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The Palaeontology Newsletter

Contents

Reminder: The deadline for copy for Issue no 80 is 11th June 2012.

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Editorial

The publication of *Newsletter* 79 marks the end of the beginning of my new post as *Newsletter* editor. Many thanks to my predecessor Dr Richard Twitchett, who prepared a most useful guide to my editorial duties and tasks before moving to the even more demanding Council role of Secretary. Unlike the transition to editor in the world of journalism, I did not inherit an expenses account, tastefully furnished office and a PA, but I do now have the <**newsletter@palass.org.uk**> account. That is how to contact me about *Newsletter* matters, send me articles, and let me, and Council, know what you want, and don't want, from the *Newsletter*.

The *Newsletter* has expanded greatly in the past decade and there is a great deal more copy and content, which you can check by investigating the *Newsletter* archive on the Association website. Such an expansion relies on a steady flow of copy from the membership and our regular columnists. We are fortunate to have the regular contributions from Prof. Norm MacLeod in the shape of the *PaleoMath* column, which is essentially an open-access volume on quantitative techniques that contributes to the Association's charitable aims, as it is freely available from the website; from Dr Jan Zalasiewicz, who has maintained his columns on a range of topics while also publishing books aimed at a wider audience (see the review of his *Planet in a Pebble* on p. 98); Dr Liam Herringshaw fulfills my previous role as Reporter. However, I would like to hear from other aspiring columnists with ideas for series. Dr Charlotte Jeffery-Abt also needs reviewers for books on a regular basis, as well as books to review – so if you've published a relevant book or edited volume, ask the publisher to consider sending a copy to Charlotte.

Beyond the regular columns, we are always glad to get meeting reports, occasional articles and announcements of forthcoming meetings. For instance, I am planning to develop a series of articles highlighting palaeontological research and institutions in locations that are neglected for whatever reason. This could range from a regional museum that has a fantastic collection from a particular time interval or site to areas where new research opportunities are available but being neglected. Good writing needs practice and articles in the *Newsletter* are one means of getting that experience, especially during the long haul of a Ph.D. Or perhaps you are thinking about branching out into science writing, journalism or communication. Articles in the *Newsletter* can form part of a portfolio of work in that context and I'm always willing to give editorial support to get articles ready for publication without the dread "major revisions" letter.

Al McGowan
University of Glasgow

Newsletter Editor
<**newsletter@palass.org**>

Association Business

Nominations for Council: AGM 2012

At the AGM in December 2012, the following vacancies will occur on Council:

- Vice President
- Newsletter Reporter

Nominations are now invited for these posts. Please note that each candidate must be proposed by at least two members of the Association and that any individual may not propose more than two candidates. Nomination must be accompanied by the candidate's written agreement to stand for election and a single sentence describing their interests.

All potential Council Members are asked to consider that:

> 'Each Council Member needs to be aware that, since the Palaeontological Association is a Registered Charity, in the eyes of the law he/she becomes a Trustee of that Charity. Under the terms of the Charities Act 1992, legal responsibility for the proper management of the Palaeontological Association lies with each Member of Council'. Responsibilities of Trustees can be obtained from <**secretary@palass.org**>.

The closing date for nominations is **1st October 2012**. They should be sent to the Secretary: Dr Richard J. Twitchett, School of Geography, Earth and Environmental Sciences, Plymouth University, Plymouth, PL4 8AA, UK; email: <**richard.twitchett@plymouth.ac.uk**> or <**secretary@palass.org**>.

The following nomination has already been received:

> Newsletter Reporter: Council nomination Dr. L. Herringshaw

Grants and Awards

Grants-in-Aid

The Palaeontological Association is happy to receive applications for loans or grants from the organizers of scientific meetings that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application should be made in good time by the scientific organizer(s) of the meeting on the online application form. Such requests will be considered by Council at the March and October Council Meetings each year. Enquiries may be made to the <**secretary@palass.org**>, and requests should be sent by **1st March** or **1st October**.

Grants-in-Aid: Workshops and short courses

The Palaeontological Association is happy to receive applications for loans or grants from the organizers of scientific workshops or short courses that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application should be made in good time by the scientific organizer(s) of the meeting on the online application form. Such requests will be considered by Council at the March and October Council Meetings each year. Enquiries may be made to <**secretary@palass.org**>, and requests should be sent by **1st March** or **1st October**.

Lapworth Medal

The Lapworth Medal is awarded by Council to a palaeontologist who has made a significant contribution to the science by means of a substantial body of research; they are not normally awarded on the basis of a few good papers. Council will look for some breadth as well as depth in the contributions in choosing suitable candidates.

Nominations must be supported by a resumé (single sheet of details) of the candidate's career, and further supported by a brief statement from two nominees. A list of ten principal publications should accompany the nomination. Council will reserve the right to not necessarily make an award in any one year. Details and nomination forms are available on the Association Website at <**www.palass.org**>. Deadline is **1st May**. The Medal is presented at the Annual Meeting.

Small Grant Awards AGM 2011

The small grants awarded by the Association include the Sylvester-Bradley Award and, for the first time this year, the Callomon and Whittington awards. Council agreed that the following applicants should receive awards: P. Andreev (Sylvester-Bradley Award: £1,300); S.L. Brusatte (Sylvester-Bradley Award: £1,460); M.F. Chavez-Hoffmeister (Sylvester-Bradley Award: £1,500); B. Hedrick (Sylvester-Bradley Award: £1,200); P. Hull (Sylvester-Bradley Award: £1,500); J. Ortega Hernández (Callomon Award: £1,464); A. Otero (Whittington Award: £1,225); and O. Rodríguez Reyes (Sylvester-Bradley Award: £1,148). The project proposals are summarised in the following pages:

Scale characters of basal chondrichthyans

Plamen Andreev
(University of Birmingham)

The project seeks to investigate the squamation of Carboniferous euchondrocephalan and iniopterygian chondrichthyans from the collections of the Field and Carnegie Museums of Natural History (USA). This material is represented by many exceptionally-preserved, articulated specimens from the Mississippian Bear Gulch Limestone of the Heath Formation and the Pennsylvanian black shales of the Mid-North American Forest City and Illinois basins. The purpose of the project is to document the gross morphology, growth patterns and hard tissue types of scales from members of stem euchondricephalan groups (Petalodontiformes, Orodontiformes, Eugeneodontiformes and Gregoriidae) and the basal chondrichthyan order Iniopterygia. This research proposal is an integral part of a larger PhD programme that aims to resolve the phylogeny of stem chondichthyans, in a time of major revisions of early gnathostome relationships. The collected data would contribute to our understanding of the apomorphic state of scale characters in basal chondrichthyans and help determine the systematic position of many pre-Devonian gnathostome scale taxa.

Tracking Vertebrates across the Permo–Triassic Extinction

Stephen L. Brusatte
(American Museum of Natural History)

The ~20 million years bracketing the Permian–Triassic Boundary (260–240 Ma) was a remarkable interval of Earth history, during which ecosystems were devastated by the worst mass extinction in geological history, faunas subsequently recovered, and numerous major groups of vertebrates originated and diversified. Understanding the patterns of vertebrate extinction, recovery, and evolution across the P/T boundary is a major objective, but is difficult because few fossil localities preserve terrestrial vertebrates spanning the P/T boundary. I propose a two-week field expedition to Poland, a country that boasts a remarkable record of Late Permian to Early Triassic vertebrate footprints. Footprints have been virtually ignored in studies of P/T vertebrate evolution and provide an untapped source of data for understanding the tempo and dynamics of the mass extinction. I will visit seven new Late Permian and six new earliest Triassic footprint sites and conduct a rigorous census of footprint diversity, evenness, abundance, and size. These data will help address several major questions, including: Is there a dramatic and sudden drop in footprint diversity and evenness across the P/T boundary? When do diversity and evenness recover to pre-extinction levels? Do diversity and evenness recover in concert or does one recover first? How does the relative abundance of different major footprint types, corresponding to major vertebrate clades, change across the boundary?

A review of the Peruvian Neogene penguins

Martin F. Chavez-Hoffmeister
(University of Bristol)

South America has been recognized as one of the world's richest areas for fossil penguins, but until the late twentieth century this record was limited to Argentina. However, since 2002 three new species have been described from the Neogene of the Pisco Formation in Peru, all belonging to the extant genus *Spheniscus*. These included the oldest record for the genus, *S. muizoni* from the Middle Miocene, of which the type belongs to the Muséum National d'Histoire Naturelle, Paris, France. The other two species are *S. megaramphus* and *S. urbinai* from the Late Miocene to Late Pliocene, both belonging to the Museo de Historia Natural de la Universidad de San Marcos, Lima, Peru. These species include associated skeletons, offering a unique opportunity for the realization of anatomical and phylogenetic studies. However, the original researches lacked phylogenetic analysis or even a detailed anatomical description in the case of *S. megaramphus* and particularly in *S. urbinai*.

This project aims to resolve the deficiencies found in the literature through a direct review of the type specimens along with new specimens that contribute significantly to our knowledge of these species, including new skeletons and the first known partial skeleton of *S. megaramphus*, in order to delve into their anatomy and phylogeny. This is part of my PhD research that aims to explore the phylogeny of penguins, relating aspects of their morphological evolution to climate and oceanographic changes.

Understanding Gait Transitions in Basal Ceratopsia

Brandon Hedrick
(University of Pennsylvania)

Using evolutionary robotics and computational modelling, we are attempting to reconstruct the plausible gaits of an early horned dinosaur, *Psittacosaurus*. *Psittacosaurus* was spread across Asia during the Early Cretaceous period from about 125 million years ago to 115 million years ago. It is the most common dinosaur found in Mongolia and China and is represented by over 200 specimens. The animals that *Psittacosaurus* evolved from were likely bipedal and the animals that evolved from *Psittacosaurus*, like *Triceratops*, were quadrupedal. It has never been definitively shown whether *Psittacosaurus* was bipedal or quadrupedal as it has characteristics of both types of posture. By using a 3D musculoskeletal reconstruction it is possible to model its gait in a computer. We can decipher plausible gaits, and which gaits were more likely than others, based upon metabolic cost (a useful by-product of the GaitSym software). Understanding the potential gaits of *Psittacosaurus* will help us to resolve how bipedal posture evolved into quadrupedal in the earliest horned dinosaurs. It will also help us understand more on how *Psittacosaurus* moved and its locomotor ability (*e.g.* speed). Given that it was such a widely distributed dinosaur and survived for ten million years, knowing more about this successful organism's locomotion will provide a better understanding of this species.

Planktonic foraminifera and the K–Pg mass extinction

Pincelli Hull
(Yale University)

The Cretaceous–Paleogene (K–Pg) mass extinction is the most recent and best understood of the five great mass extinctions in Earth history. As such, it provides a natural experiment for understanding processes of extinction and recovery. This is particularly true in open ocean sediments, which preserve the histories of countless microfossils across this interval. Among these microfossils are representatives from three trophic levels: tiny primary producers (calcareous nannoplankton), consumers (planktonic foraminifera and radiolarians), and mid-level consumers (fish teeth and shark scales). These fossils, along with environmental proxies, allow us to move beyond studying the recovery of species diversity, to reconstructing the re-evolution of ecosystem structure.

However, as with all research, challenges remain. One of these challenges pertains to the accurate and consistent identification of planktonic foraminifera to species level. Early Palaeocene planktonic foraminifera are notoriously difficult to identify due to their generalized appearance and wide morphological variation. Here I propose to work with Dr Helen Coxall to document the practical application of planktonic foraminiferal species concepts from the 'Atlas of Paleocene Planktonic Foraminifera' across multiple sites in the Palaeocene. We aim to produce a large set of reference images documenting the accepted species variability and a revised set of datums for key biostratigraphic markers.

A new Burgess Shale-type locality from British Columbia

J. Ortega Hernández
(University of Cambridge)

The impact that the study of Burgess Shale-type biotas has had on our understanding of Cambrian palaeobiodiversity and the early evolution of animal phyla cannot be over-emphasized. Since the discovery of the now iconic Walcott Quarry (Middle Cambrian Stephen Formation) in British Columbia, several new fossiliferous localities have been found; the discovery of additional productive outcrops, as well as the information that can be extracted from them, will continue to increase in direct relation to the efforts invested in field exploration, careful collection and detailed descriptive work. The aim of this project is to describe a new locality with Burgess Shale-type macrofossils in the vicinity of Mummy Lake in Kootenay National Park (British Columbia). After a very brief reconnaissance visit during the Summer of 2010, it was possible to make a preliminary assessment of the fossil diversity preserved in the locality, which includes: abundant trilobites (*e.g. Oryctocephalus*, *Olenoides*, *Elrathia*), chancelloriids, gogiids, *Pirania*-like taxa and a small number of soft-bodied organisms, such as isolated *Eldonia* guts and a vermiform organism with an annelid-like body construction. These findings provide a clear indication of the potential value of the "Mummy Lake locality", and suggest that more extensive exploration and sampling will likely lead to the discovery of a new and meaningful source of information about Life in the Cambrian.

Functional anatomy in the transition Prosauropoda-Sauropoda

Alejandro Otero
(La Plata University)

The transition from basal sauropodomorphs to sauropods is one of the most dramatic evolutionary transformations recorded in the history of dinosaurs but is currently poorly understood. Key points in the origin of Sauropoda are the transformations of the postcranium related to the acquisition of quadrupedalism and graviportal locomotion from the bipedalism present in basal sauropodomorphs. The objective of the project is to increase the knowledge of morphological, evolutionary, and functional aspects of sauropodomorph dinosaurs, understanding the locomotor transition between basal sauropodomorphs and sauropods. The project focuses on functional and biomechanical aspects of the appendicular skeleton of *Anchisaurus*, *Seitaad* and *Sarahsaurus*. I will then integrate these new anatomical and functional inferences within a phylogenetic framework to determine the sequence of appearance of appendicular characters of functional significance in the evolutionary transition from basal sauropodomorphs to sauropods.

Miocene woods from Panama: palaeoecology and palaeoclimatology

O. Rodríguez Reyes
(Royal Holloway, University of London)

Widening of the Panama Canal offers a once-in-a-century opportunity to study the events leading up to the Great Biotic Interchange that resulted from the collision of the Americas. In my PhD project (commenced October 2010), I am examining spectacular Miocene fossil forests from the Canal Zone that provide base-line data on the region's vegetation prior to collision. However, my initial work has thrown up something of a paradox: preliminary studies of the fossil trees imply a rather open, seasonally dry forest in contrast to palynological data that suggest dense, wet rainforests held sway. Testing between these two hypotheses is important to resolve the habitats, ecology and migration patterns of megafauna (rhinos, horses, elephants) found in association with the fossil plants – and hence the responsiveness of communities to the later fusion of the Americas. In my proposed Palaeontological Association-funded study, I am going to analyse quantitative wood anatomical characteristics for modern trees along a seasonally dry to ever-wet tropical gradient based on material collected in Central America but accessioned in Austria. Comparison of modern data with my fossils will further resolve the nature of Central American vegetation in mid-Miocene times and improve understanding of mammalian habitat, community ecology and migration potential.

Problems with Palaeontological Association card payments through Worldpay

In the Summer of last year, we altered the system for making payments to the Association using credit or debit cards. All payments for subscriptions, sales and the Christmas Meeting are now made through WorldPay, who take the payment on our behalf and forward it (less costs) to our bank account. WorldPay is the biggest online payments gateway, and they are responsible for making sure that the system is not subject to any fraud. When it works, it works well for both yourselves and us.

Unfortunately, the system is rather inclined to reject certain payments, and between 10% and 15% of attempted payments are refused. We can see these listed on our WorldPay secure site, and they are frequently long-standing members who are well-known to us and who are completely blameless. Usually (but not always) they are outside the UK. The card details that they have given always check out, but still the payments are refused. Sometimes 'suspicion of fraud' is quoted as the reason, but usually no reason is given. WorldPay will not give us any more information, except sometimes to say that the cardholder's bank has withheld the payment.

There are a couple of minor things that people can do to reduce the chance of rejection:

- Use the same cardholder's address as your card statements are sent to;
- Put the postcode / zipcode into the space reserved for it, not in the body reserved for the rest of the address;
- Try to have goods delivered to the same country as the card was issued in (often not appropriate in our profession, I know);
- Give the CVV/CVC (security) number (the last three digits on the signature strip), where asked;
- Make sure your e-mail address is correctly formatted.

If there is still a problem and you are outside the UK, it is quite likely that your bank is suspicious of a payment being made to a UK source, and they are preventing the money from being collected by WorldPay. It is well worth you contacting your cardholder and asking them to allow this, before trying again using the same card.

If you are still refused payment, then we have other mechanisms to allow us to meet your wishes. We are still running our old card payments account, and you can send you card details (16-digit number; CVV number; Expiry Date) direct to me (Executive Officer Palaeontological Association, IGES, Llandinam Building, Aberystwyth University, Aberystwyth, SY23 3DB, UK). The easiest way is to e-mail it to me at <**palass@palass.org**> (a site checked only by me). Many people are happy to do this if they split the relevant information between more than one e-mail message. Many others are not happy to do this; please use snailmail or leave your card details on my voicemail at +44 (0)1970 627107. This is also a number used only by me. We are also happy to accept cheques in GBP drawn on a UK bank, or checks in US Dollars drawn on a US bank.

I'm very sorry about the problems that a few of you are having. As some of you have pointed out, it is not doing any good to the Association's reputation, and we are doing as much as we are currently able to ameliorate the situation. We ask you to help do your bit as well.

Tim Palmer
Executive Officer, The Palaeontological Association

news

The following awards were made at the Annual Meeting in Plymouth:

Lapworth Medal: Prof. Richard J. Aldridge

Paul Smith, Howard Armstrong, Mark Purnell and Phil Donoghue write: Richard J. Aldridge obtained a first class degree in Geology at the University of Southampton before completing a PhD at the same institution, supervised by Ronald Austin. The initial topic of Dick's thesis was Carboniferous conodont stratigraphy, and he published a paper in *Nature* based on his first period of study, before switching his thesis topic to the conodont stratigraphy of the British Silurian which, at the time, was an entirely unknown quantity. Dick's thesis, published as a *Bulletin of the British Museum (Natural History)* in 1972, remains a landmark publication in Silurian conodont stratigraphy, and it defined his research programme for the first phase of his career, extending his research from the British Silurian to Europe, the Arctic, the Arabian Peninsula, and South East Asia. Dick exploited the conodont fossil record in many other and innovative ways. He was an early adopter of the Conodont Alteration Index which he applied to understanding the Caledonides. He also wrote seminal papers exploring the application of numerical taxonomy to conodont systematics, the concept of homology in conodonts and application of a biologically meaningful anatomical terminology, as well as the first papers applying numerical cladistics to understanding the evolutionary relationships of conodonts and the internal phylogeny of the clade.

Dick's taxonomic and stratigraphic work contributed to establishing the Silurian stratotypes which, of course, provided the model on which other stratigraphic systems were subsequently defined. With David Siveter, he led a research programme exploring the micropalaeontology of Silurian stratotypes, including ostracod, foraminiferal, acritarch, chitinozoan and spore biostratigraphy. This work led to a revised understanding of Silurian stratigraphy, but also revealed faunal and floral evolutionary dynamics in response to environmental change. This work culminated in the development of the P and S Cycle theory of climate and oceanographic change in the Early Palaeozoic that he developed with Lennart Jeppsson. This theory is both controversial and provocative and, as such, it has served as a vehicle for debate over climate change in truly Deep Time.

The second phase of Aldridge's career focused on conodont palaeobiology and the nature of the conodont organism. As late as 1981 the celebrated palaeozoologist and conodontologist Klaus Müller identified the affinity of conodonts as 'one of the most fundamental unanswered questions in systematic palaeontology'. In that same year, in collaboration with Derek Briggs and Euan Clarkson, Dick Aldridge identified the first soft tissue remains of the conodont organism (published in 1983) and in the ensuing years they constrained debate to chordates – no mean feat since conodonts had previously been attributed to almost every major animal phylum, as well as to plants and to fungi. Aldridge then led an international renaissance of conodont palaeobiology that revolutionised understanding of every aspect of the biology and evolution of these organisms, and brought the significance of these advances to global prominence in the debate over the origin of vertebrates, demanding the attention of molecular and developmental biologists, comparative morphologists and phylogeneticists alike. In so doing, Aldridge built a dynamic research team that survived several academic generations, the legacy of which is a series of distinct research teams in United Kingdom, led by former PhD students and postdocs, fostered to these prominent positions by the love and care he has always directed to the personal and intellectual development of his research students and postdocs.

