment smaller? Or is this the result of a preferential transportation of smallest elements in the distal area? The study of this oceanic conodont fauna, and its comparison with the ones from limestone deposits, gives a new clue for the understanding of conodont palaeoecology.

Early Mid Ordovician (Kundan) brachiopods from the Eastern Baltic: Biostratigraphy, palaeogeography and palaeoecology

Christian Mac Orum Rasmussen and David A. T. Harper
Geological Museum, University of Copenhagen, Denmark
<c@orum.dk>, <dharper@savik.geomus.ku.dk>

The Ordovician brachiopod fauna of the East Baltic is abundant, diverse and generally well preserved (Hints & Harper 2003). Whereas the Early Ordovician faunas show strong Gondwanan affinities, the early Mid Ordovician faunas reflect a major biotic turnover in the Baltic palaeobasin. Distinctive brachiopod groups, like the clitambonitoids, which are almost exclusively found in Baltoscandia (Vinn & Harper 2003) are more and more diverse, suggesting the increasing independence of the Baltic fauna during this interval.

New collections based on bed by bed sampling of calcareous tempestites from five localities in Northern Estonia and Western Russia along the Baltic–Ladoga Klint, in the *Asaphus expansus* trilobite zone (Upper Arenig), have yielded a very diverse although not particularly abundant brachiopod fauna. Especially striking are the diversifications amongst the clitambonitides, plectambonitoids and porambonitoids. These groups, together with the orthides, characterize the typical Baltic brachiopod province.

This pattern apparently also continues through the overlying Lower Llanvirn trilobite zones, *Asaphus raniceps, A. minor* and *A. pachyophthalmus,* based on detailed sampling in Putilovo Quarry, Western Russia.

Palaeoecological investigations suggest a wide range of ecospace utilization both in marl and limestone facies. Furthermore a series of depth related brachiopod associations are established along the sampled localities.

Hints, L. & Harper, D.A.T. 2003: Review of the Ordovician rhynchonelliformean Brachiopoda of the east Baltic: their biostratigraphy and biofacies. *In* Harper, D.A.T. & Stouge, S. (eds): *Studies in Ordovician geology: the Baltoscandian region. Bulletin of the Geological Society of Denmark*, **50**, 29–43

Vinn, O. & Harper, D.A.T. 2003: Diversification patterns in the clitambonitoid brachiopods of the Ordovician of Baltoscandia. *In* Harper, D.A.T. & Stouge, S. (eds): *Studies in Ordovician geology: the Baltoscandian region. Bulletin of the Geological Society of Denmark*, **50**, 55–61.

Cut- and Bite-marks on Pleistocene and Holocene mammal bones

Christina Karla Reimann[1] and Manfred Schlösser[2]
[1]*Geologisch-Paläontologisches Institut der Universität Münster, Corrensstr. 24, 48149 Münster, Germany* <reimi@uni-muenster.de>
[2]*Westfälisches Museum f. Naturkunde, Sentruperstr. 285, 48161 Münster*

In an old oxbow of the Ems river close to the city of Greven, Münsterland, Gemany, a huge amount of Pleistocene and Holocene mammal bones have been found. Many of these different taxa from warm and cold periods show striking bite- and gnaw-marks, as well as cut- and hit- grooves. The marks can be recognized both on domestic animals and on bones of wild forms.

As one source of these marks the proven carnivores (*Crocuta spelaea, Panthera leo spelaea, Lynx lynx, Canis lupus, Canis familiaris, Vulpes vulpes, Felis silvestris*) can be assumed.

The trove of more than 50 human remains and the existence of a mediaeval settlement very close to the sandpit explain the different cut- and hint-marks.

The bone fragments are of great value, as no fossil record has been reported in the archaeological excavations that took place.

Exceptional three-dimensional preservation in Triassic ostracods

Elodie Renvoisé and Jean Vannier
UMR 5125 Paléoenvironnements et Paléobiosphère , Université Claude Bernard Lyon 1,
Campus Universitaire de la Doua, 2, rue Raphaël Dubois, 69622 Villeurbanne, France

The exceptional preservation of small Triassic myodocope ostracods from Spitzbergen, first described by W. Weitschat in the 80s, is re-examined here in the light of new SEM studies and microprobe analysis. In addition to fine details of the exoskeleton and carapace structure, Triadocypris displays a wide range of remarkably preserved soft tissues such as appendages (*e.g.* 5th and 7th limbs bearing setae), appendage and adductor muscles, lateral eyes, gills, cluster of eggs and even ciliate parasites attached to the appendage cuticle. The extremely fine preservation of the soft anatomy of Triadocypris is due to apatite early mineralization. Three different types of microfabrics (see Wilby and Briggs 1997) are recognized: 1) substrate microfabric (apatite microspheres, diameter < 50nm), 2) intermediate microfabric (microspheres between 100nm and 1µm) and 3) microbial microfabric (microspheres < 150nm, preserved bacteria). Experimental taphonomy (E. Renvoisé, in progress) with Recent ostracods is aimed at bringing new knowledge on the processes and environmental parameters involved in the early mineralization of such small crustaceans.

Wilby, P. R. and Briggs, D. E. G. 1997. Taxonomic trends in the resolution of detail preserved in fossil phosphatized soft tissues. *Geobios Mémoire Spécial*, **20**, 493–502.

Distribution of Permian Fishes of Brazil and their palaeoenvironments

Martha Richter
Department of Palaeontology, The Natural History Museum, Cromwell Road,
London SW7 5BD, UK <m.richter@nhm.ac.uk>

Permian fishes are known from two epeiric basins in Brazil, the Parnaíba and the Paraná basins. During the Early and Late Permian, shallow neritic environments prevailed in northern and north-eastern Brazil, whilst interglacial/periglacial sequences were deposited in the southern states. The climate changed during the Late Permian in the whole of Brazil, with rapid continentalization of the intracratonic basins and shallowing of its aquatic environments. The Asselian-Ufimian Pedra de Fogo Formation (Balsas Group) of Maranhão yielded the lower actinopterygian *Brazilichthys macrognathus* Cox & Hutchindon, the oldest known xenacanthus sharks, namely *Xenacanthus tocantinensis* and *X. maranhensis* Silva Santos, a chimeroid, *Itapyrodus punctatus* Silva Santos and the eugeneodontid *Anisopleurodontis pricei* Silva Santos. From tempestites in the State of Tocantins come new ctenacanthid sharks, comprising spines, teeth and calcified cartilage. A marine sequence ('Budó' beds, Itararé Group, Paraná Basin) in the State of Rio Grande do Sul, considered Late Carboniferous/Early Permian, has yielded symmoriid shark teeth and lower actinopterygian remains. Sakmarian marine black shales of the Rio do Sul Formation in Santa Catarina contain palaeoniscid fishes (*Santosichthys mafrensis* Malabarba, *Irajapintoseidon uruguayensis* Beltan, *Daphnaechelus* sp A Richter and others), together with *Coelacanthus* sp. Overlying the Itararé, the Guatá Group contains the actinopterygian *Tholonosteon santacatarinae* Beltan. The Passa Dois Group yielded the most diversified assemblages of fossil fishes in the Paraná Basin, containing the palaeoniscid *Tholonothus braziliensis* Dunkle & Schaeffer, *Rubidus pascoalensis* Richter, a platysomid, xenacanth sharks ('*Xenacanthus*' *santosi* Würdig-Maciel, *Xenacanthus pricei* Würdig-Maciel; *Triodus* sp.) and Acanthodidae, hybodontiforms, eugeneodontiforms, petalodontids (Holocephali) and dipnoans (*e.g.* Gnathorhizidae).