Soft tissue remains of conodonts were encountered in Scotland, and the USA, but it was the discoveries of giant conodonts in South Africa that broadened Dick's interests in soft tissue preservation, and this can be recognised as the third and current phase of his career. Dick has devoted much of the last two decades to elucidating the composition, preservation and evolutionary significance of the Late Ordovician Soom Shale Lagerstätten, stimulating a comparative analysis of soft tissue preservation through low-temperature geochemistry. In turn, this led Dick back to China and the Early Cambrian Chengjiang Lagerstätte, resulting in a catalogue of papers in the world's leading journals and an encyclopaedic volume detailing its fauna that was published by Cambridge University Press.

Dick has succeeded scientifically at the highest level, but his career contributions are much more than the sum of the papers. He served two terms as Head of Department at the University of Leicester, Sub-Dean of Graduate Studies, Senator, on the University Research Committee (including Chair of Physical Sciences), as External Examiner for undergraduate degrees at a number of UK Universities and in innumerable research degree examinations worldwide. Dick also served on the Review Panel of the Natural Environment Research Council, as a Specialist Advisor for RAE2001 and RAE2008, on Royal Society research grant committees, co-chaired the Third International Palaeontological Congress (London, 2010), and co-wrote the bid to make the Chengjiang Largerstätte a UNESCO World Heritage Site. Early in his career Dick's professional duties included Chair of the Conodont Group of the British Micropalaeontological Society (as was), President of the Geology Section of the British Association, on the Councils of The Geological Society and The Palaeontographical Society, and for the Palaeontological Association he served as Marketing Manager. Dick also served as the Chairman/President of most of the major professional societies in palaeontological science, including Chairman of the British Micropalaeontological Society (1995–1998), Chief Panderer of the Pander Society (1998–2004), President of the International Palaeontological Association (2002–2006), and President of the Palaeontological Association (2008–2010). Characteristically, he did not accept any of these as honorific roles and work tirelessly to lobby for individuals and institutions under threat or seeking new opportunities.

Dick's achievements and contributions to our science have been recognised previously by the award of The Pander Medal (the highest award of the international society of conodontologists) and Honorary Visiting Professor positions in the China University of Geosciences (Wuhan) and Yunnan

University. However, what we suspect gives Dick greatest pleasure is the extent and ongoing success of his protégés. Without doubt, all of this success can be attributed to the example Dick set as a supervisor of our science, of our intellectual and of our personal growth. Even those students whose research has taken them into different fields find that, wherever they go, Dick has led them there. He encouraged us all to flourish – undergraduates, postgraduates, technicians, postdocs and colleagues alike – and his ever-expanding legacy of researchers and their research groups, entwined by an Aldridgean network, is a testament to this.

President's Prize: Dr Gregory D. Edgecombe

… digging up centipedes in Vietnam (Feb 2012)

Greg Edgecombe has been a Research Leader in the Department of Palaeontology at The Natural History Museum since 2007. This followed 14 years as a researcher at the Australian Museum, Sydney. He received his PhD from Columbia University in 1991, trained at the American Museum of Natural History. Since 2003 he has been an Associate in Invertebrate Zoology at Harvard University's Museum of Comparative Zoology. He has published more than 170 peer-reviewed articles.

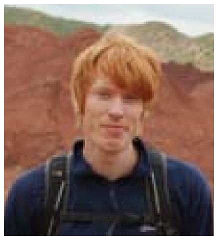
Edgecombe's research is focused on the evolutionary interrelationships of the major groups of arthropods and the position of Arthropoda in animal evolution. He has worked extensively on Palaeozoic "Burgess Shale-type" faunas and their significance for understanding early arthropod evolution. Studies on animals from Palaeozoic Konservat-Lagerstätten from China, Argentina, Canada and Australia include five papers in *Nature* and *Science*. An analysis of the evolutionary relationships of trilobite-allied arthropods, drawing heavily on original work on Cambrian fossils from China, was awarded "Best Paper" in *Journal of Paleontology* (1999). Some 65 publications on trilobite systematics focus on applying ontogenetic data from silicified fossils to phylogenetic questions and historical biogeography.

Contributions to the field of arthropod phylogeny include "total evidence" (morphological + genetic data) analyses, such as a seminal *Nature* paper in 2001 with 329 citations and a recent synthesis in *Proceedings B* that adds microRNAs to phylogenomic and morphological datasets. Edgecombe is also among the most prolific centipede systematists in the world, author of the standard phylogenetic analyses of centipedes based on morphology and DNA sequence data, and has published invited reviews on the systematics of myriapods and their position in the Arthropoda.

Contributions to animal systematics more broadly have been made as the palaeontologist on the "Assembling the Protostome Tree of Life" project. This work led to expanded phylogenomic datasets and new techniques for analyzing high-throughput molecular data. Publications in *Nature* (*e.g.*, Dunn *et al.* 2008, with 421 citations!) and *Proceedings B* on animal evolution based on samples of hundreds of genes, have been among the most computationally intensive phylogenetic analyses undertaken, and have contributed to improved resolution of the Tree of Life.

The Australian Academy of Science awarded Edgecombe its 2004 Fenner Medal for Distinguished Research in Biology. Invited keynotes include symposia at the International Congress of Invertebrate Morphology (Denmark, 2008), Advances in Crustacean Phylogenetics (Germany, 2008), Updating the Linnean Heritage (Italy, 2008), Origin of Major Groups (Sweden, 2007), and Congreso Argentino de Paleontología y Bioestratigrafía (Argentina, 2006). Edgecombe was Vice-President of the International Palaeontological Association (2006–2010). In 2001 he was awarded a visiting lectureship from Humboldt University, Berlin. He is currently an Editor or Board Member of *Proceedings of the Royal Society* (*Series B*), *Journal of Systematic Palaeontology*, *Invertebrate Systematics*, *Arthropod Structure and Development*, *International Journal of Myriapodology*, *Journal of Zoological Systematics and Evolutionary Research*, *Geodiversitas*, *Alcheringa*, *Zootaxa*, and *Zoomorphology*, and reviews for >50 journals across diverse scientific disciplines.

Hodson Award: Dr Richard J. Butler



Paul Upchurch writes: Richard is an outstanding young researcher who has already made a very significant impact on his field. He achieved a 1st Class B.Sc. in Geology at Bristol University in 2002 and completed a Ph.D. (Cambridge University) on the phylogenetic relationships of ornithischian dinosaurs in 2007. The latter resulted in a paper in the *Journal of Systematic Palaeontology* published in 2008 that has already accrued 57 citations on ISI Web Of Knowledge.

Richard's research has focused on dinosaur evolution, but he has worked extensively on other important aspects of the Mesozoic, as well as helping to develop a number of important new analytical approaches. Topics covered by his recent papers include body size evolution, diversity patterns in the Mesozoic, the effects of sampling biases on reconstructions of macro-evolutionary patterns, pterosaur and dinosaur fossil record quality, and the end-Permian and end-Triassic mass extinctions. This work has resulted in a very impressive 44 peer-reviewed papers over the past five years, plus one edited volume. Richard's publications are substantial and significant, appearing in high impact journals such as *Nature*, *Science*, *Biology Letters*, *Evolution*, and *Proceedings of the Royal Society B*. Consequently, he has already accrued over 300 citations and has an H-index of 9. Furthermore, much of this work has been funded through grants awarded to Richard, amounting to the best part of £800,000.

Richard is tackling several important issues in palaeobiology. Some of the highlights include an analysis of the relationship between sea level, sampling, and dinosaur diversity; new approaches to the analysis of morphological disparity and fossil record sampling in pterosaurs; an analysis of the latitudinal distributions of dinosaurs that indicates that the dominant latitudinal patterns seen among extant organisms on land probably do not pre-date the Eocene; and highly cited work on ornithischian dinosaur phylogeny.

Recently, Richard was awarded a grant under the highly prestigious DFG Emmy Noether Programme, which will allow him to set up and run his own research group for the next five years. These awards are extremely competitive – Richard's success indicates that the DFG also rate his track record and future prospects very highly. I have no doubt that he will go on to be a leading figure in our field during the rest of his career.

Mary Anning Award: Mr David Brockhurst

Peter Austen writes: For the past 12 years David has worked at Ashdown Brickworks in Bexhill, East Sussex, and during that period has assembled an important collection of fossil vertebrate material. David is a good example of a private collector who readily donates all important material to his local museum (Bexhill Museum, East Sussex). Examples are the partial remains of a *Polacanthus*, including the first *Polacanthus* teeth to be found on mainland UK, and the partial remains of an '*Iguanodon*', all of which are being studied for publication by William Blows and Kerri Honeysett. Other important finds include vertebrae from a new species of salamander, and the cervical vertebra of a new small Wealden theropod; papers on these two finds are currently being prepared by Steve Sweetman (University of Portsmouth). An important feature of David's collecting, apart from his generosity in donating specimens, is his meticulous recording of the beds from which all of the specimens are recovered, and his willingness to share the knowledge he has accumulated over the last 12 years.

Mary Anning Award: Dr Christopher J. Duffin

David Ward, Charlie Underwood and Andy Gale write: Chris Duffin is an amateur vertebrate palaeontologist with over 30 years research experience. He has published over 120 scientific papers and contributions to books, and is the co-author of the 2010 *Handbook of Paleoichthyology.* Volume 3D. Chondrichthyes. Paleozoic Elasmobranchii: Teeth.

His interest stems from his childhood in Wiltshire, collecting Bathonian fossils from local stream beds, road cuttings and disused quarries. As a student, his research interests began with the marine vertebrate faunas of the European latest Triassic and quickly led to specialisation in fossil fishes, particularly chondrichthyans and their trace fossils (coprolites). His main research themes since the 1980s have been aspects of shark evolution (particularly the origins of neoselachian sharks and the evolutionary history of hybodonts); morphology and taxonomy of chimaeriform holocephalians; Triassic to Cretaceous marine vertebrate faunas; Carboniferous faunas and biostratigraphy; with minor forays into Jurassic crocodilians and Triassic amphibians and reptiles. He has worked on material from the marine Permian and Cretaceous of the USA, the Cretaceous of Africa, the Carboniferous of South America, and the Carboniferous through to the Cretaceous of Europe and Russia. More recently he has been invited to study perfectly preserved fossils from various fossil-lagerstätten, including Osteno (Early Jurassic, Italy), Holzmaden (Early Jurassic, Germany) and Solnhofen (Late Jurassic, Germany). Another recent research interest is the history of vertebrate palaeontology and the uses of geological materials in medicine from classical times to around 1750. He recently helped to organise an international conference entitled "A History of Geology and Medicine" (together with Dick Moody and Christopher Gardner-Thorpe) for HOGG (History of Geology Group); this took place at the Geological Society in Burlington House on 1st & 2nd November 2011.

All this has been achieved in his spare time whilst working as a full-time secondary school science teacher.

ASSOCIATION MEETINGS

56th Annual Meeting of the Palaeontological Association
University College Dublin, Ireland *16 – 18 December 2012*

The 56th Annual Meeting of the Palaeontological Association will be held at University College Dublin, Ireland, organised by Patrick Orr, Aoife Braiden and colleagues from UCD School of Geological Sciences.

Symposium & Annual Address

The meeting will begin with a symposium on Sunday 16th December, followed by the Annual Address and an evening reception.

The topic for the Annual Symposium this year is 'Taphonomy and the fidelity of the fossil record'. Keynote speakers confirmed so far are Prof. Derek Briggs (Dept of Geology and Geophysics, Yale University), Prof. Susan Kidwell (Dept of the Geophysical Sciences, University of Chicago), Dr Maria McNamara (Dept of Geology and Geophysics, Yale University and UCD School of Geological Sciences, University College Dublin) and Dr Rob Sansom (Dept of Biology and Biochemistry, University of Bath).

The Annual Address 'New views on the origin of our species' will be given by Prof. Chris Stringer (Dept of Palaeontology, Natural History Museum, London, England).

We are extremely grateful to the Palaeontological Association for their sponsorship of this symposium and the Annual Address.

Conference and UCD Earth Institute Lecture

The conference itself will commence on Monday 17th December with a full day of talks and posters and the Association AGM. In the evening there will be a reception followed by the Annual Dinner. Tuesday 18th December will comprise a dedicated poster session and talks. The time allocated to each talk will be 15 minutes; parallel sessions, if required, will be organised for part of each day to accommodate as many speakers as possible.

Our meeting will conclude on Tuesday 18th December with an early evening lecture by Prof. Andy Knoll (Department of Organismic and Evolutionary Biology, Harvard University) on 'Systems Paleobiology: Physiology as the link between biological and environmental history'. We are extremely grateful to the UCD Earth Institute (<**http://www.ucd.ie/earth/**>) for their sponsorship of this lecture.

Please note that Prof. Knoll's lecture is being held in collaboration with the British Sedimentological Research Group (<**http://www.bsrg.org.uk/**>); their Annual Meeting will also be hosted by UCD School of Geological Sciences and is to be held between 18th and 20th December – so why not come to Dublin for both?

Venue and travel

The conference will take place at Belfield, the main University College Dublin campus, which is approximately 4km south of the city centre.

We hope to be able to provide a coach service in the morning and evening between the campus and the city centre where the suggested accommodation (and our evening social activities, including the Annual Dinner) will be based. The campus is extremely well served by various bus routes from the city centre for those who wish to travel independently.

Getting to Dublin

For those who wish to avoid flying, Dublin can be reached by combining rail or bus links to a number of ferry terminals in Scotland, England and Wales. Some routes also cross to southern Ireland from Brittany and Roscoff in France. However the weather can be rough in December and ferries delayed or cancelled. See <**http://www.aferry.co.uk/ferry-to-ireland-irish-ferries-uk.htm**> for more details on prices and routes.

Plane

Dublin is served by Dublin International Airport, which is located north of Dublin City Centre. There are currently direct air links into Dublin from a large number of airports globally, and, in particular, from Britain, continental Europe and North America. Irish airlines serving the airport are Aer Lingus (<**http://www.aerlingus.com/**>), Aer Arann (<**http://www.aerarann.com/**>) and Ryanair (<**http://www.ryanair.com/**>), with regular flights from most other international carriers.

For further details see

<**http://www.dublinairport.com/gns/flight-information/destinations-airlines.aspx**>

or

<**http://www.meetinireland.com/**>.

Transferring from the airport

There are frequent connecting buses from the airport to the city centre, including a shuttle service, Airlink, which brings passengers directly to Busáras (Central Bus Station, Dublin). Further details are available at <**http://www.dublinbus.ie/**>.

Aircoach operates a service from Dublin Airport to Leopardstown / Sandyford / Stillorgan which passes the UCD main entrance. Further details are available at <**http://www.aircoach.ie/**>.

Taxis from the airport should cost no more than €40 to the city centre and €50 to UCD.

Train

Dublin is served by two main railway stations: Connolly Station and Heuston Station. It is a short walk from Connolly Station to O'Connell Street, where Dublin Bus numbers 2, 11 and 46A can be boarded for UCD. Service 145 provides a direct route from Heuston Station to Belfield via the city centre. For further information please visit Iarnróad Eireann (Irish Rail) at <**http://www.irishrail.ie/**>.

Bus: Dublin Bus

Dublin Bus numbers 2, 3, 11, 17, 39A, 46A, 84 and 145 all provide services to the Belfield campus. The 39A terminates within the Belfield campus, and can be boarded in the City Centre from College Street. Services 2, 3, 11 and 46A can be boarded at O'Connell Street. Several additional Xpresso services operate directly to campus during morning and evening peak times. For timetable information please visit the Dublin Bus website at <**http://www.dublinbus.ie/**> and search for "University College Dublin".

Taxi

There are usually abundant taxis in operation in the city centre at any given time. It is possible to hail a taxi from the street, but convenient taxi ranks in the city centre are located on O'Connell Street, Middle Abbey Street, Dame Street and St Stephen's Green.

Accommodation

Rooms in a variety of hotels, hostels and guest-houses at a range of prices are available in Dublin city centre and can be reserved through the usual channels. In addition, we have organised discount rates at major city centre hotels and hostels. More information on these and alternative accommodations will be provided in the next edition of the *Newsletter* and on the website in due course.

Registration and booking

Registration and booking (including abstract submission) will commence in June 2012. Abstract submission will close at midnight on Monday 10th September 2012; abstracts submitted after this time will not be considered. Registration after this date will incur an additional administration charge of approximately €30, with the final deadline of Friday 16th November 2012. Registrations and bookings will be taken on a strictly first-come-first-served basis. No refunds will be available after the final deadline.

Registration, abstract submission, booking and payment (by credit card) will be available online via the Palaeontological Association website (<**http://www.palass.org/**>) from June 2012. Accommodation must be booked separately; details of our suggested choices will be available on the website.

Travel grants to student members

The Palaeontological Association runs a programme of travel grants to assist student members (doctoral and earlier) to attend the Annual Meeting in order to present a talk or poster. For the Dublin 2012 meeting, grants of less than £100 (or the € equivalent) will be available to student presenters who are travelling from outside the British Isles. The actual amount available will depend on the number of applicants and the distance travelled. 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 (e-mail <**palass@palass.org**>) once the organisers have confirmed that their presentation is accepted, and before 1st December 2012. Entitle the e-mail "Travel Grant Request". No awards can be made to those who have not followed this procedure.

Why not make a stay of it?

Dublin at any time of the year is an excellent destination for a short break; why not come a few days early and see what the city has to offer? Alternatively, if anyone travelling with you is not enthralled by the idea of three days at a PalAss conference there is plenty to do. We'll provide further details in the next *Newsletter* (and are happy to advise if we can). In the meantime, try <**http://www.discoverireland.ie/Places-To-Go/Discover-Dublin**> and <**http://www.visitdublin.com/**>.

We look forward to seeing you in Dublin in December!

UNIVERSITY OF CAMBRIDGE

THE PALAEONTOLOGICAL ASSOCIATION

PROGRESSIVE PALAEONTOLOGY

CAMBRIDGE 2012

Department of Earth Sciences

UNIVERSITY MUSEUM OF ZOOLOGY CAMBRIDGE

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For any queries, please contact the organizers at **progpal@palass.org**
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Organisers: *Caroline Sogot, Chloe Marquart, Emily Mitchell, Kelly Richards, Rick Thompson, Nick Crumpton and Javier Ortega Hernández*

From our Correspondents

Encore des Buffonades, mon cher comte?

The cat returns – naturally. Not to be loved or hated this time, but simply – anatomized. Peer into the feline soul, and what do we find? Our cat sits and listens. To hear, now, that it has 'an innate malice, a false character, a perverse nature'… (a paw is licked, thoughtfully) … which age increases even more and education only masks'. The green eyes open a little wider. The analysis continues. The words are of 'determined thieves … flexible and flattering like rogues … they have the same deftness, the same taste for wrongdoing, the same bent for plunder … the appearance of attachment is seen by … their ambiguous looks'. The cat looks up, ambiguously, and yawns. One aristocrat can always recognise another.

The aristocrat here – the clumsy two-legged one, that is – is George-Louis Leclerc, the Comte de Buffon. He is giving a taxonomic description of a creature that had not long ago been called *Felis catus* – though he had no truck with this classification. The binomial epithet, Linnaeus's new invention, was to him quite simply inadequate and – worse – a guess at inferred biological relationship. Buffon gave much thought to this kind of problem, and to many others. He was a scientist by choice even before the profession properly came into being. He lived long – but, luckily for him, not too long. He died in 1788, just a year before the French Revolution. Had he lived longer, Madame Guillotine would likely have claimed him (she took, instead, his son[1]).

Political fashion aside, Buffon was influential – Ernst Mayr called him the most important naturalist between Aristotle and Darwin. He was quite literally epoch-making. To be precise, he made seven of them (the cat, in its domestic variety, appeared in the seventh). The epochs will detain us later. As far as stratigraphy goes, it wasn't a bad start. But first things first.

George-Louis Leclerc was born into the kind of family that might figure in the slow, patient novels of a century ago. They lived at Montbard, in the Bourgogne region of France. Generation by generation, by judicious choice of employment and spouse, they climbed gradually higher. Labourers first, most likely; then a barber-surgeon's apprentice, who earned enough to send his son to train as a doctor – and his son, in turn, became a local judge. This was Buffon's grandfather. Buffon's father became a lawyer – and bought the rights to collect the unpopular (but lucrative) salt tax locally. Marriage improved the family prospects yet further – his wife's uncle was wealthy (from tax collection, also), and he was childless, too, so when the young George-Louis arrived into the world, it was a good move to ask him to be godfather. He died soon after, leaving his fortune to the infant: with it, the father bought for him the rights to the holding of Buffon, a small village a few miles away, and the lord's rights to the castle there.

[1] It's a sad story. The young Buffonet (the nickname says it all, really) could not live up to the almost superhumanly high standards set by the father. His youth was short and somewhat erratic. He came of age, briefly, in the Revolution – joining, indeed, the revolutionaries. This revolution, famously and greedily, ate its own children – even the adopted ones. There came a denunciation – and after that, the scaffold. His last words, facing the tricoteuses, were 'Citizens, my name is Buffon'.

The young Buffon, therefore, grew up into a tradition of careful and solid security: a lesson that he wasn't to forget. He could – he *should* – have grown up to become a person of some standing in local government. But, somehow, he became France's greatest naturalist. That's the assessment of Jacques Roger, his biographer, made in the full knowledge of that redoubtable trio who followed him – Geoffrey St. Hilaire, Lamarck and Baron Cuvier. (The shade of the Baron, at least, may well be taking offence at this point.)

He trained in law – but during his studies developed a taste for the scientific ideas then being discussed, avidly, among small groups of like-minded people. He declared that he would be a scientist. His father was not amused, not least because that profession barely existed – and even if he secured any kind of position, it would mean stepping down (or falling off) the social ladder. The young George-Louis was to prove him wrong, on both counts. Relations with his father seem never to have been good. They took a turn for the worse when the father, a widower, married a young woman, threatening George-Louis's inheritance from the rich uncle. George-Louis threatened a lawsuit, and won. He kept the Montbard estate, and its castle, and that provided him with a base – and a workplace – for the rest of his life.

His career, too, progressed – because he carefully cultivated his contacts and, mainly, because he developed a tradition of work (12 to 14 hours a day) that he sustained, day in, day out, for the rest of his life. He made his reputation first with mathematics, obtained a junior position at the Academy of Sciences, researched (at Montbard, largely) the properties of timber, then became head of the Royal Botanic Gardens. He had arrived.

Mathematics had been abandoned: at the highest levels, it wasn't his calling. He was an effective administrator, both at the Gardens and at Montbard. His own studies turned to natural history, and over a lifetime he systematically described everything, from minerals to animals and plants – to humans, even, in his *Histoire Naturelle*, amounting to 36 volumes. Voluminous in every sense, but brilliantly written, it put him on the same kind of level as Voltaire and Rousseau in public philosophical debate.

His most widely read work, though, was shorter in content – a single slim volume – but the one that ranged most widely over time and space. It was *Les Époques de la Nature* – the story of the Earth, written late in his life. Vividly imagined, evocatively written, popular with the public, controversial among his peers and more than a touch heretical, it was also the first science-based narrative of the Earth: its first stratigraphy. It was the crowning achievement of a remarkable life.

It is curious that there seems to be no English translation of *Les Époques*. Not just in modern times – there seems to be no translation, even, that can be tracked down in the contemporary electronic jungle (a jungle that otherwise seems to have developed quite respectably deep roots, temporally speaking). Is that because Buffon became so quickly passé, a figure of the *ancien régime*, that he dropped out of sight with uncommon speed? Or is it, as Jacques Roger notes, because he wrote too much: all those weighty volumes of the *Histoire Naturelle*, mostly published in his lifetime. Now, the *Origin of Species* isn't a slim paperback – but it's just a single doorstop of a book at least. Or is it because he was too popular? He wrote French beautifully, evocatively, excitingly – and he wasn't shy of big ideas. So, with more than a hint of sour grapes, some of his fellow savants spoke of him as a 'phrasemonger', the inference being that that excluded him from the highest levels of the scientific elite.

Perhaps. For whatever reason, he's not terribly well served in the English-speaking world. For a quick introduction, there's a fine essay by Stephen Jay Gould (with whom, by the way, there is a more than a hint of resemblance as regards character, scientific and literary), in *The Lying Stones of Marrakech*. There is also an English-language version of Roger's biography of him. That's rather larger, and dauntingly comprehensive, but it's a gem. Very considerable scholarship is worn lightly and with elegance – and, as a bonus, is quite beautifully translated by Sarah Lucille Bonnefoi. There's John Lyon's and Phillip Sloan's varied compendium. And there's also honourable mention of Buffon in Martin Rudwick's magisterial (no, there really is no other word for it) accounts of the origins of geology in *The Meaning of Fossils* and *Bursting the Limits of Time*.

Nevertheless, Buffon remains somewhat in the shade of his illustrious successors as regards the big ideas of the day. Take the question of extinction, for instance – the idea that, long ago, strange and unfamiliar plants and animals walked the Earth, then died out. In my mental landscape, taken largely from Rudwick[2], it is Cuvier who 'invented' extinction, by showing that the mammoth is both different from the elephant and is nowhere present today. It's a lovely, persuasive account. But Buffon, I am now persuaded, got there first.

It's all there in *Les Époques*. The structure of the book is a little unusual to modern eyes, mind. There is a 'First Discourse', a kind of introduction, then the main text – the seven epochs given a chapter each – followed by a considerable amount of 'Justifying Notes' – in which detailed evidence to support the narrative is provided, chapter by chapter (there's a useful glossary, too).

Part of the reason to have the 'First Discourse' was to get the apologies in first. Buffon was writing, of course, when the religious orthodoxy held considerable sway, and when it was dangerous to one's career – even when one was as well-connected and politically astute as Buffon was – to disseminate ideas that ran counter to prevailing biblical interpretation. It is sometimes said that Buffon scorned the religious hierarchy, and wrote his apologias in carefree irony. But to me he seemed to be taking care to cover his back, and was genuinely concerned to placate the Sorbonne (which was then the main theological college in France). Thus, after working hard to argue that the Biblical timescale – that he was about to shatter – was written metaphorically rather than literally, he wrote that his 'purely hypothetical' ideas concerning the Earth could in no way harm the 'unchanging axioms' of religious faith, that were 'independent of all hypothesis'. The stratagem worked, on the whole – though he did have some anxious moments on the way.

In that 'First Discourse', he noted that in rock strata there were the remains of animals and plants that could not be found in nearby land or in adjoining seas. Therefore, these had either died out, or moved elsewhere on Earth. So there, at the beginning of the main text, there is a modest suggestion, hedged about with some caution. Go to the 'Notes Justificatives', though, and the equivocation disappears. He quotes the 'large petrified volutes' (*i.e.* ammonites, that were 'up to several feet across'),'bélemnites', 'numismales' (nummulites) and other such that were common in the limestones around Paris. The significance of these, he noted, for sure depended on 'long study and reflective comparison of all of the species of petrifactions found in the heart of the Earth': that is, he was looking forward to the start of a science, not yet born, that came to be palaeontology. *Nevertheless*, 'these examples, and others I can cite, are sufficient to prove that species of shells and crustaceans used to be present in the sea that do not exist any longer'. You can't have a clearer – and more reasonably founded – statement than that.

2 'Life's revolutions', Chapter 3 in *The Meaning of Fossils*.

He also detailed at length reports of enormous fossil skeletons pulled from the swamps adjoining the Ohio River, in North America. These had bones and tusks (of 'very good ivory') resembling those of an elephant – but the teeth were quite different, without complex grinding surfaces, but terminating in five or six blunt points, thus being more like those of a hippopotamus. After considering, then rejecting, the notion that these might represent a mixture of elephant bones and hippopotamus teeth (among many bones, none other like the hippopotamus were found) Buffon concluded that this was an animal that had not survived to the present. For 'an animal that is larger than an elephant cannot hide anywhere on Earth and still remain unknown'. This was pretty much the argument that Cuvier later, and influentially, applied to the mammoth. Here was Buffon using this logic two decades (and one political revolution) earlier, on what we now know as the mastodon.

There's more to *Les Époques*, though, than one flash of palaeontological insight (a lucky hit, some might say). In this first attempted history of the Earth (and of the planets, indeed), from beginning to end, time's arrow flew inexorably from the white heat of (non-divine) creation to envisage a future Earth, frozen and biologically dead. It is a history derived from the evidence of the ground, some seen by him personally, and the rest taken from his prodigious reading and correspondence. A good deal of the history is not original to him, but was a weaving together of ideas that were then beginning to circulate, by word of mouth or in print. But *le tout ensemble* is his alone. And the evidence told him, quite clearly, that Bishop Ussher's few thousand years did not come close to being sufficient. The Earth had to be older. How much older?

His measuring stick was essentially the same as that later used by Lord Kelvin – the cooling of the Earth. In an early trial run at *Les Époques*, the 'Theory of the Earth', one of the first volumes of his Natural History, he had, in effect, an Earth without a history, without a beginning or end. (It was somewhat akin, indeed, to that of James Hutton's vision). Within a rather vague timescale, land and sea, now and then, changed places. Later, though, he was persuaded (through Leibnitz's work) of an originally molten state of the Earth. That fitted in with the evidence he knew of (such as that temperature increased upon descending into mines underground), and with the overall vision that he was developing. Moreover, it gave him a measuring stick for Earth time.

How to calibrate that measuring stick, though? He heated up variously-sized balls of iron and measured how long they took to cool. Measuring the temperature of such objects was not so simple, then. Buffon did not trust the crude thermometers of the day (this was when ideas of phlogiston were still current, remember) and measured instead the time it took for the ball to cool sufficiently to be held by hand for a minute without injury[3].

Projecting his data gave him a figure of 75,000 years since the Earth had formed as a molten globe. He was aware that the error bars were very large, and he was very deliberately conservative. But, even so, that gave a starting point for the whole narrative. He, and the Earth itself, could begin.

How to construct an Earth? In Buffon's chosen process, the first epoch begins with a comet striking a glancing blow against the sun, the material flung out then condensing as the planets, that therefore start their existence as molten masses surrounded by vapour. They subsequently cooled – but how did the Sun stay white-hot? Buffon did not (deign to?) consider it as, for

[3] One suspects that with trial and error of this sort, occasional injury was part and parcel of the process. Worse, it seems that Buffon regarded women's hands (more sensitive, you see) as the best measuring devices. Scientific, perhaps, but not ideally gallant.

instance, a stupendously large burning coal-ball. For him, it was the effect of all the bodies of the Solar System, seen and unseen, orbiting around it. He thus seems to be invoking gravitational stretching and squashing – which is what we now know provides the heat energy to keep, for example, the volcanoes of Io erupting. Buffon was wrong, of course (the effect on the Sun is trivial) – but he was thoughtfully and interestingly wrong.

In the second epoch, the Earth cools, and begins to solidify. A crust develops on the surface, and this develops wrinkles and ridges – these are the present mountain chains – and, beneath those, bubbles that become underground caverns and cavities (he was to need those, later). To us now, it may seem that he had actually gone backwards from a steady-state Huttonian Earth where mountain ranges rose and fell, to a single-cycle Earth that has retained its primordial contours to the present day.

That would be a little unfair. In creating the first science-based whole-Earth narrative, he was positing a logically consistent succession of different states, through his empirically determined time scale. This fixed time scale could only allow a single basic geography, so this is far from Hutton's 'deep time'. Nevertheless, to a child beginning to swim, the shallow end of a pool may seem scarily deep. Even with his 75,000 years, Buffon went out of his way to reassure his readers (who measured time in hours, years and, perhaps, human lifetimes), suggesting ways to them of mentally coping with the unimaginable temporal abyss of those seventy-five millenia (think in terms of money, he said, and not years[4]).

It took, he said – extrapolating from his iron-ball experiments – two thousand, nine hundred and thirty-six years for the Earth to solidify. Even as he wrote, he knew these figures were likely out by orders of magnitude[5]; but he maintained this precise conservatism partly, perhaps, to avoid his readers contemplating yet more outlandish time-spans, partly not to deepen his sinfulness vis-à-vis the watchful Sorbonne, and partly to keep the story rattling along.

Because, goodness me, the story does move on. In its original version, shorn of the notes, glossary – and without Roger's illuminating but lengthy commentary in the widely-recommended 1962 edition – it's just a shade over two hundred pages long – and that's with large print and small pages. It's a slim paperback ideal for a short railway journey – had railways been invented then, of course.

So, on with the story. Buffon word-paints a picture of a solid, but still hot, Earth wreathed in water vapour, a jagged barren landscape formed of igneous ('*vitrescible*') rocks. Below, precious metal ores form within rock fractures – and there's a lot on the details of this: metals were big business, of course, then as now, and a good early school for practical geology.

Some thirty to thirty-five thousand years after the Earth formed, he reckoned, it was cool enough for the gathering rainfall to begin to settle on the surface, without instantly being vaporised, as thick mists swirled, and tempests raged. It's evocative stuff, reminiscent of Conan Doyle (or Jules Verne); one can see how the lay reader could be entranced – and the scientific establishment could look on, a little sniffily. And what an ocean formed! Buffon took the information he had – that strata with fossils could be found on mountains up to 4,000 metres high – and that's where he placed the primordial sea level.

4 Well, that might have worked for the wealthier of his readers.

5 His unpublished manuscripts show that he was stretching his timescale, some forty-fold, to three million years. Out of prudence, he didn't publish this.

It was a Waterworld – but one where the broad-brush geology is perfectly sensible. There's no debate here between Plutonism and Neptunism. Buffon simply states, matter-of-factly, that the primary rocks are broken down, decomposed by the water to produce the salts in the world ocean and the sands and muds that accumulate in layers on the sea floor. What's more, he sees the link between muds and shales and slates, attributing the various states of these strata to different degrees of drying and compaction (his one-way history doesn't allow for much in the way of metamorphism).

There was lithostratigraphy, though, based on that of the hills and valleys around his beloved Montbard. He is clear that, in that region, there are layers of shale, overlain and succeeded by limestone. He describes, for instance, the three-dimensional connection between a well sunk in a valley (through fifty feet of shale) and the layers of limestone in the valley sides above. The limestone is full of shells, so the stuff of the rock, therefore, is made of the remains of countless generations of ancient animals; they extracted their shell-material out of the waters in which they lived (into which it had previously been put, of course, by the action of the waters upon the primordial fire-rock). *Ancien régime*, perhaps, but there's some very modern-seeming sedimentary geochemistry here.

Now, he sees that the shales contain many fossils, too – those ammonites and belemnites. Life, therefore, appeared in his history pretty much together with the formation of sedimentary strata. The organic particles of which life is made, he thought, more or less automatically formed themselves into complex organisms, as soon as conditions became tolerable for life. There is no long gestation period for organic molecules here, still less any notion that it is the smallest, simplest kind of life that comes first. Life is thus an inevitable, and immediate, outcome of chemistry – on the Earth and, he said, on other planets too.

Buffon was not an evolutionist in anything like the modern sense or, indeed, really at all. But in a sense he was a biostratigrapher, for he could see that, in any one place, there was a succession of strata and fossils (the 'elephant bones' from the surface sediments he knew came later than the ammonites). Perhaps more exactly, he was a biogeographer charting the course of life, as it followed the conditions of a changing Earth.

The pattern in such a model was – *must be* – clear and logical. The first regions to cool are the polar regions, and this is where rain first falls, and the oceans first gather. The cooling proceeded equator-wards, and the watery and habitable zone followed. Indeed in one of Buffon's more Hollywood-esque flights of fancy, he saw the southern tips of South America and southern Africa as having been carved by the ocean waters, as they rushed northwards from the southern ocean (he had no idea, then, that those waters might conceal an Antarctica).

The polar regions, therefore, saw complex and abundant life while the low latitudes remain fiercely hot and inhospitable. As the Earth cooled, the polar regions gradually congealed, and the baton of life was passed on towards the equator. Species of animals and planets migrated, became extinct, or came into existence – assembled ready-formed from organic particles – as the Earth's climate belts migrated. It's phantasmagoric stuff, but somewhere in there lie the beginnings of palaeoclimatology.

That might be stretching it a touch. But there is, for sure, in Buffon's account of his third epoch, some astonishing palaeoenvironmental reconstruction. For as well as the ammonite-bearing shales, he was aware that, elsewhere, there were strata containing coal seams. He knew that the coal strata and the marine shales tended to be tilted[6] and near-horizontal, respectively, and he guessed correctly that the marine shales lay on top. He could see, too, that the coal-bearing strata contained many impressions of plants that looked 'tropical' in nature, hence fitting in nicely with his cooling trend.

The coals, he went on, were the remains of the Earth's first vegetation, swept from the mountaintops that poked above the water, and into the sediment layers that surrounded them. Successive layers of plant debris and mineral sediment accumulated, to form the many layers of coal in these beds. He wondered at the immense amount of plant material that grew and was buried, and mused on the immensity of past time that they must represent. More: he expressly compared these ancient coal-accumulating environments with the mouths of the Mississippi and the Amazon – and then (in some detail) with the coastal swamps of Guyana, where trees live and die and fall into the morass, there to decay[7].

As an identification of a modern analogue, it's a bulls-eye. Not that he saw any of these places, but he travelled in his mind through his extensive correspondence and his voluminous reading. The mind, he said once, is the best crucible.

In his fourth epoch, the waters receded, and the land masses (draped with fossil-bearing strata) were exposed. The water went, he thought, underground, as the roofs of caves and caverns (those bubbles in the cooling crust, you might recall) cracked and foundered (accompanied by earthquakes), allowing the waters to drain downwards.

As the sea-level dropped, another phenomenon began: volcanism. This is not just Buffon trying to please the book-buying public, to pack as much of the Earth's genuine melodrama as possible into his narrative. It was his deduction of cause-and-effect in Earth processes, based upon imperfect information, mostly drawn from secondary sources. He knew that many active volcanoes were at or near sea level – Stromboli, Etna and so on. He also knew that there were extinct volcanoes in France, inland on high ground in the Auvergne. This was before, too, scientist-explorers such as Alexander von Humboldt explored the high Andes, to bring back reports of Chimborazo and Cotopaxi.

Therefore, he reasoned, the mechanism that produces volcanic eruptions is something to do with the proximity of rock, air and water – and he surmised the spontaneous, catastrophic combustion of minerals such as pyrite. It was wrong, of course, but for the day not unreasonable[8]. And, it gave his pen free rein to indulge in colourful descriptions of a ravaged Earth with emerging (and foundering) landscapes, vanishing seas and volcanoes. Once the general mayhem died down, though, the world, now just 15,000 years ago, emerged into the fifth epoch, with new lands: the northern kingdom of the giant elephants.

Buffon knew of the many finds of bones that resembled elephants, rhinoceri, hippopotami and such in Europe – and the stories of similar bones, extracted in large numbers from the frozen lands of Siberia. He more or less ignored the common assumption that their remains had

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[6] The tilting he thought was due to the sedimentary layers accumulating on steep slopes.

[7] So frequently in those thick forests, he noted, that travellers needed to be careful to sleep next to healthy and not rotting trees, to avoid being crushed in their sleep.

[8] The most violent eruptions, we must recall, are typically phreatomagmatic ones, where the flash-heating of water suddenly introduced into a magma chamber can greatly increase the explosivity of an eruption.

been swept into those regions by Noah's Flood. He knew there were simply too many of these skeletons for such an explanation to be true. And – other than his carefully crafted assertions, aimed at the Sorbonne, of the absolute primacy of divine scripture – he did not try to look for evidence of Biblical events in the strata (and criticized those who did). He simply interpreted the evidence in terms of natural – *i.e.* physical, chemical and biological – processes[9].

For him, this was evidence of a warmer Earth – still unbearably hot in the tropics, he thought, but with a tropical-style fauna inhabiting northern lands that are now mostly frozen wastes. And those lands might have been yet hotter, because some of the Siberian bones were larger than those of modern elephants. Thus, although he did not distinguish elephant from mammoth (as Cuvier was to do later), he did note differences. He ascribed these to what we might today call ecophenotypic variation, with morphology controlled by environment (in this case, temperature). This fitted, quite reasonably, within his over-arching narrative of a cooling Earth.

With the sixth epoch there came the separation of the continents. For the bones of the 'elephants' were scattered across Europe, Asia and North America. Thus, he deduced there must have been free movement, then, between these continents. It's not quite continental drift that Buffon is invoking here. It is ocean formation, though – that of the Atlantic, in particular – with Buffon invoking former connections between North America, Greenland, Scotland, Scandinavia. It is another episode of crustal foundering that he saw as the cause. Islands such as the Azores and Newfoundland are seen as remnants of a former landmass, the great 1755 Lisbon earthquake is mentioned as, in effect, an after-shock of these larger crustal displacements and (of course) the legend of Atlantis is brought in, too.

The Earth's new geography though, remained old in human terms. For he could see the new, later stratigraphy was building: the Nile and Mississippi deltas, the coastal plain of Guyana, built of Amazon muds. These new (and enormous) masses of sediment must, he saw, have post-dated the birth of the Atlantic. As we get nearer to the present, Buffon's timescale, amazingly, is not so far off our modern late Pleistocene-Holocene chronology. And, of course, these new landscapes were the foundation of the seventh epoch: the epoch of mankind.