The true identity of the supposed giant fossil spider Megarachne

Paul A. Selden[1*], José A. Corronca[2] and Mario A. Hünicken[3]
[1]*Department of Earth Sciences, University of Manchester, Manchester M13 9PL, UK*
<Paul.Selden@man.ac.uk>
[2]*CONICET Facultad de Ciencias Naturales, Universidad Nacional de Salta, Av. Bolivia 5150, CP 4400, Salta, Argentina* <spider_2002@ciudad.com.ar>
[3]*Centro Regional de Investigaciones Científicas y Transferencia Tecnológica (CRILAR, Conicet), Anillaco, 5301, Provincia de La Rioja, Argentina* <mhunicken@crilar-conicet.com.ar>

Megarachne servinei Hünicken, 1980, from the Permo-Carboniferous Bajo de Véliz Formation of San Luis Province, Argentina, was described as a giant mygalomorph spider ('tarantula') and, with its body length of 339 mm, the largest spider ever to have lived on Earth. The interpretation was based on: the carapace shape, position of the eye tubercle, interpretation of the carapace anterior protrusion with median ridge as a pair of chelicerae, and a posterior, circular structure as the abdomen. Morphology hidden in the matrix was suggested by x-radiography: cheliceral fangs, sternum, labium and coxae; and so a reconstruction of *Megarachne* as a giant spider was presented. Difficulties with the interpretation (unusual cuticular ornament, suture dividing the carapace, and spade-like anterior border of the chelicera), together with non-preservation of synapomorphies of Araneae, provoked debate about its interpretation as a spider. Now, the holotype and a new specimen have become available for study. *Megarachne* is not a giant fossil spider; its true identity will be revealed!

A new Eocene conifer flora from Seymour Island, Antarctica

Rosemary S Stephens[1], Jane E Francis[1], J. Alistair Crame[2], Alan Haywood[2]
[1]*School of Earth Sciences, University of Leeds, Woodhouse Lane, Leeds, UK*
<r.stephens@earth.leeds.ac.uk>, <jane@earth.leeds.ac.uk>
[2]*Geosciences Division, British Antarctic Survey, High Cross, Madingley Road, Cambridge, UK*
<JACR@bas.ac.uk>, <ahay@bas.ac.uk>

Exceptionally well preserved plant material has been collected from new floras in Eocene strata (approximately 50Ma) on Seymour Island, Antarctic Peninsula. The plants are preserved in concretions within the La Meseta Formation, in sediments that formed in a marine shallow shelf environment.

The flora is dominated by well preserved conifer branches, preserved in three dimensions with their leaves still attached. The leaves are often replicated by delicate layers of calcite, which display cellular detail and stomata. The conifers are members of the Araucariaceae and are represented in this flora by intact branches, isolated leaves and cone scales. Several types of angiosperm leaves are also present, but are fragmented and not as well-preserved as the conifer material.

The excellent preservation of the plant material may allow computer-generated reconstruction of the conifers to be made. The fine detail preserved in this araucarian flora will provide new information about the biogeography and evolution of these Gondwanan plants, and data collected from the material can be used to infer palaeoclimate and palaeoenvironment in the Antarctic Peninsula region during the late-Early Eocene. This poster outlines conclusions drawn from initial data collection as part of an ongoing PhD project.

The Brach Pack: a composite brachiopod fossil from the Silurian Herefordshire Lagerstätte

Mark D. Sutton[1], Derek E. G. Briggs[2], David J. Siveter[1] and Derek J. Siveter[3]

[1]*Department of Earth Sciences, University of Oxford, Parks Road, Oxford OX1 3PR, UK*
<mark.sutton@earth.ox.ac.uk>, <djs@le.ac.uk>

[2] *Department of Geology & Geophysics, Yale University, P.O. Box 208109, New Haven, USA*
<derek.briggs@yale.edu>

[3]*Department of Earth Sciences, University of Oxford, Parks Road, Oxford OX1 3PR, UK and Geological Collections, University Museum of Natural History, Oxford OX1 3PW, UK*
<derek.siveter@earth.ox.ac.uk>

Articulate brachiopods are among the most familiar of fossils, but their soft-part record is almost non-existent. No unequivocal fossilised articulate pedicle, for example, has been reported previously, and the soft-parts of major extinct brachiopod clades are known only from analogy and inference. We present here a three-dimensionally preserved strophomenid from the Herefordshire Lagerstätte (Wenlock Series) that provides direct data on the soft-parts of an extinct brachiopod. The specimen probably represents a new genus, and is a juvenile. Its pedicle is robust and nearly as long as the valves, with prominent sub-transverse ridges; it terminates in an array of rootlets attached to a tubular structure in the sediment. The lophophore is a zygolophe, with thickened connective tissues forming prominent lateral lobes fringed by lophophore tentacles. Details of the mantle and canals are also preserved. Small articulate brachiopods are attached to both valves of the strophomenid; two preserve pedicles, and one, probably an atrypid, also bears marginal setae. Other epibionts of uncertain affinity are attached to the dorsal valve. The distribution of this demonstrably *in vivo* epifauna, together with the form and attachment of the pedicle, imply a near-vertical orientation of the commissure, supporting existing models of juvenile strophomenid ecology.

Endosymbiosis in corals and stromatoporoids: a new lingulid with preserved pedicle and its trace from the Ordovician and Silurian of eastern Canada

Leif Tapanila[1] and Lars E. Holmer[2]

[1]*Department of Geology and Geophysics, University of Utah, UT 84112-0111, USA*
<ltapanila@mines.utah.edu>

[2]*Institute of Earth Sciences-Palaeobiology, Norbyv. 22, S-75236 Uppsala, Sweden*
<lars.holmer@pal.uu.se>

A new species of the lingulid *Rowellella*? is preserved with a probable pedicle inside the cavities of Trypanites borings, which penetrate tabulate corals and stromatoporoids. The earliest known record of lingulid-coral associations is described from Ashgill tabulate corals preserved on Manitoulin Island, Ontario. Lingulid infestation of tabulate corals and stromatoporoids is also locally abundant in Ashgill and Llandovery limestones on Anticosti Island, Québec. In all examples, lingulids appear to nestle in previously formed *Trypanites*, likely in a dead host coral or stromatoporoid. In some instances, regeneration of host growth while infested by lingulids is evidenced by a new type of compound trace fossil. Similar endosymbiotic relationships previously observed in Silurian corals from Wales and Sweden suggest that the lingulid association with tabulate corals and stromatoporoids was widespread in shallow marine settings of the Iapetus Ocean.

DNA, shell morphology and clades: palaeontological implications of delimiting biospecies in a species-rich radiation of Neotropical snails (Turridae: Polystira)

Jonathan A. Todd[1] and Timothy A. Rawlings[2]

[1]*Dept. of Palaeontology, The Natural History Museum, London SW7 5BD, UK*
<J.Todd@nhm.ac.uk>

[2]*Dept. of Biological Sciences, Florida International University, Miami, FL 33199, USA*
<rawlings@fiu.edu>

Palaeontologists parcel their organisms into species yet there are only a handful of studies that analyse how well morphologically based 'palaeospecies' correspond to Recent species within closely related metazoan clades. How often is membership of palaeospecies liable to be conceptually equivalent to extant species … occasionally, sometimes, or never? Combined genetic (DNA) and morphological studies of extant species-rich clades can provide clues.

The morphologically unspectacular marine snail *Polystira* ranges through the Late Oligocene to Recent of the American subtropics and tropics and comprises at least 82 living and narrowly separable (semi-cryptic) morphospecies in the Atlantic and Caribbean alone, and probably a hundred or more known extinct species.

Phylogenetic analyses of three gene fragments (16S, 28S, COI) for 25 Recent species produced trees showing almost perfect congruence between genetic clades and independently delimited morphospecies, despite them having been split as finely as possible. Doing so we uncovered many previously unnoticed species that had been concealed by ineffective taxonomy.

Clearly gastropod shell morphology can provide as good resolution of species level clades as DNA sequence. In these cases it will be possible to identify fossils that are conceptually equivalent to Recent biospecies. For *Polystira* this opens the possibility of examining meaningful species diversification dynamics through its fossil record.

Reorientation ability in modern and fossil brachiopods: predictions from dorsal pedicle muscle scars

Adam Tomasovych

Institut für Paläontologie, Würzburg Universität, Pleicherwall 1, 97070 Würzburg
<adam.tomasovych@mail.uni-wuerzburg.de>

Size and shape variation of pedicle muscle scars in brachiopods can be used to infer their ability to reorient to ambient currents. Reorientation ability may also help in competition for space and overgrowth inhibition and in keeping stable position on sediment-water interface. This project is focused on morphometric analysis of dorsal pedicle muscle scars in modern and fossil rhynchonelliform brachiopods. As hypothesized in earlier studies, the size and the inter-scar distance of dorsal pedicle muscle scars should be good indicators of their reorientation ability. Due to a marked decrease in the reorientation ability during ontogeny, modern brachiopod *Terebratalia transversa* provides a potential test of these hypotheses. As follows from this project, *T. transversa* exhibits 1) significantly positive allometry in the inter-scar distance of dorsal adjustors (the distance between adjustor scars becomes relatively larger than the size of cardinalia with growth), and 2) significantly negative allometry in the size of dorsal adjustor scar during ontogeny (adjustor scars become relatively smaller than the size of cardinalia with growth). Therefore, these trends are in accord with the predicted trends which would be expected if there is a decrease in reorientation behaviour during ontogeny. Pedicle scars of several Mesozoic brachiopods are analyzed and compared with these predictions.

Diachronous ecosystem recovery after the Late Permian mass extinction event

Richard J. Twitchett

University of Tokyo, 7-3-1 Hongo, Tokyo, 113-0033, Japan, and University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK <rtwitchett@plymouth.ac.uk>

In terms of global diversity, the recovery interval after the Late Permian mass extinction event is the longest of all post-extinction recoveries in the Phanerozoic. However, recent, detailed studies indicate that the recovery was a complex affair, with ecosystems in different regions recovering at different rates. Based on their work in the Cretaceous, Kauffman and Harries (1996, *Geological Society Special Publication* **102**, pp. 15–39) predicted that post-extinction recovery should be faster at higher latitudes. Is a similar pattern observed after the Late Permian event?

Quantifying biotic recovery is not straightforward. Approaches based on simply counting shelly taxa face the obvious problems of fossil preservation. Also, an increase in diversity does not necessarily equate with an increase in the level of recovery, as alpha diversity may actually increase through the extinction interval with the appearance of numerous, short-lived, pioneering species. Instead, a semi-quantitative 'recovery scale' based on ecological parameters such as tiering, organism size, the dominance and evenness of fossil assemblages, and the presence or absence of specific ichnotaxa was used to assess levels of ecosystem recovery. The fastest initial recovery is recorded in shallow settings of western Neotethys, at tropical southern palaeolatitudes. However, outside Neotethys, in the northern hemisphere, rates of recovery appear to follow the predicted latitudinal pattern, with fastest rates at higher palaeolatitudes.

SPARTA (Simulation Package for Area-Taxon Analysis): A tool for testing the relative performance of cladistic biogeographic methods

Paul Upchurch and Alistair J. McGowan

Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT <p.upchurch@ucl.ac.uk>, <alistair.mcgowan@ucl.ac.uk>

Over the past 30 years, numerous analytical biogeographic methodologies have been devised. The robustness of these methodologies has received limited study, and data on the performance of the techniques are critical in selecting appropriate method(s) for future biogeographic studies. SPARTA (Simulation Package for Area-Taxon Analysis) is a computer simulation that generates coupled area-taxon evolutionary histories. Many user-variable geographic and biological parameters have been incorporated into the model to make it applicable to fields ranging from host-parasite co-evolution to historical biogeography. Rapid generation of large numbers of replicate data sets is a major advance over 'hand-built' data sets. SPARTA can also degrade data to simulate sampling problems associated with the fossil record. A program implementing the modified version of Brooks Parsimony Analysis proposed by Lieberman has also been written, to allow detailed analysis of the performance of this relatively new technique. Trial versions of both freeware programs will be presented at the meeting. Comparative tests of the ability of the various cladistic biogeographic methods to recover accurately "known" area-taxon histories generated by SPARTA are now underway. The outcome of these tests will provide clear guidance as to which method(s) are optimal for particular classes of evolutionary problems.