It has a curious title: *Lorsque la Puissance de L'homme a secondé celle de la Nature*. That doesn't mean that the power of human actions on the Earth were secondary to natural forces – but rather that they assisted them. Here, humans arise (as an animal species set apart from all others) and begin to transform the world. It is the first real expression of the Anthropocene concept[10], and it is mixed in with history that is both real (Egyptian, Chinese) and very speculative (a much earlier, peaceful and enlightened civilization). Generally Buffon saw this as a good thing – not only in itself, but because humans could, for a while, warm the world and stave off the final, terminal freeze. He finishes as an optimist, looking forward to humanity seeking glory not through war but through science – and finding true happiness in peace[11].

Well, it was quite an epic, in scope if not in length. There was something to please – and annoy – everybody. The reception it received was mixed – and, among Buffon's fellow savants, generally

9 Jacques Roger discusses at length the evidence of what religious belief Buffon may or may not have had. He didn't give much away in his writings, and attended Mass regularly – because that was the done thing. Roger's view is that privately Buffon was by and large an agnostic.

10 Crutzen, 2002.

11 … and we all know how *that* aspiration turned out.

critical. The atmosphere is nicely given by a letter written (and perhaps sent) by Jean Etienne Guettard[12], which can only be referring to *Les Époques*. 'Yet more Buffonades, my dear Count…' it begins, going on (in rather rambling fashion, to be honest) to first faintly praise the 'delicate and elegant phrases' with which Buffon 'with brilliant spirit, like Syrano (sic) de Bergerac', traced his 'hypothetical ideas'. Guettard then made clear that he thought this brilliance was put to ends that were not worthy of 'the great Buffon' who was now 'incorrigible, and that is not good, my dear Count, that is not good'. The fine adventure story, he went on, warming to his theme, 'would be devoured by the maidservant and then amuse the lackey' – but it was unworthy of one who could shine a light for the most sublime Spirits…

In truth, Buffon's optimistic cosmology of his first epoch offered an easy target. Even as he was writing, realisation was dawning that comets were not objects that were sufficiently large and dense to tear planet-sized masses of material from the Sun. And, there were complaints, as predicted, from among the theologians, who realised the significance of Buffon's timescale for the literal interpretation of the Scriptures. But, these were an annoyance rather than a danger for Buffon – who, in any event, was hard at work on continuing the *Histoire Naturelle*, with the world of minerals his latest enthusiasm.

And, *Les Époques* did bring him a new readership that went far beyond the servant classes that Guettard seemed so disdainful of. Catherine the Great of Russia ordered a copy, was captivated – not least because her Siberia was shown as a cradle of life on land – and corresponded with Buffon over the next two years. Buffon was delighted, and replied in glowing (if not downright flattering) tone to the formidable monarch.

As royalty went into sharp decline just after Buffon's death (he was 81), so did his reputation, at least in France. Even in natural history, these things matter, and the reputation of the man ennobled by Louis XV suffered with respect to that man of the people, Citizen Linnaeus. And, of course, there came the wave of the new with Cuvier *et alii*, to eclipse the works of the past.

Buffon might rest, today, in the shade of his illustrious successors. But he's not to be forgotten completely, as the man who tried to put together a truly holistic account of the Earth and its inhabitants. And did it in style. Indeed, the phrase he is probably most associated with now, is '*le style c'est l'homme même*' ('the style is the man himself').

At this point, one might detect, somewhere in that comfortable spot in the back of the room, a superior twitch of long whiskers. The paws stretch out, sleepily. There is no need, though, to wake to loudly protest the case. It is naturally self-evident that the monopoly of *real* style on this planet has been entirely feline – from long, long before the seventh epoch.

Jan Zalasiewicz

Acknowledgements: I am indebted to Jacques Grinevald for prompting me to explore Buffon's life and work (and for his subsequent comments on this essay). The initial motive was utilitarian – his role in the Anthropocene story – but there were many and deeper layers to Buffon's life and work, as I came to realise.

[12] A botanist and mineralogist; he first recognized the Auvergne volcanoes as such; and in plotting the locations of minerals and their enclosing rocks in France, made a geological map, in 1746. This was more than half a century before William Smith, though Guettard lacked Smith's stratigraphical insights.

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PalaeoMath 101
The Centre Cannot Hold II: Elliptic Fourier Analysis

The Zahn and Roskies (1972) shape function represents a comprehensive, generalized, and highly adaptable method for avoiding the limitations of centre estimation when conducting a closed-form outline analysis via Fourier decomposition. However, this approach never really caught on with Fourier analysis practitioners and/or morphometricians. To a large extent this was probably a matter of not catching on with the authors of textbooks on Fourier analysis and the teachers of Fourier analysis methods. Indeed, most of the canonical numerical taxonomy and morphometrics textbooks (*e.g.*, Blackith and Reyment 1971, Sneath and Sokal 1973, Pimentel 1976, Bookstein *et al*. 1985, Zelditch *et al*. 2004) scarcely discuss outline-based methods at all, while others have been highly critical of the very idea of trying to analyze outlines (*e.g.*, Bookstein 1991). A lack of easily accessible, public-domain software that could be used for implementing a Fourier analysis based on Zahn & Roskies (ZR) shape functions also hampered its application and so its acceptance. I will return to a discussion of the ZR shape function in the next column when I take up the topic of eigenshape analysis. However, I'd like to close this section on Fourier-based outline semilandmark analysis with a presentation of the most popular current method of implementing a Fourier-based outline analysis, elliptic Fourier analysis (EFA).[1]

Although I've never seen it acknowledged in any description of the EFA method, there is quite a suspicious similarity between EFA and ZR-based Fourier analysis that has always struck me as being suggestive of a conceptual link. In order to illustrate this let's return to the pathological outline of the benthic foraminiferal species *Ramulina globulifera* (Fig. 1).

[1] This technique was originally named elliptic Fourier analysis (Giardiana and Kuhl 1977), but has also been referred to as elliptical Fourier analysis (*e.g.*, Lestrel 1997).

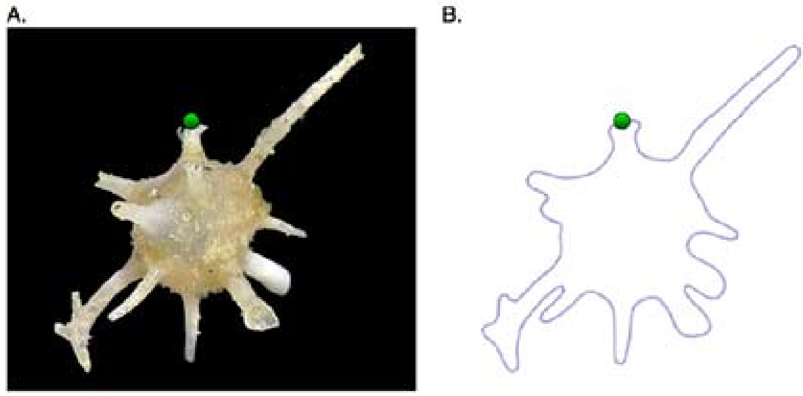


Figure 1. Shape of the spinose benthic foraminifer species Ramulina globulifera*. A. Image of* R. globulifera *specimen; B. implied outline defined by an interpolation of 300 equally spaced boundary outline semilandmarks. The starting point for digitization is shown by the green landmark.*

As you will recall from the last column, the problem with this outline is that it's very far from exhibiting a single-valued character. No matter what centre is selected the outline cannot be represented accurately by a shape function based on the lengths of radius vectors drawn from the centre to the periphery such that the angle between the radius vectors is constant and all radius vectors cross the outline at one, and only one, point. The ZR shape function solves this problem by interpolating a set of semilandmark points around the outline such that the inter-point distance is constant and the shape represented by a series of net angular deviations from a starting segment. This operation transforms the outline of any curve, no matter how complex, into a pattern that conforms to the definition of a mathematical function (Fig. 2).[2]

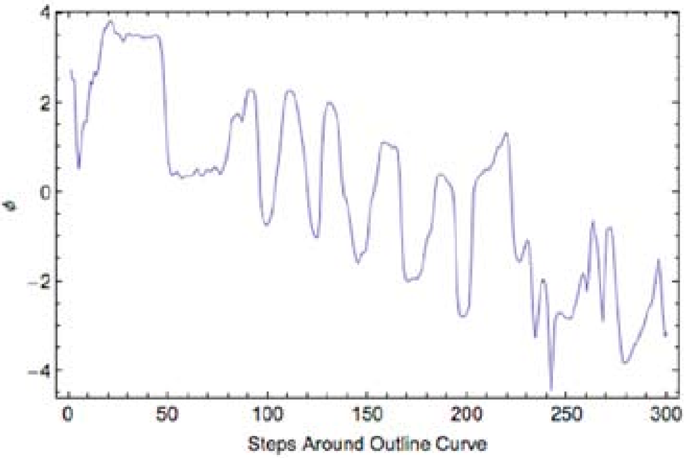


Figure 2. Zahn and Roskies shape function for a 300-point interpolation of the R. globulifera *outline semilandmark data expressed as the net deviation of angles drawn between successive semilandmarks around the form (ϕ).*

[2] In mathematics a function is a statement or argument in which every input value is associated with one and only one output value.

The ZR technique transforms a complicated outline into an alternative format that loses none of the outline's geometric information content, but is tractable to handle in the context of a Fourier analysis. It works fine. But this isn't the only solution to the complex outline representation problem that exists.

Note that the abscissa (traditionally the 'x-axis') of the plot in Figure 2 is simply the ordinal number of intervals round the the outline. There are n such intervals in any curve, where n is the number of semilandmarks used to represent the curve's form or shape. Obviously the ZR shape function is employing variations in the coordinate positions of both the x and y axes in order to determine the next angular direction to subsequent boundary outline locations (ϕ). But what if we considered these x and y deviations between successive semilandmark locations separately?

Figure 3 shows the form functions that result from plotting the x coordinates and the y coordinates of successive semilandmark points separately.

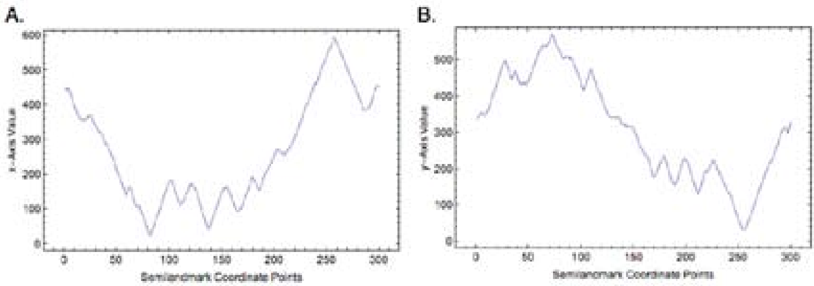


Figure 3. Form functions for separate x (A) and y (B) coordinate values of the R. globulifera *outline.*

These are form functions rather than shape functions because, as the raw coordinate values were used, the x and y values retain their scale. Since only one form is shown here the distinction between form and shape is not important. Regardless, it should be noted that, since this representation can utilize the raw coordinate values, it is possible to use this shape function to perform a form analysis or, if the semilandmark points are rescaled to eliminate size differences among a set of outlines, a shape analysis.

Like the ZR shape function, all the geometric information present in the original semilandmark coordinate data is present in these plots. Also as with the ZR shape function, the advantage of this format is that the resulting data conform to the definition of mathematical functions, and so can be subject to methods of analysis designed to extract information from function-type datasets. This will always be the case for any conceivable outline; even open outlines and/or those that intersect themselves. Moreover, because these shape/form functions are simply direct readings of variation in the x and y aspects of the outline boundary coordinates, the constraint of equi-angularity (standard radial Fourier analysis) or equal inter-coordinate spacing (ZR Fourier analysis) is relaxed. Forms can be represented by any number of semilandmark coordinate points the analyst deems appropriate, and inter-landmark spacings can assume any value(s) necessary to ensure comparable portions of the outline are aligned properly in the semilandmark sequences. The only requirements are that the same number of semilandmarks be used to represent the form/shape of the outlines of all specimens in the sample and (for EFA) that all outlines in the sample be closed (= end at the same landmark coordinate position at which they began). In practice, the ability to vary the inter-semilandmark spacing as a strategy for ensuring biological correspondence between outline segments has rarely been used in any EFA application. But this does not mean it could not be used to boost biologically important signals in the data and improve the interpretability of EFA results.

If an alternative form of outline shape/form function representation was all that was involved with an EFA it would simply represent a minor variant of the ZR shape function approach. However, the developers of this method went further than Zahn and Roskies (1971) and used the separation of x and y form/shape functions as the beginning of a new approach to the Fourier analysis of closed-form outlines. Their key insight in this regard was to think of the total set of length and orientation steps around any outline (t) as being the sum of apparent displacements in x and y directions (see Kuhl and Giardina 1982, Ferson *et al.* 1985, Lestrel 1997).

$$x(t) = \sum_{n=1}^{N}\left[A_n \cos\left(\frac{2\pi nt}{T}\right) + B_n \sin\left(\frac{2\pi nt}{T}\right)\right] \quad (25.1)$$

$$y(t) = \sum_{n=1}^{N}\left[C_n \cos\left(\frac{2\pi nt}{T}\right) + D_n \sin\left(\frac{2\pi nt}{T}\right)\right] \quad (25.2)$$

Where: n = the harmonic number
N = the maximum harmonic number
t = displacement along outline
T = total displacement

This allowed Kuhl and Giardina (1982) to derive a set of parametric equations that could be used to fit a set of Fourier harmonic amplitudes to the outline semilandmark data directly. The elliptic Fourier coefficients for the x aspect of the form/shape function are:

$$A_n = \frac{T}{2n^2\pi^2}\sum_{p=1}^{k}\frac{\Delta x_p}{\Delta t_p}\left[\cos\left(\frac{2\pi nt_p}{T}\right) - \cos\left(\frac{2\pi nt_{p-1}}{T}\right)\right] \quad (25.3)$$

$$B_n = \frac{T}{2n^2\pi^2}\sum_{p=1}^{k}\frac{\Delta x_p}{\Delta t_p}\left[\sin\left(\frac{2\pi nt_p}{T}\right) - \sin\left(\frac{2\pi nt_{p-1}}{T}\right)\right] \quad (25.4)$$

Where: k = the total number of steps around the outline
n = the harmonic number
Δx = the displacement along the x axis between point p and p+1
Δt = the length of the step between point p and p+1
t_p = accumulated length of step segments at point p
T = sum of lengths of all steps around outline

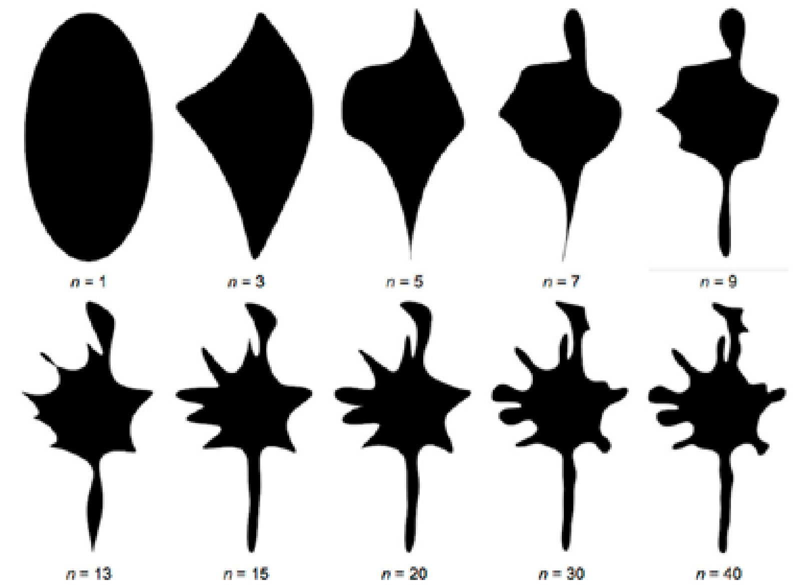
Similarly, the elliptic Fourier coefficients for the y aspect of the form/shape function are:

$$C_n = \frac{T}{2n^2\pi^2}\sum_{p=1}^{k}\frac{\Delta y_p}{\Delta t_p}\left[\cos\left(\frac{2\pi nt_p}{T}\right) - \cos\left(\frac{2\pi nt_{p-1}}{T}\right)\right] \quad (25.5)$$

$$D_n = \frac{T}{2n^2\pi^2}\sum_{p=1}^{k}\frac{\Delta y_p}{\Delta t_p}\left[\sin\left(\frac{2\pi nt_p}{T}\right) - \sin\left(\frac{2\pi nt_{p-1}}{T}\right)\right] \quad (25.6)$$

Giardina and Kuhl (1977) showed that equations 25.1 and 25.2 specify an outline-specific series of elliptical shapes of monotonically increasing spatial detail that, when summed together, represent an approximation of the form. This approximation minimizes the deviation of the empirical outline with respect to the estimated model in a least-squares sense. The EFA outline estimation process can be illustrated by reconstructing the form of the *R. globulifera* outline using different numbers of EFA harmonics (Table 1). All harmonics calculated in this manner are independent from each other. Therefore, the sets of harmonic coefficients representing each can be used as empirical form-descriptors in their own right, either singly or in combination.

Table 1. Sequential reconstruction of the *R. globulifera* form from the four elliptic Fourier terms calculated over different sets of harmonic amplitudes (*n*).



As can be appreciated from Table 1, the four terms of the elliptic Fourier spectrum, calculated over a series of harmonic amplitudes (n), are sufficient to represent the form of any outline shape to any desired level of accuracy. Generally speaking, an empirical assessment of the number of harmonics necessary to represent the most complex shape in the sample is made either by eye or by reference to some tolerance criterion (see MacLeod 1999). Each specimen in the sample is then re-described by using this number of EFA harmonics.

Mistakes are often made by inexperienced EFA practitioners (indeed by inexperienced outline data analysts in general), by the use of arbitrary criteria to decide how many Fourier harmonics to use to quantify the shapes present in a sample. This is especially important in the context of EFA analysis because four terms are required to quantify each harmonic: two terms for the x series and two for the y. If reduction of the dimensionality of a shape representation problem is the purpose of undertaking an EFA, the most accurate representation of the *R. globulifera* outline presented in Table 4 (n = 40) would require 160 terms to represent it. While this is a distinct improvement over the 300 x,y coordinates used to quantify the outline of the original shape, it remains a high-dimensional dataset. However, if the number of harmonics used to represent this form was cut back to a lower number—say 10—in order to achieve substantial dimensionality reduction (from 600 variables to 40), the quality of the form's representation would suffer. Of course, the *R. globulifera* outline is an extreme example. In many cases relatively small numbers of harmonics will be able to represent biological forms of interest (see Ferson *et al.* 1985 for an example). Nevertheless, it is always advisable to make this critical decision on the basis of an inspection of reconstructed forms rather than simply plucking a value for N out of thin air.

In addition to containing information about the shape of an outline, the A_n, B_n, C_n, and D_n coefficients contain information about the location, size, and rotational orientation of the outline. In some cases this information may be of interest. But in most cases biological morphometric analyses shape variation is the primary target. Although these extraneous variables could always be corrected for through various *ad hoc* normalization procedures or by subjecting the semilandmark sets to generalized least-squares *Procrustes* alignment (see Rohlf and Slice 1990, MacLeod 2009a) prior to EFA, Kuhl and Giardina (1982) specified a direct procedure for normalizing the EFA coefficients calculated from raw outlines for these factors. The basic equation for achieving this normalization is as follows.

$$\begin{bmatrix} a_n & b_n \\ c_n & d_n \end{bmatrix} = \frac{1}{E^*}\begin{bmatrix} \cos\phi & \sin\phi \\ \sin\phi & \cos\phi \end{bmatrix} \cdot \begin{bmatrix} A_n & B_n \\ C_n & D_n \end{bmatrix} \cdot \begin{bmatrix} \cos n\theta & -\sin n\theta \\ \sin n\theta & \cos n\theta \end{bmatrix} \quad (25.7)$$

Obviously several of the terms of this expression need to be explained and defined. The E^* coefficient is the magnitude of the best fitting ellipse. This is what Kuhl and Giardina (1982) regarded as, effectively, the size term, the influence of which is removed from the data by reciprocal scaling. This E^* coefficient is calculated using the following expressions.

$$E^* = \sqrt{a^{*2} + c^{*2}} \quad (25.8)$$

Where:

$$a^* = A_1 \cos\theta + B_1 \sin\theta \quad (25.9)$$

$$c^* = C_1 \cos\theta + D_1 \sin\theta \quad (25.10)$$

Of course, the A_1, B_1, C_1, and D_1 terms in equations 25.9 and 25.10 are the four coefficients associated with the first EFA harmonic which is, in all cases, an ellipse (see Table 1). The θ term is the angle between the starting point of the outline digitization sequence and the major axis of the ellipse. This angle is given by the following expression.

$$\theta = 0.5 \arctan\left[\frac{2A_1B_1 + C_1D_1}{A_1^2 + C_1^2 - B_1^2 - D_1^2}\right] \quad (25.11)$$

The θ correction factor is used in equations 25.7, 25.9, and 25.10 to align the EFA harmonic sequence to an internal standard set by the first harmonic. The final set of EFA coefficients is adjusted to bring the estimated outline model into a standing rotational orientation via calculation of the ϕ coefficient, as follows.

$$\phi = \arctan\left(\frac{c^*}{a^*}\right) \quad (25.12)$$

When these normalizations are applied the values of a_1 = 1.0 and those of b_1 and c_1 = 0.0, signalling the loss of information inherent in the normalization procedure. This procedure is formally equivalent to the normalizations applied by *Procrustes* superposition. A comparison of the raw and normalized EFA coefficients for the first ten EFA harmonic amplitudes for the *R. globulifera* outline is shown in Figure 4.