Chitinozoans from historical type areas and key sections in the UK: Towards a biozonation for the Upper Ordovician on Avalonia

Thijs R. A. Vandenbroucke

Research Unit Palaeontology, Ghent University, Krijgslaan 281 / S 8, 9000 Ghent, Belgium, Research Assistant of the Fund for Scientific Research - Flanders (F.W.O. - Vlaanderen)
<Thijs.vandenbroucke@ugent.be>

Working towards an Upper Ordovician chitinozoan biozonation for Avalonia, several historical type areas and other UK key sections were investigated. These include the Onny Valley, Shelve Inlier, Cautley district (type Ashgill area), Pus Gill, Greenscoe and Cardigan area (see poster Vandenbroucke & Williams) sections. Preliminary data from the Whitland section will be included. Eleven biozones are recognised, reflecting Baltoscandic, Gondwanan and endemic Avalonian affinities. The recognition of the Baltoscandic *Fungochitina fungiformis* Zone in the Onnian and Pusgillian of the Pus Gill section, and in the Pusgillian to lowermost Cautleyan of the Cautley district is of particular interest, allowing a tight correlation between both areas and demonstrating that the base of the Ashgill Series lies within the *F. fungiformis* Zone, rather than in the stratigraphically higher *Tanuchitina bergstroemi* Zone, as previously assumed. The Baltoscandic chitinozoan biozones are consequently better tied to the British chronostratigraphy. In addition, the co-occurrence of the *F. fungiformis* biozone (Van Nieuwenhove *et al.*, in prep) with the *Amorphognathus superbus* conodont biozone (Smith, 1999) in the Greenscoe road cutting fits with the records from the Cautley district (Orchard, 1980). The Pus Gill Onnian below the FAD of *F. fungiformis* is correlated with the topmost Onnian in Onny Valley.

ORCHARD, M. J. 1980. Upper Ordovician conodonts from England and Wales. *Geologica et Palaeontologica*, **14**, 9–44.

SMITH, C. J. 1999. Evolutionary palaeobiology of deep water conodonts. Unpublished PhD thesis, University of Durham.

posters

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Upper Ordovician chitinozoan biostratigraphy of the Cardigan area, southwest Wales

Thijs R.A. Vandenbroucke[1] and Mark Williams[2]

[1]*Research Unit Palaeontology, Ghent University, Krijgslaan 281 / S 8, 9000 Ghent, Belgium; Research Assistant of the Fund for Scientific Research - Flanders (F.W.O. - Vlaanderen)* <Thijs.vandenbroucke@ugent.be>

[2]*British Antarctic Survey, Geological Sciences Division, High Cross, Madingley Road, Cambridge, CB3 OET, UK* <mwilli@bas.ac.uk>

The Caradoc rock succession between Fishguard and Cardigan has been remapped (Davies *et al*., 2003) and studied for graptolites (Williams *et al*., 2003). Thirty-five samples have been studied for chitinozoans. Although not extremely well preserved or rich, the chitinozoan assemblages have good potential for correlation with the Baltoscandian biozonation, and with several assemblages from northern England. Occurrence of the index fossil of the Baltoscandic *Cyathochitina reticulifera* chitinozoan Subzone, within the Newport Sands section (*clingani* graptolite Biozone, *morrisi* Subzone), together with *Spinachitina* ?*coronata*, *Lagenochitina baltica* and *Lagenochitina prussica*, indicate the *F. fungiformis* chitinozoan Biozone, although the index fossil itself has not been reported from Wales. The latter biozone has been reported from northern England, where it spans the base of the Ashgill.

Higher in the Cardigan stratigraphy, *Tanuchitina* ?*bergstroemi*, the index fossil of the eponymous Baltoscandic chitinozoan biozone overlying the *F. fungiformis* biozone, is reported from Frongoch (SN 0749 4108), at the level of the *Pleurograptus linearis* graptolite Biozone. The *bergstroemi* Biozone can tentatively be correlated with post-*fungiformis* levels in the Type Ashgill area. Preliminary chitinozoan-based correlations suggest that the base of the Ashgill in the Cardigan area is slightly lower in the rock succession than suggested by the graptolites.

DAVIES, J. R., WATERS, R. A., WILBY, P. R., WILLIAMS, M. & WILSON, D. 2003. The Cardigan and Dinas Island district – a brief explanation of the geology. 1:50 000 Series England and Wales Sheet 193 (including part of sheet 210). Keyworth: British Geological Survey.

WILLIAMS M., DAVIES J. R., WATERS R. A., RUSHTON A. W. A. & WILBY P. R. 2003. Stratigraphical and palaeoecological importance of Caradoc (Upper Ordovician) graptolites from the Cardigan area, southwest Wales. *Geological Magazine*, **140**, 549–571.

Tuzoia: a giant bivalved arthropod of the Cambrian seas

Jean Vannier[1], Jean-Bernard Caron[2], Jin-Liang Yuan[3], Derek Briggs[4], Desmond Collins[5], Yuan-Long Zhao[6] and Mao-Yan Zhu[3]

[1]*UMR 5125 Paléoenvironnements et Paléobiosphère, Université Claude Bernard Lyon 1, Campus Universitaire de la Doua, 2, rue Raphaël Dubois, 69622 Villeurbanne, France* <jean.vannier@univ-lyon1.fr>

[2]*Zoology Department, University of Toronto, 25, Harbord Street, Toronto, Ontario, M5S3G5, Canada*

[3]*Nanjing Institute of Geology and Palaeontology, Chinese Academy of Science, East Beijing Road, Nanjing 210008, China*

[4]*Department of Geology and Geophysics, Yale University, P.O. Box 208109, New Haven, CT 06520-8109, USA*

[5]*Royal Ontario Museum, 100, Queen's Park, Toronto, Ontario, M5S 2C6, Canada*

[6]*Department of Resource Engineering, Guizhou University of Technology, Guiyang 550003, China*

The external morphology and soft anatomy of *Tuzoia* are interpreted in the light of new observations of specimens from both the Middle Cambrian Burgess Shale (British Columbia, Canada) and Kaili (Guizhou, China) Lagerstätten. *Tuzoia* was a very large (up to 180 mm long) bivalved arthropod with a non-mineralized dome-like carapace often strengthened by prominent pointed features (cardinal angles, posteroventral spines) and flanked by a long lateral ridge bearing a spiny frill. Huge stalked, spherical eyes protruded through the anterior notch. Other information on its soft anatomy (e.g. gill-like structures) indicate that *Tuzoia* had possible flap-like (not leg-like) trunk appendages. The reticulate ornament of *Tuzoia* is comparable with that of present-day crustaceans (*e.g.* myodocope ostracods) and may have been produced through epidermal cells underlying the cuticle. Reticulation is interpreted as a structural compromise between exoskeletal lightness and high resistance to mechanical stress. This ornament may have improved the hydrodynamics of the animal in water (*e.g.* swimming, sinking). *Tuzoia* typically occurs as laterally (lc) or dorsoventrally (dvc) compressed carapaces or single valves. Each type (lc or dvc) emphasizes particular aspects of the morphology (*e.g.* spiny lateral ridge, ventral margin) that were often mistakenly interpreted by former authors, leading to numerous unnecessary taxa and taxonomic confusion. A revision of *Tuzoia* is proposed with nine different species instead of 21. *Tuzoia* sp. nov. is described from the Burgess Shale. *Tuzoia* is tentatively placed within a group of large bivalved arthropods along with *Isoxys* and *Zhenghecaris*, that may have affinities with thylacocephalans (Lower Cambrian-Upper Cretaceous). In the Middle Cambrian, *Tuzoia* distributes across Laurentia, South and North China and the peri-gondwanan area (Bohemia) within a narrow transequatorial belt indicating high dispersal capabilities and latitudinal control, presumably related to sea temperatures. Functional morphology and distributional pattern both suggest that *Tuzoia* was a free-swimming arthropod.

Konservat-Lagerstätten from the Arenig (Early Ordovician) of Morocco

Peter Van Roy[1], Joseph P. Botting[2], Thijs Vandenbroucke[1], Dirk Van Damme[1] and Kay Van Damme[3]

[1] *Department of Geology & Soil Science, Ghent University, Krijgslaan 281/S8, B-9000 Ghent, Belgium* <peter.vanroy@ugent.be>, <thijs.vandenbroucke@ugent.be>, <dirk.vandamme@ugent.be>

[2] *Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK* <joseph00@esc.cam.ac.uk>

[3] *Department of Biology, Ghent University, K.L. Ledeganckstraat 35, B-9000 Ghent, Belgium* <kay.vandamme@ugent.be>

Exceptional fossil deposits preserving labile tissues are of primary importance for understanding ancient ecosystems and metazoan evolution. These "Konservat-Lagerstätten" have an irregular temporal distribution, being most common during the Cambrian and Jurassic. Ordovician labile tissue preservation is exceedingly rare; only two major occurrences have been described: Beecher's Trilobite Bed (U.S.A.), and the Soom Shale (Republic of South Africa), respectively of Caradoc and Ashgill (Late Ordovician) age. Here we report the discovery of labile tissues in several outcrops of Arenig (Early Ordovician) mud– to fine sandstones of the Upper Fezouata Formation northeast of Zagora, Morocco. Most fossils are of benthic organisms preserved essentially *in situ*. A rich classical shelly fauna, including abundant articulated echinoderms, is complemented by several elements that are usually not preserved: articulated specimens of typical Burgess Shale-type sponges like *Choia*, *Pirania* and *Hamptonia*; soft-bodied vermiform organisms, including probable annelids and a possible planarian; a cheloniellid arthropod; a *Tremaglaspis*-like arthropod; large bivalved arthropod carapaces; an articulated plumulitid machaeridian; and a tuboid graptolite and perhaps *Clonograptus* preserving soft tissues. Also noteworthy are "wrinkled" trilobites, co-occurring with undeformed specimens, and probably representing freshly moulted, soft individuals. Although labile-tissue preservation is not abundant in the area, it is widespread, suggesting it may occur through the entire formation. The Moroccan Konservat-Lagerstätten are not only important because of the general rarity of Ordovician labile-tissue preservation; they significantly pre-date the two previously described major occurrences, providing an improved view of early Ordovician faunas, and significantly reducing the large temporal gap between Cambrian and Ordovician Konservat-Lagerstätten.

A Late Ordovician aglaspidid arthropod from Morocco

Peter Van Roy

Department of Geology & Soil Science, Ghent University, Krijgslaan 281/S8, B-9000 Ghent, Belgium <peter.vanroy@ugent.be>

Aglaspidids are a group of predominantly Cambrian arthropods. The Order Aglaspidida is rather poorly defined, but the possession of a paired post-ventral plate is generally regarded as a unique character identifying this clade. The systematic placement of aglaspidids is problematic. Here, a possible aglaspidid from a sandstone outcrop in the Ashgill (Late Ordovician) of the Ktaoua Group east of Erfoud, Morocco is discussed. Although disarticulated, the single specimen provides enough information to reconstruct the exoskeleton. The wide prosoma carries a pair of eyes and exhibits a faint glabellar area. A median notch divides the anterior prosomal doublure and accommodates the anterior part of a hypostome-like plate bearing a pair of large lateral wings. The faintly curving tergites are arranged parallel to each other and the body terminates in a relatively short tail spine. Below the posterior tergites and the base of this tail spine, a paired post-ventral plate is located. In general appearance, the prosoma of the new fossil somewhat resembles that of the problematic Caradoc arthropods *Zonozoe* and *Zonoscutum*. While considered to be a typical trilobite character, a hypostome-like plate was also described in the Tremadoc (Early Ordovician) aglaspidid *Tremaglaspis*. However, the anterior plate of the Moroccan fossil most strongly resembles that of the problematic Early Cambrian arthropods *Kodymirus* and *Kockurus*. A structure similar to the aglaspidid post-ventral plate is also present in the Middle Cambrian arthropod *Emeraldella*. It is apparent that, in order clearly to define Aglaspidida and to establish aglaspidid relationships, a revision of all relevant taxa is needed.

How small mammal fossils accumulate: an example from the Late Eocene of the Isle of Wight

Katerina Vasileiadou[1], Jerry Hooker[2] and Margaret Collinson[3]

[1] *Royal Holloway University of London, Dept. of Geology, Englefield Green, Surrey TW20 OEX, UK* <k.vasileiadou@gl.rhul.ac.uk>

[2] *Natural History Museum, Department of Palaeontology, Cromwell Road, London SW7 5BD, UK* <j.hooker@nhm.ac.uk>

[3] *Royal Holloway University of London, Dept. of Geology, Englefield Green, Surrey TW20 OEX, UK* <m.collinson@gl.rhul.ac.uk>

Micromammalian fossils have been collected from the Osborne Member, Headon Hill Formation, Late Eocene, NW Isle of Wight, and their taphonomic history is being studied. The cheek teeth of the theridomyid rodents *Isoptychus* and *Thalerimys* are described in terms of postmortem modifications shown on their enamel and dentine (*e.g.* etching, cracking, scratching). More than half of both the *Isoptychus* and the *Thalerimys* teeth show etching of the enamel attributable to digestion. The distribution of the teeth in etching groups shows different patterns for the two genera. Furthermore, 42% of the *Isoptychus* teeth and 31% of the *Thalerimys* teeth show cracking of the dentine (on occlusal surface and/or roots) attributable to sub-aerial weathering. No substantial skull elements were found and none of the teeth of either genus show polishing or rounding.

The likely process for the accumulation of most, if not all, of the *Isoptychus* and *Thalerimys* remains is predation by an avian or mammalian carnivore. It is possible that the predator is different for the two genera. Much of the material was exposed on the surface for some time before being incorporated into the sediments. The remains may have been subjected to trampling by other animals but have not been transported for long distances by water. Thus, the two theridomyid rodents belong to the local micromammalian community.

Complex dynamics and Self-Organized Criticality might describe biodiversity patterns of Palaeozoic marine microphytoplankton

Marco Vecoli

UMR 8014 du CNRS, Sciences de la Terre, SN5, USTL, 59655 Villeneuve d'Ascq, France.