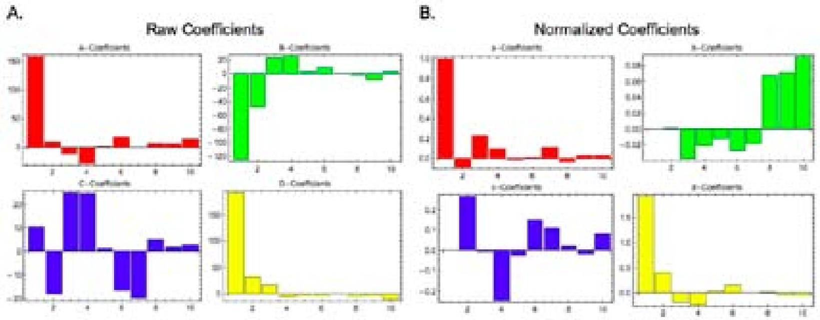


Figure 4. Raw (A) and normalized (B) EFA coefficients for the first 10 EFA harmonic amplitudes of the R. globulifera *outline. Note rescaling of all harmonic spectra as well as the setting of a_1 to 1.0 and both b_1 and c_1 to 0.0 as a result of the normalization procedure.*

While most applications of EFA in morphometric contexts will require implementation of all three normalizations, there may be occasions in which size, location of the starting point for digitization, and/or rotation are parameters of interest. In these cases the form of equation 25.7 can be adjusted so that one or more of these factors remains present in the harmonic spectra.

Once a set of normalized harmonic spectra have been obtained from a sample of shapes these are most typically used as input into a secondary multivariate data analysis procedure (*e.g.*, PCA, PCoord, MDS, CVA, PLS) in order to extract the major dimensions of shape variation, represent patterns of shape variation in a low-dimensional ordination space, investigate questions of group separation or distinctiveness, and/or document the association of particular aspects of outline shape variation with variables external to the morphological data *per se* and, in so doing, test causal hypotheses. As I have noted in previous discussions of these procedures, results generated by their application can be inspected and/or used as input into tertiary statistical procedures designed to test specific patterns via reference to a probability or likelihood models. They can also be used to obtain models of shape variation patterns at particular points, along the axes of the ordination spaces so defined, or along any trajectory through the hyper-dimensional ordination space that the data analyst cares to specify.

As an example of the use of EFA in the context of a morphometric investigation I will apply it to the same benthic foraminiferal test outlines I used in the last column to illustrate use of the ZR shape function with standard Fourier analysis. The images from which these outlines were derived are shown in Figure 5.

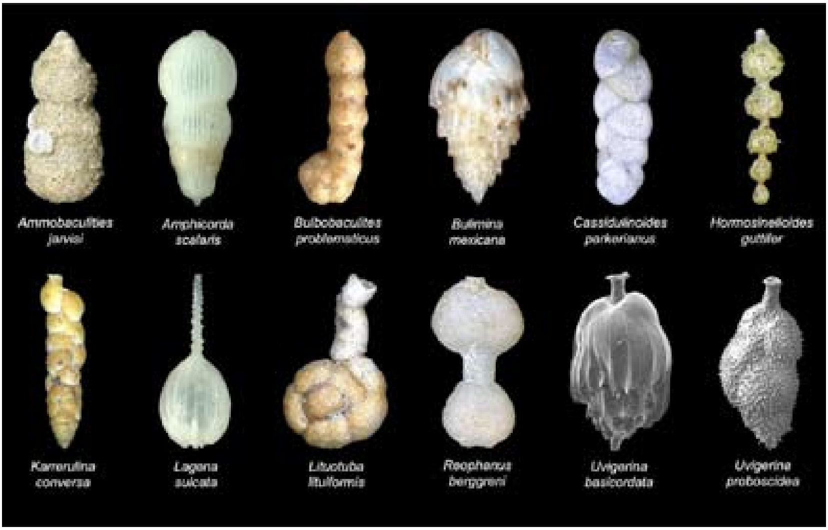
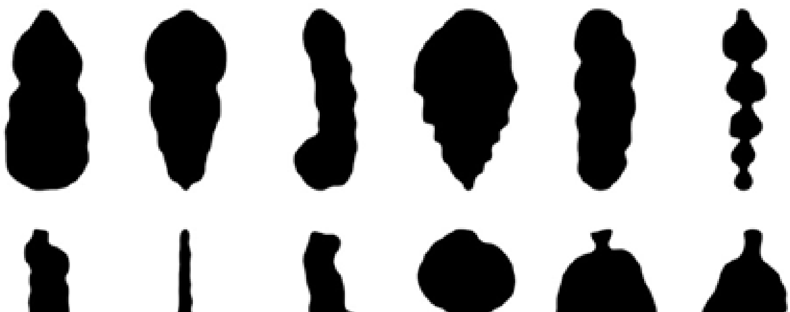


Figure 5. Benthic foraminiferal shapes used in the example analysis. Note the presence of shapes with multi-valued outlines.

Each outline was quantified using 200 equally-spaced semilandmark points, with the landmark from which digitization started being located at the centre of the aperture. Inspection of outline morphologies reconstructed using different numbers of EFA harmonic amplitudes indicated that, for this dataset, the major features of each outline could be captured using the first 25 normalized elliptic Fourier harmonics (see Table 2).

Table 2. Outline silhouettes for benthic foraminiferal shapes reconstructed from normalized EFA coefficients using 25 harmonic amplitudes. See Figure 4 for species names.



These EFA coefficients were then assembled into a data matrix. This matrix did not include the a_1, b_1 and c_1 amplitude coefficients as these were set to constant values of 1.0, 0.0 and 0.0 respectively as a result of the size, position, and rotation normalization procedure (see above). Overall, the

EFA procedure resulted in these outlines being described by (25 x 4) – 3, or 97 variables. These were used as input to a covariance-based principal components analysis (PCA) whose purpose was to assess the major modes of shape variation in the sample and establish a low-dimensional ordination space within which patterns of shape similarity and difference could be assessed. Results of the PCA analysis indicate that over 90 percent of the observed outline shape variation can be represented on three orthogonal principal component axes. Ordinations of the outline shapes within this three-dimensional subspace are shown in Figure 6.

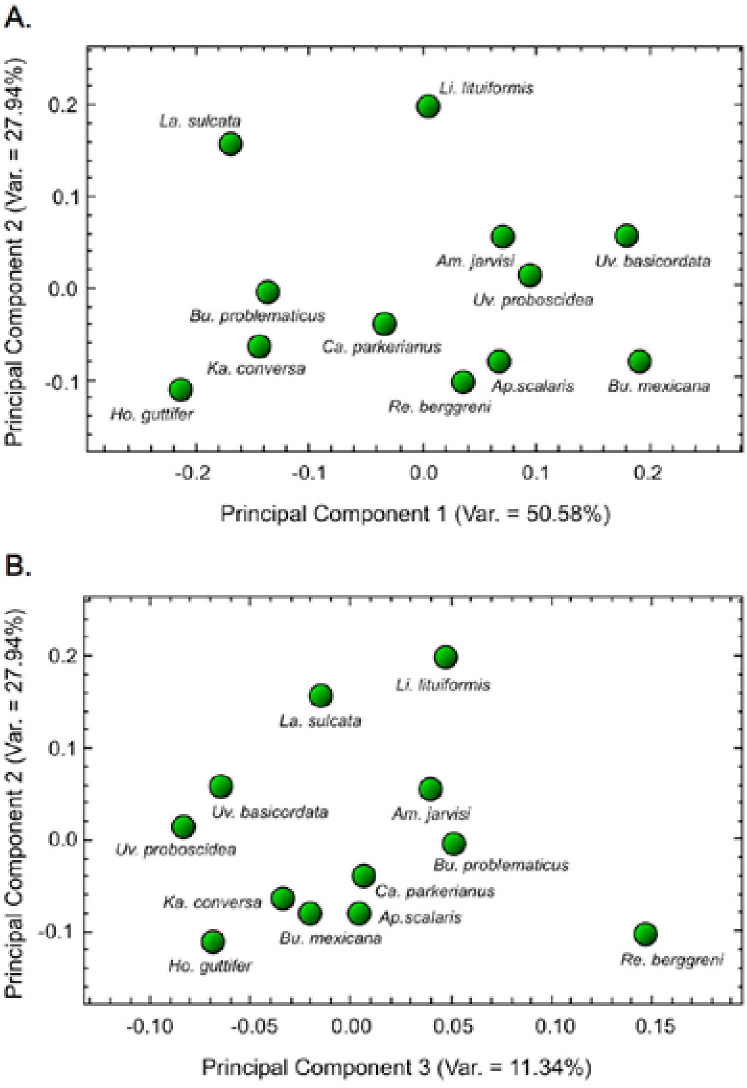


Figure 6. Distribution of the 12 benthic foraminiferan test outlines shown in Figure 5 and Table 2 in the shape space formed by the first three principal components of the covariance matrix calculated between normalized EFA coefficients. See text for discussion.

Inspection of the distribution of species along these three principal component axes suggests that PC-1 captures the distinction between tests characterized by uniserially-arranged globular chambers (*e.g.*, *Hormosinelloides guttifer*) and flaring tests with multi-serially arranged chambers (*e.g.*, *Bulimina mexicana*), PC-2 the distinction between tests whose chambers increase in size with development (*e.g.*, *Hormosinelloides guttifer*) as opposed to those whose tests are characterized by a relatively thin, tubular neck (*e.g.*, *Lituotuba lituiformis*), and PC-3 the distinction between tests with complex, lobulate peripheries that are thick in the middle (*e.g.*, *Uvigerina proboscidea*) relative to those characterized by a medial constriction (*e.g.*, *Reophanus berggreni*). It's also important to note that, in terms of outline shape variation, for this sample *Lagena sulcata*, *Lituotuba lituiformis* and *Reophanus berggreni* all represent shape outliers.

While sufficient for an interpretation of the generalized geometry of the principal component spaces, the qualitative trends described above fail to represent the detailed geometric contrasts that exist along the primary PCA vectors, information which has been captured by the original outline data and employed by the eigenvector equations that define PC-1, PC-2, and PC-3. Fortunately, we are not restricted to such qualitative approaches to EFA shape space interpretation.

The eigenvector loading coefficients that define PC-1, PC-2 and PC-3 represent a series of cosines that quantify the angular relationship between these eigenvectors and the original variables in a manner that takes note of covariance structure of these data (see MacLeod 2005). Since this is the same information we used previously to construct geometric modes of PCA form/shape spaces for landmark (MacLeod 2009b, 2010a) and outline data (MacLeod 2011), it should be possible to create similar models for the EFA-defined PCA ordination spaces shown in Figure 4. It's possible to calculate these models using either the direct landmark or thin plate spine approaches (see MacLeod 2009b and 2010a respectively), though the former seems the more natural and informative choice for these data. The models calculated by this method will be expressed in terms of the original variables submitted to the EFA-PCA analysis. These may be converted back to sets of x,y coordinate data using the following equations.

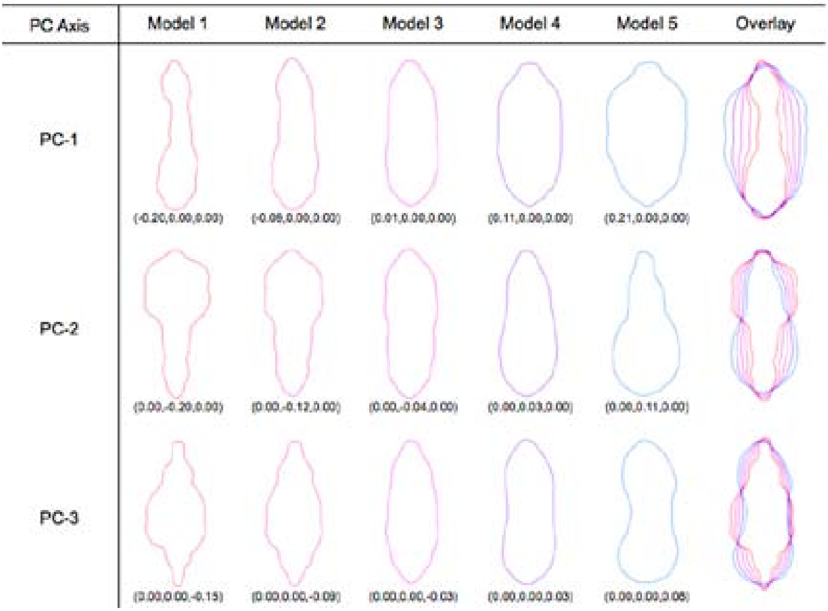
$$x_n = \sum_{n=1}^{N} a_n \cos(nt) + b_n \sin(nt) \qquad (25.13)$$

$$y_n = \sum_{n=1}^{N} c_n \cos(nt) + d_n \sin(nt) \qquad (25.14)$$

Where: n = harmonic amplitude
N = maximum number of harmonic amplitudes used in the construction
t = evaluation angle (varies from 0 to 2π)

Application of equations 25.13 and 25.14 to sets of EFA amplitude coefficients calculated at a series of coordinate point locations along the PC-1, PC-2 and PC-3 axes resulted in construction of the along-axis shape models shown in Table 3.

Table 3. Elliptic Fourier amplitude coefficient models existing are coordinate locations along the first three principal component axes of the outline shape covariance matrix. The specific coordinate position at which each model was calculated is shown below each model (in parentheses).



As can be seen graphically in the table—especially when the individual along-axis shape models are overlain to create a 'strobe' effect—the geometric trend being expressed along each axis is a function of (1) the degree of inflation (PC-1) and lobateness (PCs 2 & 3) of the test peripheries on either side of the test's long axis. Based on these results the distinction between low scores and high scores along PC-1 reflects the distinction between broadly elliptical shapes with concave to convex lateral margins respectively. The PC-2 axis captures aspects of spatial changes in lateral lobateness with respect to the test's long axis, with low scores representing lobe formation confined to late stages of test development and high scores representing patterns of lateral lobe formation that occur at earlier developmental stages. Finally, PC-3 expresses distinctions between the lobateness of the medial portion of the test with respect to the two ends. Here, tests characterized by strongly convex medial outlines sandwiched between distinctly pinched terminal regions project to low positions along this axes, while those characterized by bulbous terminal regions separated by a narrow, concave, medial lobe project to high positions. The dramatic increase in geometric insight into the nature of EFA ordination spaces that can be achieved through use of models to query and interpret the EFA-PCA is (I hope) obvious.

Like ZR Fourier analysis, elliptic Fourier analysis effectively addresses the need for a numerical method that can be used to represent outline form/shape variation in a rigorously quantifiable, geometric manner while overcoming the limitations of radial Fourier analysis in terms of its ability to treat single and multivalued outlines and its freedom from being subject to the centroid-location problems which plague the latter, at least with respect to some outlines. Elliptic

Fourier analysis is fully extensible to the treatment of 3D outlines (see Lestrel 1997). Owing to its dependence on ellipses EFA is technically restricted to the analysis of closed outlines. However, Kuhl and Giardina (1982) include example analysis of forms that come very close to being open curves in their discussion of EFA applications, though the ability of EFA to reconstruct such curves seems decidedly suboptimal to me.

Owing to the availability of public-domain software for performing EFA, the technique has proven reasonably popular with morphometricians despite the fact that much of the early geometric morphometric literature was rather hostile to outline analysis methods in general and Fourier-based methods in particular. There were two reasons for this. The first has to do with non-correspondence between the biological features that sequences of semi-landmark points may fall on when an outline is sampled. This is a well-known problem that I'll have more to say about in my discussion of eigenshape analysis. In terms of sampling the form, EFA can circumvent this issue rather easily because it does not assume that the spacing between semi-landmark points will be equal. Accordingly, it is a relatively simple matter to subdivide the outline into segments at true landmarks and use semi-landmark sequences to 'join' the landmarks in a manner that accurately represents the form/shape of the inter-landmark boundary curves (see MacLeod 1999 for an example of this procedure). Data collected in this way can be submitted to an EFA analysis without any further processing. However, this sampling protocol has rarely been used with EFA despite the clear advantages of doing so.

The second criticism that has been made of the EFA (and all Fourier-based) procedures is that they are unnecessary. The point of all Fourier analyses is to estimate the form of a signal—in the case of morphometrics a morphological signal. The Fourier approach provides sophisticated and mathematically elegant tools with which to do this. But that's all they do. Fourier harmonic amplitudes and phase angles provide a means to describe outline form/shape variation in quantitative terms. But sample ordinations, the major directions of sample form/shape variation, discrimination between sample sub-groups, comparison of patterns of co-variation, form/shape modelling, statistical testing of various sorts, *etc.*, all must be performed on Fourier-based re-descriptions of morphological variation by other procedures. This raises the question of why to take one's morphological data through a Fourier analysis in the first place, as opposed to working directly with the semilandmark outline coordinates themselves, as these can easily be aligned and normalized for various sources of extraneous information using other methods (*e.g.*, Bookstein shape coordinates, *Procrustes* shape coordinates).

As an experiment to address this question empirically we can perform a quick analysis of the same benthic foraminiferal outline data using the *Procrustes* PCA technique. Results of the projection of the outline shape coordinate data into the spaces formed by the first three eigenvectors of the shape-coordinate covariance matrix are shown in Figure 7. Close comparison of Figures 6 and 7 reveals a few differences (*e.g.*, position of *Am. jarvisi* along PC-3). Some degree of difference is to be expected considering the differences between the EFA and *Procrustes* PCA datasets. However, both the gross and detailed similarities between the two ordinations are even more striking. It is doubtful that routine interpretations of these two spaces would differ substantially.

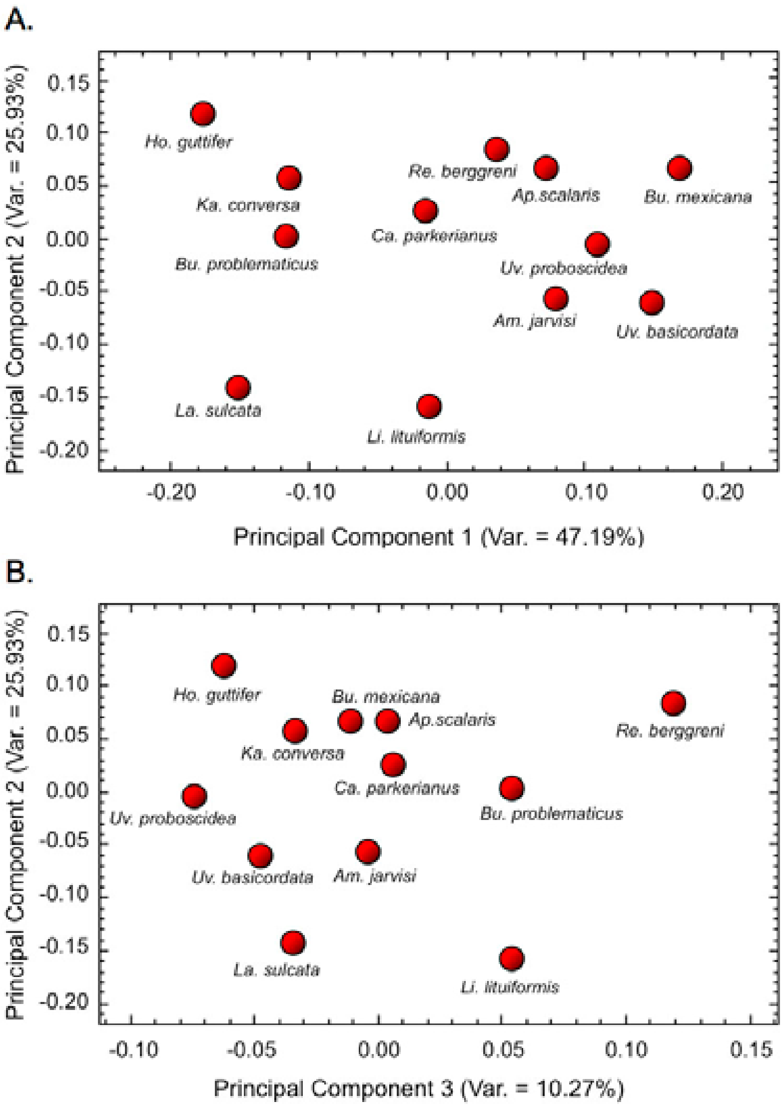


Figure 7. Distribution of the 12 benthic foraminiferan test outlines shown in Figure 5 and Table 2 in the shape space formed by the first three principal components of the covariance matrix calculated between Procrustes *superposed shape coordinates. See text for discussion.*

Rohlf (1986) argued that Fourier analysis might be preferred to the analysis of coordinates because use of only the first few Fourier harmonics, in effect, causes the outline to be smoother—thus eliminating small-scale variation that may not (or may) be of importance in any given analysis. If a sub-set of EFA harmonics are selected for analysis a smoothing of the represented outline would certainly be the case. But Rohlf's argument strikes me as one that misses the point. If smoothing of an outline is acceptable or important there are many approaches to this operation that could be employed as an initial data-processing step. The most obvious of these is to reduce the number of coordinate points used to represent the boundary form/shape to the minimum needed to achieve an objective geometric tolerance (see MacLeod 1999 for an example algorithm). When this is done it is often surprising how few boundary outline semilandmarks are really necessary to replicate even complex outlines. But once this is done the difference between raw coordinates, ZR Fourier and EFA become apparent. Taking (say) 50 semilandmarks as an example, the raw analysis of coordinates would imply the analysis of 50 x and 50 y coordinates, 100 variables in total. Under the ZR Fourier approach 25 amplitudes and 25 phase angles or, more commonly, just the 25 unique harmonic amplitudes would be required, totalling to either 50 or 25 variables respectively. But under EFA each of the 25 unique Nyquist harmonics would require four Fourier coefficients to represent the series, specifying either 100 or 97 variables in total, depending on whether these coefficients were normalized. Of course, the data analyst could simply throw all these EFA variables into a PCA analysis and discard all but the first few principal components as being unimportant. But this standard dimensionality-reduction technique applies equally well to PCA results from raw coordinates, ZR Fourier shape functions, and indeed to radial Fourier data.

Quite clearly the jury remains out on the question of whether any real advantages are gained by performing a Fourier analysis as a processing step that re-describes the shape in an alternative quantitative format. In this way ZR Fourier and EFA are reminiscent of principal warps analysis (see MacLeod 2010b). If you are considering using EFA for an outline study I encourage you to explore some of its more unique, yet little-used, variants (*e.g.*, the ability to analyse non-uniformly-spaced semilandmarks) in order to add useful and distinctive features to your investigation's design. But more than this I would recommend you defer the analysis until we have had an opportunity to consider a far more flexible outline sampling-data analysis procedure in detail: eigenshape analysis.

In terms of software, a number of different outline processing, outline digitization, and EFA applications for 2D and 3D data are available from the SUNY Morphometrics website, at <**http://life.bio.sunysb.edu/morph/**>. The industry standard in this area, however, has to be Jim Rohlf's EFA application for Windows operating systems. Among the more comprehensive software packages, only Jim Rohlf's NTSYS (<**http://www.exetersoftware.com/cat/ntsyspc/ntsyspc.html**>) and Øyvind Hammer's Past (<**http://folk.uio.no/ohammer/past/**>) packages have implemented forms of the EFA procedure. All the analyses and graphics used in this column (including the EFA models) were calculated using custom software I have written for Wolfram Researcher's Mathematica™ software, any or all of which I'd be happy to share on request.

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Don't forget the *PalaeoMath 101* web page, at:

<http://www.palass.org/modules.php?name=palaeo_math&page=1>

>>***Future*** Meetings of Other Bodies

5th Workshop on Non-Pollen Palynomorphs
Amsterdam, The Netherlands *2 – 5 July 2012*

This workshop will be held at the Institute for Biodiversity and Ecosystem Dynamics of the University of Amsterdam, The Netherlands, with an (optional) excursion for participants on 5th July.

The systematic use of NPP (for example fungal and algal spores, cyanobacteria) in Quaternary lake and peat deposits started more than 40 years ago at our Institute and nowadays more and more palynologists use the extra information that can be obtained from NPP-analysis. Based on the number of participants during the first four workshops we will organize the fifth workshop for a maximum of 50 persons. If more than 50 colleagues respond with a pre-registration form then we will put these persons on a waiting list.

If you are interested in participating, please e-mail <**b.vangeel@uva.nl**> asking for the pre-registration form. Those who respond will be informed with further circulars. Final registration will be by paying the registration expenses (probably *ca*. €50).

Statistical Approaches to PaIeobiological Questions: International Statistical Ecology Conference 2012
Krokkleiva, Norway *3 – 6 July 2012*

ICSE2012 has a special session for palaeobiologists chaired by Dr Lee Hsiang Liow of the Centre for Ecolgical and Evolutionary Synthesis, University of Oslo.

Paleobiology is the study of the ecology and evolution of both extinct and extant organisms, using data from the fossil record. The estimation of ecological and evolutionary parameters from such data is subject to both similar and different statistical issues as those based on living flora and fauna. This session comprises of invited contributions that present a spectrum of studies, spanning plankton to mammals, highlighting statistical concerns in analysing paleontological data and studying very long-term ecological and evolutionary dynamics.

This conference will convene experts from around the world to present and discuss issues of interest to ecological statisticians and biologists. Pre-conference workshops will take place from 30th June to 3rd July.

For more information, visit the main meeting website at <http://www.cees.uio.no/isec2012/> to register.

45th Annual Meeting of AASP – The Palynological Society
Lexington, Kentucky, USA *22 – 24 July 2012*

This meeting will be held on the campus of the University of Kentucky and co-hosted by the Kentucky Geological Society and the Department of Earth and Space Sciences at Morehead State University. A CIMP-sponsored symposium will be convened at the Lexington Meeting in honour of Dr Geoffrey Clayton and Dr Kenneth Higgs who have made tremendous contributions to our understanding of Late Palaeozoic palynology for more than three decades.

There will be a pre-meeting field trip on 21st July 2012 to Natural Bridge State Park – the centrepiece being a natural arch of Early Pennsylvanian sandstone. The post-meeting field-trip on 25th July 2012 will explore the world-class outcrops that expose Devonian and Carboniferous strata focusing on the Devonian "black shales". Collecting of macro- and microfossil samples will be encouraged.

For additional information on the meeting and organisational updates please visit the Palynological Society website at <**http://www.palynology.org/**>.

34th International Geological Congress
Brisbane, Australia *5 – 10 August 2012*

The IGC was first held in 1878, and the Oceania region has only hosted the event once in its prestigious history. High-level political and scientific support secured in Australia and New Zealand for the Congress will underpin this outstanding event.

Under the theme "Unearthing our Past and Future" the IGC will showcase the Oceania region's geoscience strengths, innovations and natural wonders, through an exciting range of pre- and post-Congress field-trips.

AUSTRALIA 2012, to be held at the Brisbane Convention and Exhibition Centre, will include a GeoExpo, an education outreach programme, and a support programme to encourage young delegates to attend. The IGC will demonstrate the crucial role that geoscience plays in the quest for sustainable development and show how geoscience contributes directly to the future of its resource-based industries, land and water management and mitigation of geohazards.

Further details can be found on the conference website at <**http://www.34igc.org/index.php**>. Early-bird registration is until 30th April 2012.

Ichnia 2012 – The Third International Congress on Ichnology
Memorial University of Newfoundland, St John's, Canada *11 – 23 August 2012*

The Third International Congress on Ichnology will be held at the Memorial University of Newfoundland, St. John's, Canada in August 2012. The meeting will bring together scientists working on all aspects of trace fossils and bioturbation, and will be of interest to palaeontologists, sedimentologists, ecologists and biologists.

The Congress will begin with a pre-conference field-trip to western Newfoundland, examining the Cambro–Ordovician ichnology of the region, and studying benthic ecology at Memorial University's Bonne Bay research station. The intra-conference field-trip will visit Bell Island, home to some spectacular early Palaeozoic trace fossils, and the post-conference excursion will examine the Precambrian–Cambrian GSSP at Fortune Head, as well as the famous Ediacaran biota of the Avalon Peninsula.

The meeting will be hosted by the Ichnology Research Group in the Department of Earth Sciences. Pre-register your interest in attending by visiting the Ichnia 2012 website at <**http://www.ichnology.ca/index.php/preregistration**>, or for more information, please e-mail <**ichnia@mun.ca**>.

12th International Paleolimnology Symposium

Glasgow, Scotland *21 – 24 August 2012*

This Symposium, organized by the International Paleolimnology Association and covering all aspects of paleolimnology, will be held in Glasgow, Scotland. The lead organizers are Helen Bennion, University College London, and Andy Henderson, University of Newcastle.

The meeting will take place in the Scottish Exhibition and Conference Centre (SECC) in the centre of Glasgow where there are first-rate facilities for both oral and poster sessions.

Further details can be found on the conference website at <**http://www.paleolim.org/ips2012/**>. Abstract submission deadline: 1st July, 2012.

13th International Palynological Congress / 9th International Organisation of Palaeobotany Conference

Chuo University, Tokyo, Japan *23 – 30 August 2012*

Our world is changing dramatically. There are many urgent environmental issues, such as pollution, climate change, landscape and land-use changes, that have affected the ecosystem, biological diversity and human life. Palynology and Palaeobotany have provided baseline information on the past biological and environmental changes, which have in turn become critical for sustainable environmental management and nature conservation.

In Japan and elsewhere more medical doctors are actively involved in Aerobiology and Palynology to prevent further spread of pollen-related allergies influenced by human-induced environmental changes. Our disciplines now have wider implications and applications relevant to modern society than ever. The main theme "Palynology and Palaeobotany in the Century of the Environment" is thus timely for the IPC/IOPC 2012 meeting in Tokyo, Japan.

Further details can be found at <**http://www.psj3.org/ipc-iopc2012/Welcome.html**>.

32nd International Geographical Congress
Cologne, Germany *26 – 30 August 2012*

The Theme ‘Down to Earth’ will focus on Global Change and Globalisation, Society and Environment, Risks and Conflicts, Urbanisation and Demographic Change.

Further details can be found on the conference website at <**http://www.igc2012.org/**>.

5th ESA-European Symposium on Aerobiology
Krakow, Poland *3 – 7 September 2012*

The 5th European Symposium on Aerobiology will be held in Krakow, Poland, on 3–7 September 2012, and will be organised under the patronage of the Rector of Jagiellonian University.

Further details can be found on the conference website at <**http://www.5esa.cm-uj.krakow.pl/**>. The Early-bird registration deadline is 15th June 2012.

29th International Association of Sedimentologists (IAS) Meeting of Sedimentology
Schladming, Austria *10 – 13 September 2012*

The International Association of Sedimentologists (<**http://www.sedimentologists.org/**>), and the Department of Applied Geosciences and Geophysics, Montanuniversitaet Leoben (Austria) invite you to the 29th IAS Meeting of Sedimentology.

The Meeting will bring together all facets of sedimentology under the theme of Sedimentology in the Heart of the Alps. It will feature a wide-ranging interdisciplinary scientific programme, and an exciting range of pre- and post-meeting field-trips, which are being organised with important contributions from our Austrian partners and inputs from our Slovenian, Croatian, Hungarian and Slovakian neighbours. Expert training pre- and post-meeting short courses, an exhibition and leisure options will be other features.

Further details are on the conference website at <**http://www.sedimentologists.org/ims-2012**>. (Early-bird registration and abstract submission deadline: 30th April 2012.)

Centennial meeting of the German Palaeontological Association
Museum für Naturkunde, Berlin *24 – 29 September 2012*

On the occasion of the 100th anniversary of the “Paläontologische Gesellschaft“, we cordially invite you to participate in the 2012 Annual Meeting organised by the Museum für Naturkunde in Berlin. The Centenary Meeting’s theme is Palaeontology in Society – 100 Years of the Palaeontological Society, underscoring the relevance of palaeontology not only to science, but also to society and the public at large. The deep time perspective of the fossil record provides a unique baseline for current environmental concerns such as global climate change, loss of biodiversity, and the recovery from mass extinctions. Palaeontology also raises public awareness in addressing questions about the origin and the evolution of organisms, ourselves included. 'Palaeontology in Society' also refers to the multidisciplinary and integrative nature of palaeontological research, including organismic and molecular biology, geology, and geochemistry. Finally, 'Palaeontology in Society' highlights the role of palaeontology in communicating authentic research, based on real fossils, to the general public. This meeting is dedicated to celebrating the past and, more importantly, to exchanging and developing new ideas and projects 'in society' with your colleagues.

For more information visit the meeting website at <**http://www.palaeo100.naturkundemuseum-berlin.de/**> or contact Dr Martin Aberhan (e-mail <**martin.aberhan@mfn-berlin.de**>).

Annual International Conference on Geological and Earth Sciences (GEOS 2012)
Hotel Fort Canning, Singapore *3 – 4 December 2012*

Topics of interest include, but are not limited to: Mineralogy, Petrology, Geochemistry, Geomorphology, Palaeontology, Stratigraphy, and Structural Geology. For a complete list view the 'Call for Papers' section of the conference website <**http://www.geoearth.org/CallforPapers.html**>.

Best Paper and Best Student Paper awards will be conferred at the conference, and there is the opportunity to submit papers for the conference proceedings publication.

For further details see the conference website <**http://www.geoearth.org/**>. (Final paper submission deadline: 13th July 2012; Early-bird registration until 13th September, 2012.)

6th International Symposium on Lithographic Limestone and Plattenkalk
Museo del Desierto, Saltillo, Mexico *4 – 8 March 2013*

The Museo del Desierto invites you to the 6th International Symposium on Lithographic Limestones and Plattenkalk. This multidisciplinary meeting is planned to address aspects of the study of lithographic limestones and plattenkalk deposits across all disciplines, from palaeontology (taxonomy, palaeoecology, taphonomy), to geology (stratigraphy, sedimentology, palaeoenvironments), and also mineralogy and petrology of Plattenkalk deposits and related Fossil-Lagerstätten. The meeting is organized in collaboration with the Institute of Earth Sciences of the University of Heidelberg, Germany. We plan field-trips to the famous plattenkalk deposits of Vallecillo, but also to new localities.

Please e-mail <**ISLLP2013@geow.uni-heidelberg.de**> for more information.

10th North American Paleontological Convention
Venue TBA *Summer 2013*

Please send your proposals for the meeting venue to Mark Wilson (e-mail <**mwilson@wooster.edu**>, Department of Geology, The College of Wooster, Wooster, OH 44691).

Check The Paleontological Society website (<**http://www.paleosoc.org/**>) for updates.

9th European Palaeobotany-Palynology Conference
Padua, Italy *end August – early September 2014*

The Italian group of Palaeobotany and Palynology is very glad to be able to invite all of you to Padova in 2014 for the next EPPC.

All scientific sessions will be held at the new Department of Geoscience, however also the famous Botanical Garden and the Museum of Palaeontology will be involved during this conference. Field-trips are planned in the fascinating landscapes of the Dolomites, Sardinia, Emilia-Romagna, Latium and Tuscany.

For further information contact the conference secretary at <**Evelyn.Kustatscher@naturmuseum.it**>.

4th International Palaeontological Congress (IPC 2014)
Mendoza, Argentina *28 September – 3 October 2014*

Local organizers are planning a comprehensive Congress with an intellectually motivating scientific programme. The Congress will create opportunities for participants to present and share experiences, explore new directions and debate topics among specialists from across the globe.

A varied array of meeting styles with a combination of keynote lectures, special symposia on leading issues, interactive workshops, technical sessions, and short courses promises to hold sessions of interest to all palaeontologists.

Delegates will have the opportunity to enjoy a wide range of conference excursions to rich and well-known Argentinean palaeontological sites involving a combination of scientific and touristic attractions. The schedule of field-trips covers superbly exposed sedimentary successions, representing a great diversity of marine and continental palaeoenvironments, and encompasses near the whole stratigraphic record.

Further details will follow.

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

Meeting REPORTS

Geobiology and Environments of Silica Biomineralizers
University of Lille 1, France *4 – 7 September 2011*

For scientists of the siliceous realm, 2011 will be remembered as a year rich in events organized under the patronage of The Micropalaeontological Society. The Silicofossil and Palynology Groups Joint Spring Meeting was held in March in Tromsø, Norway, and the Geobiology and Environments of Silica Biomineralizers took place in Lille, northern France, between 4th and 7th September. The latter conference, also known as the Siliceous Geobiology meeting, was organized by Taniel Danelian and hosted by Université Lille 1. This meeting brought researchers together from many nationalities in Lille on the theme of Geobiology and environments of siliceous biomineralizers who work on the biology of extinct and extant organisms with siliceous skeletons.

The meeting began with an icebreaker party held at the Natural History Museum of Lille on Sunday 4th. During the guided tour of the Museum, the meeting participants were given an excellent overview of the geology of northern France, and the history of the economic mainstays of the area: coal mining, textile manufacturing and brewing. The social events during the meeting also included a gala dinner, which allowed us to taste some of the excellent local cuisine.

Meeting participants on a guided tour of the Natural History Museum, Lille.

The opening ceremony for the meeting began with a beautiful presentation by **Jean-Pierre Caulet** on the life and work of George Deflandre (1887–1973). He was the first French naturalist to make an in-depth study of siliceous microfossils. Caulet, one of Deflandre's former students, told of a passionate man who brought much to the study of siliceous microfossils until his death in 1973. After this biographical introduction, **Patrick De Wever** presented the case for the deposition of radiolarites in the Tethys Ocean being due to the establishment of monsoonal conditions during the Mesozoic.

The first session of the meeting, on 'Silica biomineralization and biogeochimical cycles', opened with an interesting presentation by **Paul Treguer**, which discussed silic acid leakage hypotheses and the evidence to support the case for changes in the spatial distribution of silic acid production affecting atmospheric CO_2 levels. This presentation made the complexity of the issue much clearer. Next, **Virginia Panizzo** explored the Holocene productivity history of the Southern Ocean around East Antarctica with the $\delta^{30}Si$ proxy. **Aleksey Sadekov** gave an overview of how radiolarian geochemistry could allow them to be used as a new palaeoclimate proxy. **Luis O'Dogherty** closed the first session with a presentation that explained the diversification of radiolarians during the Mesozoïc.

After a lunch of good food and fine French beer, the second series of discussions began with the theme of diatoms in ancient and modern marine environments. **P. Lopez** opened with a discussion of the impact of ocean acidification on the dynamics of diatom morphogenesis. **Jonathan Tyler** spoke on the influence of vital effects on oxygen isotope fractionation in diatoms. **Luis Felipe Artigas** detailed the diversity dynamics of diatoms from the Amazon aquatic continuum, and showed a high spatio-temporal variability in phytoplankton dynamics driven by the Amazon's plume waters circulation. The presentations continued with a synopsis by **D.U. Hernandez** of the results of cruises in the central Mexican Pacific aimed at elucidating the environmental conditions that favour high densities of planktonic diatoms in the region. The session closed with a discussion of the study of diatom silica oxygen isotope records from Antarctic margins that yielded information on the vital and habitat effects of seasonal changes in freshwater flux in this area.

The last session of the day was entitled 'Siliceous Plankton and Paleoenvironmental Studies', and began with **Jean Prygiel** outling the conservation status of diatoms in Europe. **R. Ramanibai** described the use of diatoms as a general indicator of environmental conditions and their specific use as a proxy for water quality. The use of the diatom record to reconstruct climatic variability through the last 200ka in the Zaire deep sea fan was outlined by **Tristan Hatin**. **Eduardo Morales** presented ongoing taxonomic work on the diatom flora of the Bolivian altiplano and their possible consequences on paleoeological evaluations. **David Lazarus** closed the day with a presentation on advances in tools for analyzing the deep sea microfossil record, including recent advances in developing the Neptune database, taxonomic dictionaries and age-model library.

A pre-dinner poster session offered the chance to mull over the day's presentations and the topics covered by the posters. All meeting participants then adjourned to *L'escale* where, over a selection of regional dishes from Lille and the surrounding area, they were able to continue their discussions.

The gala dinner.

The second day of the meeting opened with a session on the theme of Siliceous biomineralization and environment. **Kaoru Ogane** gave the presentation on the function of pseudopodia in polycystine cells as silica accumulation organelles. The next speaker, **Noritoshi Suzuki**, showed the patchwork silicification system of living polycystine radiolarian, as detailed by long-term continuous video recording. After this, **Paulian Dumitrica** explored the relationship between skeletal malformations in some polycystine Radiolarian and silicoflagellates with environmental factors. **Jakob Witkowski** finished this session with a presentation on ODP sites 748 and 1051 that explored trends in siliceous plankton productivity in response to the late middle Eocene greenhouse warming.