Classic interpretations of marine microphytoplankton biodiversity patterns in the Phanerozoic emphasize the importance of external causes («environnemental pressures») on the shaping of diversity curves, tending to find *ad hoc* cause-effect explanations for any given specific bio-event. Marine transgressions are generally believed to promote diversity increase among the microphytoplankton, and the opposite is assumed for regressions. Glaciations are causally associated with extinction events. Catastrophes such as bolide impacts have been invoked to explain inferred (but not adequately documented) microphytoplankton «mass extinction» events for example at the Ordovician–Silurian transition.

Analyzing the Palaeozoic fossil record of the acritarchs, I demonstrate that such kinds of "regular" relationships are not so obvious as normally considered.

I then test the hypothesis that the fossil record of marine microphytoplankton reflects the evolution of a highly connected natural system which has reached a state of Self-Organized Criticality (SOC), and that diversity fluctuations might result also from spontaneous generations of patterns independently from external physical controls. The quasi-linear power-law distributions of extinction/origination events and of species life spans of Ordovician acritarchs supports the SOC hypothesis which also may constitute the ground for explaining the observed decoupling between acritarch and marine invertebrate diversities and the enigmatic "Carboniferous phytoplankton blackout".

Occurrence of the trilobite Taihungshania on the North Gondwana margin during Lower Ordovician

Muriel Vidal[1], Mansoureh Ghobadi Pour[2] and Gian Luigi Pillola[3]

[1]*CNRS-UMR6538, UFR Sciences et Techniques, Université de Bretagne Occidentale,*
6 av. Le Gorgeu, C.S. 93837 – 29238 Brest Cedex 3-France <mvidal@univ-brest.fr>
[2]*Department of Geology, University of Esfahan, Esfahan 81746, Iran*
<m_ghobadipour@yahoo.com>
[3]*Dip.to di Scienze della Terra, via Trentino 51, 09127 Cagliari, Italy* <pillolag@unica.it>

The trilobite genus *Taihungshania* is known to occur in South China, Iran, Turkey (Taurides), Sardinia (Italy), Montagne Noire (southern France) as well as in its western prolongation in Aquitain basin (cored well samples). The terrigenous nature of deposits and associated sedimentary structures give evidence of an open platform depositional environment, between the median part of upper offshore up to proximal part of lower offshore in Sardinia, Montagne Noire and Iran.

According to recent studies about the larval development of *T. miqueli* (Bérard *et al.* 2000), it is expected that *Taihungshania* had a planktic mode of life during protaspid stages—which could represent a relatively short period of larval dispersion—and then adopted a benthic mode of life at the transition protaspid/meraspid period.

The specific habitat and inferred short period of larval dispersion of Taihungshaniids confirm close palaeogeographic relationships between South China, Iran, Turkey, Sardinia, Montagne Noire and Aquitain basin during Lower Ordovician. Moreover, stratigraphic and systematic comparisons show the precise migration route of this fauna along the North Gondwana margin.

The Lower Cambrian Halkieria is a mollusc

Jakob Vinther[1] and Claus Nielsen[2]

[1]*Institute of Geology, Copenhagen, Ostervoldgade 10, 1350 Copenhagen K, and*
Geological Museum, Copenhagen, Ostervoldgade 3–5, DK-1350 Copenhagen K, Denmark
<stegocephal@hotmail.com>
[2]*Zoological Museum, Universitetsparken 15, DK-2100 Copenhagen*
<cnielsen@zmuc.ku.dk>

The Lower Cambrian *Halkieria evangelista* Conway Morris and Peel, 1995 was in its final description interpreted as part of the brachiopod stem group, and a link between the brachiopods and annelids, as sister groups, was suggested.

Although a number of authors have indicated molluscan affinities of *Halkieria*, none (apart from Runnegar 2000 and 2002) has systematically examined the halkieriid characters and compared them to those of living molluscs.

We have compared all the preserved morphological details of *Halkieria* with those of living molluscs, especially polyplacophorans. We have also tried to deduce the growth manner of the halkieriid scleritome by comparing smaller and larger specimens.

We have found agreement in almost all important details. The combination of a dorsal integument and shells growing by marginal accretion, together with spicules being replaced as well as being arranged in the marginal zones of similar morphology, are consistent with the interpretation of *Halkieria* as a mollusc. The spicule and shell mineralogy in the halkieriids has been argued for by previous workers as being aragonitic; this further supports a molluscan relationship.

Affinities of Ordovician conulariid faunas from Central Anti-Atlas (Morocco) and Barrandian area (Czech Republic)

Zdeňka Vyhlasová

Department of Palaeontology, Museum of West Bohemia in Pilsen, Kopeckého sady 2,
301 36 Pilsen, Czech Republic <vyhlaska@volny.cz>

Close affinities of the Ordovician conulariid fauna were observed in the North Gondwana (Central Anti-Atlas, Morocco) and peri-Gondwana (Barrandian area, Bohemia) regions. Both regions are assigned to the EAP (*Exoconularia-Archaeoconularia-Pseudoconularia*) cool-water conulariid province (Van Iten-Vyhlasová, 2004) which confirms current palaeogeographical reconstructions of the Ordovician period.

The study was based on the set of 124 specimens from Anti-Atlas (Morocco) and more than 600 specimens from the Barrandian area (Czech Republic). The following species were identified to be identical in both areas: *Pseudoconularia grandissima*, *Exoconularia consobrina*, *Conularia (Archaeoconularia) insignis*, *Metaconularia imperialis*, *Metaconularia anomala*.

A very favourable preservation of the specimens from Central Anti-Atlas allowed us to identify new morphological features; *e.g.* first observation of the sculptured periderm on the surface of the species *Anaconularia anomala* is new proof for its classification among the genus *Metaconularia*. Newly studied morphological characteristics combined with the micromorphological analysis can help to improve the systematics of this group.

Brabcová, Z., Van Iten, H. (2004): Conulariids. pp.119–123. – In Barry D. Webby, Florentin Paris, Mary L Droser, and Ian G. Percival: *The Great Ordovician Biodiversification Event*. Columbia University Press, New York. 484 pp.

Ordovician conulariid diversity in the periGondwana and Baltica regions – a summary with a special view to the Ordovician of Barrandian

Zdeňka Vyhlasová

Department of Palaeontology, Museum of West Bohemia in Pilsen, Kopeckého sady 2, 301 36 Pilsen, Czech Republic <vyhlaska@volny.cz>

High biodiversity of the suborder *Conulariina* Miller and Gurley, 1896 is exhibited globally at the Middle-Upper Ordovician. In contrast to the Cambrian from which no genera is described, first occurrences of eight genera are documented from the Middle-Upper Ordovician of the periGondwana and Baltica regions.

The Perigondwana is characterised by the cool-water EAP (*Exoconularia-Archaeoconularia-Pseudoconularia*) conulariid province (Van Iten – Brabcová, 2004) typical of the following other species: *Anaconularia, Conularia, Conulariella, Eoconularia* and *Metaconularia*. Host rocks of these genera are usually fine-grained sandstones, shales, exceptional preservation is in iron ores. All the forms are medium to big conulariids with well-developed sculpture. The genus *Conulariella*, typical for its rectangular cross-section and smooth transversal ribs, is characteristic only for the Arenigian of Bohemia. The EAP Province includes France, Bohemia, Thuringia, Sardinia, Morroco, Turkey and, probably, Jordan.

The palaeocontinet Baltica is assigned to the warm-water CC (*Conularia – Climacoconus*) conularid province with the following other representatives: *Archaeoconularia*, *Conularina*, *Ctenoconularia*, *Eoconularia*, *Exoconularia*, *Glyptoconularia*, *Metaconularia* and *Pseudoconularia*. Host rocks are most often carbonates or cratonic basin shales. The CC province representatives are small to medium conulariid forms characteristic for its simple sculpture.

Brabcová, Z., Van Iten, H. (2004): Conulariids. pp.119–123. – In Barry D. Webby, Florentin Paris, Mary L Droser, and Ian G. Percival: *The Great Ordovician Biodiversification Event*. Columbia University Press, New York. 484 pp.

posters

New fossil arthropods and the evolution of the cephalic feeding system of arthropods and crustaceans

Dieter Waloszek[1], Martin Stein[2] and Andreas Maas[1]

[1]*Section for Biosystematic Documentation, University of Ulm, Helmhotzstrasse 20, D-89081 Ulm, Germany*
<dieter.waloszek@biologie.uni-ulm.de>, <andreas.maas@biologie.uni-ulm.de>
[2]*Uppsala University, Department of Earth Sciences, Palaeobiology, Norbyvägen 22, S-75236 Uppsala, Sweden* <martin.stein@geo.uu.se>

New information brought up from the Upper Cambrian 'Orsten' stem-lineage crustacean *Oelandocaris oelandica* Müller, 1983, and of several Lower Cambrian Arthropoda s. str. from the Chengjiang biota in China aided to enlight the evolutionary path of the feeding system in the head of Arthropoda and toward the crown group of Crustacea in particular. We suppose that from a rather simple mode of food intake by the first antenna, a first significant change occurred by the formation of a rigid but flat basipod for proximal food manipulation towards the mouth at the rear of the hypostome. In the stem lineage of Crustacea, the two post-antennal limbs and associated structures modified in a special way in two major steps: 1) inwardly oriented exopod setation; lobe-shaped '*proximal endite*' medially and basally to the basipod; 2) enlargement of '*proximal endite*' into a '*coxa*' portion proximal to the basipod in antenna and mandible in the Labrophora. This significant step was coupled with: development of a fleshy labrum at the rear of the hypostome; recession of the mouth in an atrium oris; fusion of the sternites of the post-oral head segments (= sternum); paragnaths on the mandibular sternite; fine setulation on all structures around the mouth. This concentrated food intake and manipulation to this region.

Faunal, sedimentological and geochemical indicators of dysoxia in Cretaceous marine sediments

Ellen L. Weavers

Department of Earth and Environmental Science, University of Greenwich at Medway, Central Avenue, Chatham Maritime, Kent ME7 4TB <we32@gre.ac.uk>

Cretaceous marine sediments worldwide are characterised by the occurrence of 'Oceanic Anoxic Events'—periods of widespread dysoxia during which organic matter was extensively deposited in 'black shale' facies on the shelves and ocean basins. These events are of considerable importance as some are major source rocks for hydrocarbons. Although many Cretaceous black shales have been characterised in terms of their organic geochemistry and carbon isotope stratigraphy, little work has been undertaken on the palaeoenvironmental signatures of dysoxia, and the recognition of grades of dysoxygenation.

Although diverse criteria for the recognition of low oxygen levels have been described, both at present and in the geological record, these have not been fully calibrated against each other. Initial work on the Folkestone Gault Clay is presented, where faunal indicators of palaeo-oxygenation are compared with sedimentological and geochemical proxies for dysoxia. Conclusions are drawn on the applicability and resolution of such palaeoenvironmental indicators with reference to their potential use in quantifying grades of dysoxia within Cretaceous marine shales.

posters

Embryonic development of the priapulid worm Priapulus caudatus L. and its phylogenetic significance

Sofia Wennberg
Department of Earth Sciences, Palaeobiology, Uppsala University, Norbyvägen 22,
SE-752 36 Uppsala, Sweden <sofia.wennberg@geo.uu.se>

Stem group members of the Priapulida are known from the early Cambrian. Today the phylum is classified as a member of the group Cycloneuralia (Ehlers *et al.* 1996) together with nematodes, kinorhynchs, loriciferans and nematomorphs. The embryonic development of *Priapulus caudatus* has been monitored from the first cell stage until the "loricate" larva stage for the first time. Priapulids are the only cycloneuralians that are likely to have a primitively large body size, and potentially at least, a relatively unmodified development. They may thus help us to resolve the early evolution of Ecdyozoa (cycloneuralians plus arthropods). One particularly important question that can be addressed with the help of this study is whether or not the segmental and coelomate features of the arthropods have been lost in the cycloneuralians or have been secondarily gained in the arthropods themselves. Resolving these questions would have an important bearing on our views of the bilaterian ancestry of these important morphogical features, and thus on our understanding of the early fossil record of animals.

Enigmatic fossils from the Soom Shale lagerstätte, South Africa

Rowan J. Whittle, Richard J. Aldridge and Sarah E. Gabbott
Dept. Geology, University of Leicester, University Road, Leicester LE1 7RH, UK
<rjw@le.ac.uk>, <ra12@le.ac.uk>, <sg21@le.ac.uk>

The Soom Shale Lagerstätte from South Africa is the only known Ordovician deposit with exceptional preservation equivalent to Cambrian occurrences at Chengjiang in China and the Burgess Shale of Canada. The horizon is located within the Cedarberg Mountains and is one of the most fossiliferous units in the Table Mountain Group. Organisms found to date include eurypterids, conodonts, orthocones, brachiopods, algae and a multitude of enigmatic forms. Soft tissues have been replicated by clay minerals and a high level of detail has been preserved. Examples include eurypterid musculature and respiratory structures, orthocones with radulae, brachiopods with pedicles and conodonts with preserved features of the head and trunk. In this study the documentation, analysis and identification of the enigmatic forms from the Soom Shale is bringing to light evidence of a greater diversity of organisms from this lagerstätte. Currently analysis is being focused on several arthropod like forms. Results test whether enigmatic features recognised in some Cambrian fossils persisted into Ordovician times.