After another coffee break the second theme of the day, 'Siliceous Sediments and their Palaeoenvironmental/Industrial Significance', was introduced by **Martial Caridroit**, who discussed the Carboniferous Lydian rock (radiolarian cherts rich in organic carbon) which can be related to different siliceous event. Next, **T.R. Gregory** presented work on the atmospheric controls in Adelie Land, East Antarctica, which had consequences for the formation of diatom-rich sediments. **Chloé Plet** moved to the lakes of the East African Rift, which could be a good analogue to the Precambrian cherts. **Nikolay Sennikov** explored the depth of formation of Lower Cambrian volcanic-siliceous-terrigenus sequences in the central part of the Gorny Altai in the SW of Siberia. This discussion finished with a timely talk from **Bob Jones** on the importance of biogenic silica in the exploration and exploitation of unconventional shale gas reservoirs.

After another good lunch and further discussion around the posters, the afternoon session was on the theme of 'Siliceous Plankton Biodiversity Dynamics'. **David Lazarus** spoke on Cenozoic diatoms and radiolarians, then **Elie Verleyen** presented contrasts in diatom diversity driven by differences in tectonics and glacial history. **Johan Renaudie** then spoke about macroevolutionary patterns in Antarctic Neogene Radiolarians. **Nikita Bragin** explored the biostratigraphic, palaeobiogeographic

Conference delegates in the Museum.

and palaeoclimatic significance of Boreal Triassic radiolarian assemblages from Arctic Russia. In a change of direction **Valentina Vishnevskaya** talked about the evolution of siliceous skeletons among genera of the radiolarian family Parcicingulidae. This series of talks concluded with a study of a radiolaria and sponge fauna from the Lower Cambrian of the Altai mountains by **O. Obut**.

The last series of discussions was about the 'Radiolaria Biotic Response to Oceanographic Changes'. **Peter Baumgartner** began with a talk on the response of modern, surface-dwelling radiolarian to nutrient-rich river plumes in the southern Caribbean. **Kiyoko Kuwahara** presented a study on the Permian–Triassic transition strata and the radiolarian record from Japan, with a particular focus on the case of the Gujo–Hachiman section. The importance of Cenomanian radiolaria from the Crimea was explored by **Liubov Bragina** in order to improve understanding of Cenomanian–Turonian radiolarian biodiversity. The last presentation was made by P**aulian Dumitrica** who spoke about Siamese twin skeletons in Mesozoic radiolarians.

The broad scope of the conference enabled a remarkably diverse group of scientists to gather in Lille, and resulted in numerous inspiring discussions that made the meeting a great success. This, in turn, indicates that such interdisciplinary meetings are increasingly necessary.

Jakob Witkowski, Tristan Hatin, Kaoru Ogane, Chloé Plet

Lyell Meeting 2011: Islands: Palaeontology, Geology and Tectonics

Geological Society, Burlington House, London *24 October 2011*

This year's Lyell Meeting was organised by Stephen Donovan, who concocted four sessions of diverse talks bringing together tectonicists, geologists, palaeontologists and geomorphologists. This cocktail resulted in thirteen entertaining talks of high scientific quality. More than 70 delegates from Europe and the Americas joined the organiser.

Following registration and a quick coffee in the stunning Lower Library, the meeting opened with a welcome from **Edmund Nickless** (executive secretary of the Geological Society) to all the participants. The first session was chaired by **David Harper** who successively introduced four speakers. First, **Grenville Draper** (Florida International University, Miami) presented the tectonic processes (collision settings) responsible for the formation of islands: tectonic flooding and tectonic emergence, with (for each case) reference to selected examples. Islands also form in extensional environments, but tend to be ephemeral; many emergent islands resulting from volcanic activity. **Trevor Jackson** (University of the West Indies, Trinidad) followed with the different stages of volcanic island evolution with examples from the Cenozoic Lesser Antilles arc, and the migration of volcanic centres that contribute to the enlargement of islands and their general oval shape. Volcanism in the Antilles is typically explosive and this has an important impact on the local environment. A joint collaboration by **Heather Viles** (University of Oxford) and **Tom Spencer** (speaker: University of Cambridge) highlighted the great diversity of landforms in the terrestrial and costal settings of tropical islands, and their evolution resulting from the interaction of endo- and exogenetic processes over short to long timescales. The last presentation of this first session was given by the organiser, **Steve Donovan** (NCB Naturalis, Leiden) on localism and the transposition of European geology and tectonics in an attempt to understand the geology of the Antillean islands, and in particular

Jamaica. This task was undertaken in the 19th century by various peripatetic specialists amongst whom Henry De la Beche is possibly the most famous. In the 20th century, Matley and Trechmann provided theories, however incorrect, about the formation of the island based on structural relationships in the Caribbean and North Wales, and gravitational tectonics, respectively.

After the first break, the next three talks were given in the second session, chaired by **Gren Draper**. **David Harper** (speaker), **Maria Liljeroth** and **Christian Rasmussen** (University of Copenhagen) debated the importance of oceanic islands as both cradles and museums of evolution with reference to the development of the global brachiopod fauna throughout the Ordovician. Some groups of brachiopods with particularly widespread distributions during this period were more than likely island hoppers. **Peter Skelton** (speaker, The Open University), **Shin-ichi Sano** (Fuki Prefectural Dinosaur Museum, Japan) and **Jean-Pierre Masse** (Université de Provence, Marseille) gave an overview of the origin, timing and patterns of migration of rudists during the Late Jurassic to Early Cretaceous interval, emphasizing the importance of the Pacific seamounts during the Early Cretaceous. Finally, before lunchtime, **Willem Renema** (NCB Naturalis, Leiden) closed the morning sessions with a talk on present day islands and past distributions, investigating the links between rich marine diversity and complex geological history, illustrated with examples of extant and fossil Foraminifera.

After lunch on the grass of nearby Green Park in sunny London, the meeting resumed with the third session, chaired by **Don McFarlane**. In a second presentation, **Steve Donovan** (speaker; NCB Naturalis, Leiden), **Roger Portell** (Florida Museum of Natural History, Gainesville) and **Isabel van Waveren** (NCB Naturalis, Leiden) discussed the composition and deposition of jumbled shell beds, sometimes comprising a combination of marine deep-water, shallow water and terrestrial taxa, with beautifully illustrated examples of faunas ranging from the Permian of Sumatra to the Pliocene of Jamaica. **Julian Hume** (Natural History Museum, London) reviewed avian biogeography on the islands of the western Indian Ocean. Although some of these islands have a long geological history their present avian diversity is only of recent origin due to eustatic sea level changes, geological events and anthropogenic changes. However, the fossil record indicates that the origins of the avifauna in these islands appear to be derived from southeast Asia rather than Madagascar or Africa. To close the session, **Daniela Winkler** (University of Hamburg) applied three-dimensional methods of dental morphometry and microtexture analysis to four species of extinct bovid endemic to Mallorca and Minorca. There is a shift from the grazer ancestor to the browser lineage end species, which suggests that either a dietary shift took place in this lineage or the species successively adapted to increased intraspecific competition.

Trevor Jackson chaired the fourth and last session. **Don McFarlane** (W.M. Keck Science Center, Los Angeles) gave an overview of Quaternary cave regions of the world. Cave fossil sites provide both opportunities and challenges for absolute dating and a range of techniques are adapted to the material found. Don emphasised that bone caves are a scarce and finite resource, but are also ephemeral in geological time and therefore need to be protected. “How near, how far?” or the difference in adaptive radiation patterns on various islands between birds and mammals was next discussed by **Lars van den Hoek Ostende** (NBC Naturalis, Leiden), **Elisa Locatelli** (Universitá di Ferrara, Italy) and **Hanneke Meijer** (National Museum of Natural History, Washington, D.C.). Many factors control radiations on islands, but, in general, bird radiations (through allopatric speciation) are found on oceanic archipelagos far from continents, and mammal radiations (through sympatric speciation) are mostly known from island arcs easier to colonise, but still isolated enough to allow evolutionary lineages to develop and diverge. To close the meeting, **Menno Schilthuizen** (NBC Naturalis, Leiden) examined the advantages and downfall of "life on a block of limestone". Limestone in Malaysia forms around 800 discrete units leading to a high degree of endemicity in terrestrial gastropods, many occurring on a single outcrop within a limestone unit. This provides a chance for testing macroecological models of niche-based and dispersal-based community assembly, but, unfortunately, the geological characteristics of these karst habitats are their demise. Extensive quarrying and land clearing endanger these endemic species, some being already extinct, and it is possible to predict future extinction.

In closing, **Trevor Jackson** and **Stephen Donovan** warmly thanked all the speakers and delegates to this successful meeting. Abstracts of talks were compiled in a booklet printed in *Scripta Geologica*, 2011, volume **142**, edited by Stephen Donovan and published by NCB Naturalis, Leiden. Copies are still available (e-mail <**Steve.Donovan@ncbnaturalis.nl**>). Speakers were encouraged to publish their talks and this will be the topic of a thematic set of papers in the *Journal of the Geological Society*.

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55th Annual Meeting of the Palaeontological Association
Plymouth University, UK *17 – 20 December 2011*

The 55th Annual Meeting of the Palaeontological Association kicked off in the maritime city of Plymouth on England's south coast on the afternoon of Saturday 17th December 2011, hosted by the School of Geography, Earth and Environmental Sciences at Plymouth University. Although this year saw the meeting return to England, the birthplace of the Association, the delegate list reflected the truly international nature of the conference attendees, with some from as far afield as North America, China and Australia. In fact, only 50% of the delegates giving talks over the next two days were based at UK institutions, with many people having travelled long distances to disseminate their research. It seemed appropriate then that the meeting should be held in this historic harbour city, from where many pioneering voyages set sail for far-flung corners of the world. For example, the Pilgrims finally left England from here in 1620 for the New World aboard the *Mayflower*, Captain Cook set sail on HMS *Endeavour* in 1768 on his voyage of discovery to Australia and New Zealand, and Charles Darwin left Plymouth on his first voyage, aboard HMS *Beagle*, in 1831, to name but a few: it seems Plymouth is genuinely a city with a spirit of discovery.

The thematic symposium "Ancient and Modern Biotic Crises" was chaired by **Malcolm Hart** (University of Plymouth) and addressed a number of key themes in relation to recent advances in our understanding of biotic crises. **Peter Ward** (University of Washington) commenced the talks with an overview of past mass extinctions and our evolving views on the causes of these different events, linking three of the biggest events to increased greenhouse conditions. **Bas van de Schootbrugge** (University of Frankfurt) then talked in more detail about the aftermath of one of these, the Triassic–Jurassic boundary event, which featured recurrent ocean anoxic events. New carbon isotope records from Germany suggest that these events may also be related to persistent greenhouse conditions. Before the coffee break **Mark Leckie** (University of Massachusetts) also discussed ocean anoxic events, linking the development of large igneous provinces to mid-Cretaceous events, which in turn caused large turnovers in planktonic foraminifera: their extinction and subsequent radiation. After coffee **Matt Friedman** (University of Oxford) continued with the extinction and recovery theme, but focused on fish, this time looking at diversity trends spanning the entire Phanerozoic. Using a broad spatial scale but specific time intervals, he concluded that just a few brief periods of turnover and recovery have had a major influence on the structure of modern fish biodiversity. Taking the audience to the depths of the oceans, **Martin Solan** (University of Southampton) then continued the afternoon with an informative look at benthic invertebrates. A mass extinction in this realm affects a variety of ecosystem properties, and he demonstrated to us that reconstructing bioturbation and trace fossil changes at mass extinction events, in particular during the Permian–Triassic extinction event, tell us about species traits and ecosystem function as a whole. The final talk of the symposium by **David Bottjer** (University of Southern California) focused on a theme that had recurred throughout the afternoon: whether anthropogenic climate change can ultimately result in a situation similar to those that caused past global warming-related extinction events. The ancient extinction events represent extremes of environmental stress and biotic change, but may serve as an analogue for the future in certain areas, such as increasing oxygen minimum zones. He concluded that, although the ancient biotic crises took place on an Earth very different to that of today, they can still teach us a lot about potential future climate change and its impact on biodiversity.

Fuelled with this interesting knowledge, we made our way to the evening icebreaker reception at the Council Houses in Plymouth city centre. Wine, soft drinks and fancy canapés were on offer, kindly sponsored by the Geological Society of London. These disappeared rapidly amongst the socialising and networking members of the Association. Despite being a large room it was thronged with eagerly conversing palaeontologists, excited to see old friends and enthusiastically making new ones. After some time people began to disperse in small groups in search of food, among the many restaurants and pubs of Plymouth.

Over the following two days, oral presentations were all given in the impressive Sherwell Centre, a converted Gothic church now part of the University, and began early on the Sunday morning after brief introductory remarks. Session 1 contained a wide variety of talks, beginning with **Douglas Erwin** (Smithsonian Institute) who discussed the abrupt emergence of diverse clades in the Early Cambrian, with **Martin Hughes** (University of Bath) then continuing the macroevolutionary theme, but this time in regard to the entire Phanerozoic. **Jennifer Hoyal Cuthill** (University of Sydney) then discussed adjusted homoplasy indices, followed by **David Nicholson** (University of York) who spoke about insect species richness at the family level and the challenges this presents to studies of macroevolution. Staying with palaeoentomology, **James Jepson** (University of Manchester) enlightened us about six new families of Neuropterida from the Lower Cretaceous of southern England, and **Maria McNamara** (Yale University) gave a fascinating talk regarding the preservation and function of bright structural colours in the wings of moths from Eocene Lake Messel. At the end of this session we were able to enjoy tea and coffee in the Main Hall of the University, and have a first look at the posters on display. Once the audience were reassembled in the lecture theatre the second session began, focusing mainly on arthropods. **David Legg** (Imperial College London) discussed the position of sea spiders based on his comprehensive phylogenetic analysis which incorporated stem-group eurarthropod taxa, before **James Lamsdell** (University of Kansas) discussed articulation morphology and its bearing on the phylogeny of basal chelicerates. **Nicholas Minter** (University of Saskatchewan), **Martin Smith** (University of Toronto) and **Allison Daley** (Natural History Museum) then kept things basal in the Burgess Shale, with three interesting talks regarding trackways, problematic organisms and their mouthparts. This concluded the morning talks and everyone moved to the Main Hall for an appetizing buffet lunch and to chat to colleagues about their posters.

The parallel sessions following lunch split the audience between the upper and lower lecture theatres of the Sherwell Centre, with session 3a keeping the focus on early life. **Julia Sigwart** (Queen's University Belfast) stepped into the breach to begin the afternoon with a talk about early molluscan evolution, followed by two talks regarding early sponges: **Jonathan Antcliffe** (University of Bristol) reported on basal Cambrian spicules from Iran and implications for Precambrian divergences, while **Joseph Botting** (Nanjing Institute of Geology and Palaeontology) described for us the fantastic Hetang Biota of southern China, which gives important insights into early sponges but also demonstrates just how much research is yet to be done on early sponge evolution. Staying in the basal Cambrian, **Xiaoya Ma** (Natural History Museum) demonstrated how an early Lobopodian from the Chengjiang Lagerstätte may not inform us on the evolution of arthropodization, as previously thought; **Thomas Harvey** (University of Cambridge) showed us exceptionally preserved crustacean appendages from the Deadwood Formation, Canada; and **Graham Budd** (Uppsala University) discussed stem-group chelicerates.

Meanwhile, over in parallel session 3b, much more modern marine species were being discussed, from Cenozoic seas around the world. **Kenneth Johnson** (Natural History Museum) began with an in-depth look at the Southeast Asian marine biodiversity maximum, based on an astounding eight tons of samples collected as part of a collaborative enterprise, followed by **Tanya Knowles** (Imperial College London) with a smaller-scale project looking at bryozoan zooid size and carbonate isotopic signatures, used to infer Pliocene seawater temperatures. **Stefano Dominici** (University of Firenze) then told us about Pleistocene barnacles and their probable co-evolution with the humpback whale, before three talks by young researchers, including **Laura McMonagle** (Durham University) who spoke about stony corals from Borneo, **Deborah Wall-Palmer** (Plymouth University) who discussed dissolution of aragonitic pteropod shells from the Caribbean and Mediterranean seas, and **Nicholas Higgs** (University of Leeds) who unveiled a first occurrence of boring marine worms from the Pliocene of Italy.

The final session of Sunday brought everyone back together in the lower lecture theatre for a varied programme, which included some themes of the previous day's symposium, yet more focused on individual taxa. Four young researchers – all eligible candidates for the President's Prize – began the session. **Kate Olde** (Kingston University London) discussed the extreme greenhouse climate during the Late Cretaceous Oceanic Anoxic Event 2 and its effect on dinoflagellates, followed by **Andrew Leighton** (Plymouth University) and **Caroline Sogot** (University of Cambridge) who spoke about variation in benthic foraminiferal forms and bryozoan size respectively, both at the K–T boundary. Staying with the same mass extinction event, **Daniel Field** (Yale University) talked about the resulting impact on avian evolution, before **Pincelli Hull** (Yale University) concluded the session with a stimulating talk on recovery after the event, looking at the impact of internal and external consequences on the ecosystems present using a multiproxy approach.

The AGM was then swiftly dealt with, opening the floor for the annual address given by **Paul Pearson** (Cardiff University), which continued the themes of biotic crises, recovery and the future impact of current anthropogenic changes. He told us how oceanic ecosystems were greatly impacted by the K/Pg boundary extinctions and then recovered over many millions of years in several phases. This recovery was also affected by the long-term post-boundary cooling trends, as greenhouse gas levels declined in relation to tectonic changes thereby setting the stage for the emergence of polar ice caps. He then described the profound impact of these changes on certain groups such as mineralizing plankton, and how the diversification, extinction/survival and speciation patterns of many can be linked to this external forcing, although some may have been influenced more heavily by intrinsic factors. Professor Pearson also commented on the rapidity of anthropogenic climate change at the present day, and how another major mass extinction may result from this.

Armed with this knowledge we set off for the Annual Dinner in the Guildhall, an imposing building situated just off Royal Parade in the city centre. Waiting for us in the foyer was a welcome drink of sloe gin, made to a unique 1883 recipe by the Plymouth Gin Distillery, the oldest working gin distillery in England. After this excellent start and a great chance to catch up with colleagues and friends, we were invited through into the mahogany-panelled main hall, with its grand Wedgwood-style carvings on the ceiling and three half-ton chandeliers that represent the three towns now forming the City of Plymouth. There to greet us was a whole herd (if that is the correct collective noun?) of smiling pink sauropod helium balloon centrepieces, many of which were soon untethered and set free to drift towards the ceiling sculptures where they probably still remain. We enjoyed a delicious meal, all impeccably served by excellent waiting staff, of butternut squash soup, stuffed

The Annual Dinner in the Guildhall, complete with pink sauropods (photo Martin Hughes).

chicken with roasted vegetables (risotto for the vegetarians) and lemon tart for dessert, all washed down with some very fine wines. As we enjoyed our coffees and the enticing West Country fudge squares, the annual awards were announced. This year two framed scrolls were given out for the Mary Anning Award, to deserving recipients **David Brockhurst** and **Chris Duffin**. **Richard Butler** (University of Munich) received the Hodson Award for his notable early-career contributions to palaeontology, before the President's Medal was awarded to **Greg Edgecombe** (Natural History Museum) in recognition of his mid-career achievements. Finally, **Prof. Richard Aldridge** (University of Leicester) was awarded the 2011 Lapworth Medal for his outstanding contribution to the science, in the area of Palaeozoic micropalaeontology. Once the awards and short acceptance speeches had been made it was time for most of us to continue with a few drinks from the foyer bar, followed by further socialising and networking into the wee small hours in the lobby bar of the Jurys Inn, where the majority of delegates were staying.

The following morning we were up early (if not exactly bright-eyed and bushy-tailed) for the dedicated poster session in the Main Hall of the University. Very welcome tea, coffee and pastries were served for the hour and a half long session, where delegates attended their posters and some interesting discussions and debates ensued. At 10.30am we all convened in the lower lecture theatre of the Sherwell Centre for session 6, where all of the young presenters were contenders for the President's Prize. **Duncan Murdock** (University of Bristol) opened the morning's four talks on morphology with a look at brachiopod bodyplan evolution, followed by **Imran Rahman** (University of Birmingham) who described how computational fluid dynamics can provide insights into the functional morphology of echinoderms. **David Marshall** (independent) then described the stellate ornamentation on the head shield of a Late Silurian chelicerate and the possibility of it being an epibiont, before **Roger Close** (Monash University) described the outcome of functional morphometric analyses on avian furculae. **Alexander Liu** and **Emily Mitchell** (University of Cambridge) both discussed Ediacaran fauna and palaeoecology, before **Richard Hofmann** (University of Zurich) gave the last talk of the morning, on the palaeoecology of an Early Triassic limestone fauna and the implications for recovery after the end-Permian mass extinction event. We then reconvened in the Main Hall for a lunch hour spent browsing posters and enjoying the excellent finger buffet of sandwiches, snacks and desserts again provided by the conference organisers.