Using guano as a tool in unravelling Cambrian palaeoecology

Lucy Wilson
Department of Earth Sciences, University of Cambridge, Downing Street,
Cambridge CB2 3EQ, UK <law41@esc.cam.ac.uk>

Defaecation is an essential part of most animals' alimentary process. As such, when preserved, it provides us with important information about who was eating whom in an ecosystem. An exceptionally well-preserved faecal pellet assemblage from the Middle Cambrian Mount Cap Formation in Canada shows a wide diversity in faecal pellet forms. Analyses of their morphology and contents allow deductions to be made about the producer and the food consumed, respectively, and shows that the complexity of the Cambrian ecosystem was already well developed. Thus we have a novel approach for gaining insight into the Cambrian ecosystem and this highlights the potential of using faecal pellets as a tool to help determine the palaeoecology of other systems.

Late triassic radiolarian from northern Thailand and its bearing on the palaeogeographic interpretation

Nutthawut Wonganan[1,2], Carine Randon[2] and Martial Caridroit[2]
[1]*Department of Geological Sciences, Faculty of Science, Chiang Mai University,*
Chiang Mai 50200 Thailand <n_wonganan@yahoo.com>
[2]*Laboratoire de Paléontologie et Paléogéographie du Paléozoïque (LP3), UMR 8014 et*
FR 1818 du C.N.R.S., Sciences de la Terre, Université des Sciences et Technologies de Lille,
59655 Villeneuve d'Ascq cedex France

Excellent preserved Carnian and Norian (Late Triassic) radiolarians have been discovered from the bedded chert and siliceous–argillitic limestone sequences exposed at north of Mae Sariang city, westernmost of northern Thailand. The radiolarian assemblage including *Multimonilis* Yeh has been reported from Norian in East Central Oregon of North America. These taxa are the characteristic species of the *Corum Parvum* assemblage and can be correlated to a biostratigraphic position of *Xipha straita* subzone. Therefore this assemblage is considered to be early to middle Norian (but not younger than late middle Norian) age. The presence of the faunas of the same assemblage in two different sedimentary facies in the area suggests the lithological transition of the sequence of the Late Triassic sediment reflects the change from deep to shallow marine environments or the narrowing of the ocean. Moreover, the occurrence of the Carnian to Norian radiolarian assemblages from these distal and proximal oceanic facies shows that the closure of the Palaeo-Tethys Ocean between the Shan-Thai and Indochina allochthonous continental terranes in this area was not prior the middle Norian time. And the similarity of fauna of Tethyan affinity to those of European Tethys and North American and Japanese oceans also suggests that this ocean was connected to the other oceans (at least by seaway). Based on our newly obtained data the closure of this ocean may have started during Late Permian or Early Triassic and the definitive closure was after middle Norian time. Owing to this very important palaeontological information the palaeogeographic scene of the palaeo-ocean between the two main continental terranes at late stage, which formed Southeast Asian mainland today, is now very much understandable.

Wallowaconcha in the United Arab Emirates – a Late Triassic bivalve a long way from home

M. A. Woods[1] and T. E. Yancey[2]
[1]*British Geological Survey, Keyworth, Nottingham, England* <MAW@bgs.ac.uk>
[2]*Department of Geology & Geophysics, Texas A&M University, College Station, Texas, USA*
<yancey@geo.tamu.edu>

Enigmatic fossils were discovered during recent fieldwork by the British Geological Survey (BGS) in the northern United Arab Emirates (UAE). The material consists of shells of the bivalve *Wallowaconcha*, a large Late Triassic bivalve with highly specialised morphology. *Wallowaconcha* is characterised by large size, thick shell and large wing-like folds of the shell wall extending from an inflated body chamber. The wings consist of parallel surfaces linked by vertical plates and were used by the animal as stabilisers for a reclining life habit on the sediment surface. 'Wing' fragments are the most common fossils found in the UAE deposits, but a few more complete valves have been found. The material occurs at three separate localities within the Ghalilah Formation (Elphinstone Group) in the UAE, dated as Late Triassic (Norian) on the basis of bivalve and brachiopod faunas. Hitherto, *Wallowaconcha* has only been recognised in displaced island arc terranes with North America tectonic affinities located in eastern Panthalassa, a palaeogeographically distant area from central Tethys in the Late Triassic.

Parasitism in favositids (Tabulata)

Mikołaj K. Zapalski

Laboratoire de Paléontologie stratigraphique, FLST & ISA, UMR 8014 & FR 1818 du CNRS, 13 rue de Toul. F 59046 Lille cedex, France, and Warsaw University, Faculty of Geology. Żwirki i Wigury 93, 02-089 Warszawa, Poland <**m.zapalski@uw.edu.pl**>

Organisms described by Sokolov as genera *Chaetosalpinx*, *Camptosalpinx Phragmosalpinx* and one genus described by Oekentorp, *Helicosalpinx,* of unknown taxonomical position, were considered in the literature as commensal organisms of favositids.

On account of the following characters:

- position between corallites,
- sometimes present in the lumen of corallites,

it seems that these organisms must have perforated the soft body of favositid colony. Such perforation probably enabled an interaction between the host and the perforating organism that was negative for the host (because of perforation and perhaps also metabolic interaction) and positive for the perforating organism (in other cases this organism would not perforate). Their relationship can therefore be described as parasitism.

The character of the relationship between other organisms known concurring with favositids (*e.g.* genera *Asterosalpinx* Sokolov, *Actinosalpinx* Sokolov) and their hosts remains unknown.

Radionuclides within shell of freshwater mollusc

Michael A. Zuykov, Boris E. Burakov and Evgeniy B. Anderson

Biomineralogical group, Laboratory of Applied Mineralogy and Radiogeochemistry, V.G.Khlopin Radium Institute, 28, 2nd Murinskiy Ave., 194021 St.Petersburg, Russia
<**zuykov@riand.spb.su**>

Radioactive elements are among commonly detected components of the shell material in any group of modern shelly fauna due to bioaccumulation from the environment. However, their concentrations in the samples are usually extremely low, therefore information on the distribution and behaviour of radionuclides within shell matrix of hydrobionts cannot be obtained from the samples collected from the natural environment even in highly polluted areas. However, such knowledge is important and could be applied in neontology, palaeontology, and biomineralogy. In this presentation we show results of the study of the ^{241}Am-doped shell material of the bivalve freshwater mollusc *Dreissena polymorpha* after contamination through the water pathway in controlled laboratory conditions. The aim of the study is to trace a distribution of this radionuclide within the shell of the mollusc using a cathodoluminescence analysis. Our data suggest a high capacity for incorporation of this radionuclide in mollusc shells in laboratory conditions. The cathodoluminescent images of Am-doped shells (containing about 0.00005 wt.% of Am) in transverse sections were characterized by light bands of blue-green colour which are parallel to the shell surface and corresponded to different shell layers. Maximum intensity corresponds to the mineralized layers boundaries containing membranes and therefore characterized by high organic content. However, there is still some uncertainty in the discrimination of the Am separately from organic and mineral components of mollusc shells, which is the subject of further investigations.