The post-lunch session was again split between the upper and lower lecture theatres, with session 7a concentrating on Lower Palaeozoic faunas, beginning with **Thomas Servais** (University of Lille) and an in-depth look at the Cambrian/Ordovician Explosion/Biodiversification events. Next came talks on new Norwegian trilobites, new data on molluscan evolution, and a new Ordovician Lagerstätte, given by **Anette Högström** (Tromsø University Museum), **Mark Sutton** (Imperial College London) and **Lucy Muir** (Nanjing Institute of Geology and Palaeontology) respectively. **Vincent Perrier** (University of Tartu) then presented the recovery patterns of Ordovician ostracods after two ash-fall events, **Mena Schemm-Gergory** (University of Coimbra) gave an engaging talk on the Devonian from Devonshire, the source of the term, and **Jennifer Morris** (Cardiff University) closed the session with a talk on charcoalified Devonian fossil plants from the Welsh borderland.

Meanwhile, in session 7b the audience were being treated to a series of talks on jawed vertebrates. **Gilles Cuny** (Natural History Museum of Denmark) began the series by presenting new data on the evolution of Mesozoic freshwater sharks in Southeast Asia, before **Philip Anderson** (University of Bristol) took us back to the Palaeozoic and gnathostome radiation. Two more talks from the University of Bristol followed, both concerning morphology, with **David Jones**' interrogation of morphospaces suggesting that functional innovation in conodonts may have driven phylogenetic expansion, and **Martin Rücklin**'s varied evidence from placoderm teeth arguing for a basal position of the arthrodire construction in gnathostome jaw evolution. **Laurent Darras** (University of Leicester) continued the morphology theme, showing how jaw microwear textures can reveal information regarding trophic diversity in Devonian aquatic ecosystems, before **Nicola Heckeberg** (University of Munich) moved things into the terrestrial realm with a talk on the phylogeny and evolution of deer. **James Tarver** (University of Bristol), also with a talk concerning phylogenetic analysis of a mammal group, closed the penultimate session of the conference by showing us how microRNAs can resolve relationships amongst Eutherians.

After coffee the 8th and final session of the meeting got under way with a talk on some of the earliest life on Earth by **Therese Sallstedt** (Swedish Museum of Natural History); she discussed Palaeoproterozoic stromatolites from India and factors affecting the growth position of filamentous bacteria. Skipping forward more than 1,300 Ma, **Ben Slater** (University of Birmingham) then took us to the Middle Permian of Antarctica and showed us invertebrate coprolites in plants, a rare example of herbivory there. **Alexander Dunhill** (University of Bristol) then enlightened us regarding bias in the fossil record and how the volume of rock available for sampling affects perceived palaeobiodiversity. Next **Alan Spencer** (Imperial College London) demonstrated how X-ray micro-tomography has helped to elucidate planes of symmetry in fossil seeds, meaning that some previous methods for diagnosing systematic affinity of seeds should be treated with caution. **Peter Falkingham** (University of Manchester) then offered a change of pace, with a talk on how to constrain the outlines of dinosaur trackways, a measurement that is subjective and likely to influence multivariate analyses if not fully considered. **Crispin Little** (University of Leeds) stood in

On the field trip: Triangle Point, Devon (photo Fabio Petti).


Corals and bryozoans at Triangle Point, Devon (photo Fabio Petti).

for **Øyvind Hammer** (University of Oslo), then took us through some exciting new Mesozoic cold seep deposits from Norway, before **Jakob Vinther** (University of Texas) wrapped up the scientific sessions with an interesting talk on understanding colour in fossil feathers.

The prizes were then given to the early stage researchers judged to have given the best presentations: the President's Prize went to **Alexander Liu** (University of Cambridge) for his excellent talk on frondose Ediacaran organisms and their ontogeny, and the Council's Poster Prize was awarded to **Sam Giles** (University of Bristol) for her attractive poster on placoderm histology and the origin of the gnathostome dermal skeleton. With that, the meeting was drawn to a close and many Association members began their journeys home.

Those of us remaining in Plymouth for an extra night got to explore a little more of the city, despite the cold and dark December evening. Standing by the waterside in the historic Barbican district it was easy to imagine the second voyage of HMS *Beagle* setting sail 180 Decembers previously. Apparently the sailing was delayed by a day due to the entire crew either missing or being drunk from Christmas festivities the night before! Many of us were similarly overcome after the annual dinner festivities the night before, but managed to sample a few local ales and the traditional fish and chips at least.

The next morning about 45 of us set off on the field trip, zipping along the A38 in a coach eastbound towards Torquay. This year's weather was very mild in comparison to last and, luckily, there was no snow to hinder the excursion this time. We were heading for the English Riviera Global Geopark, the world's first urban Geopark, which features some of the best geology in southern Britain. Within the Geopark the limestones constitute a Middle Devonian reef system with rich coral assemblages as well as brachiopods and trilobites. Our first stop was at Triangle Point to see some of these, although many of us were transfixed by a poor oiled juvenile guillemot, which at

Devonian limestones to the east of Hope's Nose, Devon (photo Richard Hofmann).

first glance looked like a lost penguin! The limestones here are part of the Daddyhole Limestone Formation and are full of corals and bryozoans. Once everybody had had a good look we were shuttled to the next stop in a minibus and enjoyed a pleasant walk down to the end of Hope's Nose. Devon, of course, lends its name to the Devonian System, and some of the rocks outcropping in this area were an integral part of the early definitions by de la Beche, as well as Murchison and Sedgwick who established the Devonian System in 1836. After exploring the much younger Quaternary raised beach deposits we moved eastwards to see the Devonian limestone sequences beneath and even saw some trilobites. The minibus then ferried us in small groups to Kents Cavern where a magnificent spread awaited us, with sandwiches, nibbles and mince pies, and local ciders were available at the bar. We were then divided into two groups for a tour of the show caves, which are a designated SSSI. Our guide was highly entertaining, with just the right mix of facts and humour, and a talented storyteller. The caves, with their impressive stalagmites and stalactites, are an important Quaternary site where the remains of many Late Pleistocene mammals have been found, including hyaena, cave lion, mammoth and bison. We were even able to touch the skull of a Pleistocene cave bear, exposed in the roof of the cave. The caves have a long history of human use, stretching back to Palaeolithic times. Flint implements made by Neanderthals have been found there. The caves have also yielded a small piece of maxilla with three teeth attached from *Homo sapiens*, recently found to be the oldest human remains in northwestern Europe to date, as published in a November issue of *Nature*. Kents Cavern really is worth a visit, and was a great place to round off the meeting.

PalAss 2011 was a highly successful conference with many varied and exciting presentations of new data and ideas. We would like to thank the conference organisers from the School of Geography, Earth and Environmental Sciences at Plymouth University, and in particular Richard Twitchett, for their meticulous planning of the event ensuring everything ran like clockwork and for catering to our every need. We would also like to thank all the delegates who presented talks and posters, and

Flowstone, stalactites and stalagmites in Kents Cavern (photo Gerhard Cadee).

Paul Pearson for giving such an engaging annual address. We look forward to seeing you all again at the 56th Palaeontological Association Annual Meeting in Dublin, Ireland: the European City of Science for 2012.

Jo Hellawell
University of Bonn

The PalAss fieldtrip party outside Kents Cavern (photo Nick Powe, Kents Cavern)

——OBITUARY——

Arthur Cruickshank
1932 – 2011

A native Gondwanan, who studied the former continent's fossil tetrapods

Dr Arthur Richard Ivor Cruickshank died on 4th December 2011, aged 79, in the Borders General Hospital, Melrose, Scotland. Arthur Cruickshank was part of the post-war generation of palaeontologists who laid the foundations on which today's researchers build. Appropriately for someone from an expatriate Scots family living in Kenya, much of his work was on the extinct reptiles of the great southern palaeocontinent of Gondwana.

Figure 1. Arthur Cruickshank in 2008, speaking at the 45th reunion of the Edinburgh University Gliding Club, of which he was a founding member. Photo courtesy Neil Hodgins.

Cruickshank was born in Nairobi, Kenya, on 29th February 1932. His grandfather was traffic manager on the Uganda Railway, which went from the port of Mombasa to Nairobi in Kenya and on into the interior and Uganda proper, through fine wildlife country. A recurring problem was the need to deal with those individual lions which developed a habit of eating staff and passengers, and the family story is that the traffic manager had to shoot at least one such lion himself. This was surely one of the lion stories he told Teddy Roosevelt, the former President of the United States, when they were travelling on a special train during Roosevelt's famous African safari of 1909–10, which yielded many zoological specimens for the Smithsonian Institution in Washington and other American museums.

Cruickshank's father was Scottish through and through, from several generations of farmers near Elgin in Moray in NE Scotland. Cruickshank's mother was of joint Devonshire and Scottish extraction. His parents travelled widely for his father's work as an engineer in the sisal plantations, often leaving their only child in a Nairobi children's home. Cruickshank contracted chronic malaria and in 1938, aged six, he was sent back to Scotland, where he boarded at Dollar Academy in Clackmannan. Wartime restrictions considerably reduced contact with his family, but eventually he was settled for his school holidays with a family in Coldstream which gave him an experience of family life and his life-long love of the Scottish Borders.

Cruickshank's National Service in the RAF did not lead to the hoped-for flying career, as his sight was not good enough for aircrew. He subsequently served with the Territorial Army in signals units, as well as carrying on with target rifle shooting, in which he gained an Edinburgh University Blue at Bisley in 1957 and later a Cambridge Blue. Cruickshank took up the sport of gliding where he found freedom and relaxation, though he did have some hair-raising stories of his time as an instructor at Grangemouth whilst at Edinburgh University, where he was a founder-member of Edinburgh University Gliding Club. There was also the tale of an emergency landing of his glider on the most convenient airfield, which turned out to have been converted into a base for Thor nuclear missiles, then a highly sensitive part of the Anglo-American nuclear deterrent. Fortunately, he was met, not by machine-gun wielding Americans, but by the RAF station commander who was so pleased to see 'a real aircraft' on his base that he treated Cruickshank to lunch at the Officers' Mess.

Cruickshank entered Edinburgh University's Department of Geology in 1953 as an undergraduate, at a time when the novel theory of plate tectonics, or at least an earlier variant set out in Arthur Holmes' *The principles of physical geology*, was arousing intense debate. It so happened that the established staff – or at least some of those with whom Cruickshank had most to do – would not then accept the new thinking. But Cruickshank had been convinced by reading Holmes' classic, and was imprudent enough to say so: appropriately enough for a Gondwanan, given that some of the key evidence was from that now split supercontinent. It is perhaps open to question who was more dissatisfied with whom, but at any rate Cruickshank found it advisable to transfer to the Department of Zoology for his Honours year. He further cemented his shift to the palaeontological side of life with his first research, a project on the teeth of the giant rhizodontid fishes from the local Carboniferous from the Lothians. In 1958 Cruickshank moved to the University of Cambridge for a doctorate under Dr Rex Parrington, studying specimens which Parrington had collected in an African expedition in the 1930s; Cruickshank's allocated beast was the dicynodont *Tetragonias*, a hefty plant-eater. His external examiner was absolutely astounded by what he had achieved from the specimens to hand. The resulting 45-page monograph was published in the *Journal of Zoology* in 1967. This was a typical example of the classic vertebrate palaeontological paper of the day: a full, bone-by-bone description, and comparison with close relatives, together with consideration of the feeding and locomotor abilities of the beast.

Figure 2. The British Museum (Natural History) East Africa Expedition 1963 – the South African group meets up with the main team at Lindazi Castle in Zambia. From left to right, the adults are Arthur Cruickshank, Barney Hershon (an interested amateur from Cape Town), Fuzz Crompton, John Attridge, Alan Charig and Barry Cox. The child was the son of the person running the hostel. (Photo courtesy Steve Tolan via Enid Cruickshank.)

Cruickshank continued with his interest in dicynodonts, publishing on other Triassic species, as well as writing overviews of their evolution and functional morphology. To non-experts, dicynodonts all look more or less the same – animals from 1 to 3 metres in length, with barrel-shaped bodies, a large head with somewhat beak-like jaws for chopping plant food, massive legs, and an inadequate-seeming stumpy tail. But to 'dicynodontophiles' like Cruickshank, they are objects of beauty – and of great importance to understanding the evolution of life on Earth, for dicynodonts comprise the first major group of plant-eating land vertebrates.

Cruickshank took up a lecturing post at the Edinburgh University Department of Zoology, where he met his future wife Enid, then a student, who came from Denholm near Hawick in the Scottish Borders, and they were married in 1963. In 1966 he took up a lecturing post at Napier College, Edinburgh, before moving in 1967 to the University of the Witwatersrand, Johannesburg, where he was Assistant Director of the Bernard Price Institute for Palaeontological Research. This gave him access to a wide range of unstudied dicynodont specimens, allowing him to sustain his passion for these beasts.

Cruickshank tackled the Permo–Triassic aged rocks of southern Africa, and their fossil reptiles, with alacrity. He had already been to Cape Town for three months to study specimens of the dicynodont *Lystrosaurus* in the museum, before he joined the 1963 British Museum (Natural History) [now the Natural History Museum, London] expedition through East Africa. The South African group drove all the way from Johannesburg via Salisbury (now Harare, Zimbabwe) and Nyasaland (now Malawi) to meet the others in the Ruhuhu Valley in south Tanganyika (now Tanzania), which was also near to where Cruickshank's mother was living in Tanga. Enid met him here after taking a ship from South Africa.

Cruickshank continued studying his beloved dicynodonts, but also began to explore the basal archosaurs – important as the ancestors of crocodiles, dinosaurs, and modern birds. In the 1970s, he published definitive works on the anatomy and relationships of some of the most basal archosaurs, *Proterosuchus* and *Erythrosuchus*. The archosaurs had evolved at the very end of the Permian Period, and they diversified rapidly in the Early and Middle Triassic, following the devastating end-Permian mass extinction around 250 million years ago. This work sparked wider interest in the evolution of the group, which today is still a hot topic of debate and research. By chance, some of the best early archosaur fossils were in the South African museums, and Cruickshank gave detailed anatomical descriptions which today are still widely quoted as definitive sources.

This work led to wider investigations of the succession of terrestrial ecosystems through the Permian and Triassic. Cruickshank wrote about overall patterns of evolution among the archosaurs, and focused also on the origin of the dinosaurs. Furthermore, with the palaeobotanist John Anderson, he wrote detailed, and then state-of-the art, overviews on vertebrate faunal successions worldwide through the Permian and Triassic. All this work on Permo–Triassic reptiles provided one of the first frameworks for understanding this crucial time: not only do Triassic rocks document the recovery of life from the most profound Phanerozoic mass extinction, the end-Permian event, but this was also the time of the origin of the dinosaurs, as well as key elements of modern vertebrate faunas, including the first frogs, turtles, crocodile ancestors, lizard ancestors and perhaps lizards themselves, and later the mammals.

Cruickshank found South Africa exciting but difficult, in terms of both the job and of the wider South African scene (see also the obituary by Bruce Rubidge, Mike Raath and John Hancox in issue 18 of *PalNews*, to be archived in due course on <**http://www.palaeontologicalsociety.co.za/index.html**>). Back in the UK, he was a life-long Liberal and active in the Liberal Party and its later incarnation the Liberal Democrat Party, especially after the family returned to Scotland in 1978. However, a new Conservative Government clamped down on university research, so Cruickshank could find no permanent teaching or research post, but took what work he could get in local universities, colleges and museums, and especially as a tutor with the Open University. He continued to collaborate with his former South African colleagues in presenting papers on Permian and Triassic faunas, and early dinosaurs from southern Africa.

Figure 3. Arthur Cruickshank examining Lower Liassic (Jurassic) shales at the classic plesiosaur locality of Charmouth, Dorset, about April 1991, on a trip with Bristol Museum and Bristol University geologists to the find-spot of David Sole's 'Charmouth Ichthyosaur'– now the holotype of Leptopterygius solei *McGowan, 1993 in Bristol City Museum and Art Gallery. (Photo courtesy David Hill.)*

The Cruickshank family moved to Hinckley in Leicestershire in 1985 when his wife obtained a post as a librarian in Rugby. Hinckley lies near the Jurassic belt that crosses England from the east to south coasts, and a contract post at Leicestershire Museums Service led Cruickshank to a change of research direction. He now began to work on the Jurassic and Cretaceous plesiosaurs, large marine reptiles with four flippers. His initial post in Leicester was a short-term contract for routine curatorial and site documentation work, but Cruickshank soon took advantage of the Museum's facilities and its fine marine reptile collections from the local Jurassic. He became for many years an honorary research associate, *de facto* and then *de jure*, of Leicestershire Museums and its Leicester City successor, as well as an Honorary Research Fellow of the Department of Geology at the University of Leicester. Some of his research work was supported by the Leverhulme Trust (through a grant to Mike Taylor, then at Leicestershire Museums).

One highlight was the description of Leicester Museum's *Rhomaleosaurus megacephalus*, locally nicknamed 'the Barrow Kipper'. The specimen originated from earliest Jurassic deposits at nearby Barrow-upon-Soar, and has become the symbol of the town. Cruickshank and his colleagues subjected the specimen to CT-scanning to study the internal structure of its nasal passages. In 1991 this was still a fairly new and unusual technique to use on fossils, but Cruickshank seized the opportunity when he found Philip Small, a doctor at the Queen's Medical Centre in Nottingham, in the evening class which Cruickshank took over when David Martill moved to Portsmouth. More recently he was part of the team which scanned a hollow 'mouldic' fossil inside a block of sandstone from Morayshire. This data was used to recreate a 3-D computer-generated rendition of the skull of a dicynodont, and then to rapid-prototype it in plastic, in one of the earliest uses of this technique in palaeontology, certainly in Britain.

Another opportunistic meeting, this time at a rather lower technical level, happened when Cruickshank observed his dentist using high-fidelity dental putty; he promptly besought the dentist to cast the tooth marks which he had observed on a bone of a kannemeyeriid dicynodont. This helped identify the characteristic dentition of the predator, a rauisuchian archosaur. The elemental simplicity of the resulting paper evidently threw at least one *Palaeontology* referee completely off balance; one praised it as a perfect piece of work, needing no changes, and another – fortunately ignored by the editors – damned it as unworthy of the august pages of that journal.

Cruickshank also happened to meet the engineer Professor Beric Skews of the University of the Witwatersrand, simply because Skews' little boy wanted to know all about dinosaurs; the result was an elegant hydrodynamical study of the long tabular horns of the Palaeozoic nectridean amphibians *Diplocaulus* and *Diploceraspis* – which look like newts with boomerangs for heads. Cruickshank and Skews concluded that the animals lurked on the bottom of rivers, raising their heads into the flow to gain a rapid lift force to help them lunge upwards at prey. Cruickshank's evening class students were often led – through initial bafflement at Cruickshank's and Skews' counterintuitive use of a wind tunnel for their model nectrideans rather than a water flume tank – to an appreciation of the Reynolds number and the concepts of scaling and dynamical similarity in fluid mechanics. Professor R. McNeill Alexander, the eminent biomechanicist, chose this study to exemplify hydrodynamics in his prestigious William Smith lecture on the biomechanics of fossil vertebrates to the Geological Society of London in 1989.

Figure 4. At Vaughan College, in front of the ruins of the Roman Baths, Leicester, February 2004: speakers at the Leicester Literary and Philosophical Society's Saturday School on Mesozoic marine and aerial reptiles, which Cruickshank was co-chairing with Andrew Swift. From left of picture to right are Darren Naish, David Martill, Richard Forrest, Lorna Steel, Leslie Noè, Arthur Cruickshank, Will Watts, and Mark Evans; today that group includes three PhD students of Cruickshank's (Forrest, Noè and Evans) and two published collaborators (Martill, Noè). (Photo courtesy Andrew Swift.)

Cruickshank's work on plesiosaurs included a study of the first Westbury Pliosaur, still on show at Bristol Museum & Art Gallery; today this work is highly relevant to the newly unveiled giant Dorset Pliosaur. He co-described the weird *Pachycostasaurus* in Peterborough Museum, its ribs swollen into ballast to help it swim slowly along Jurassic sea floors, perhaps to graze on shoals of Jurassic shrimps – a carnivorous reptilian analogue of modern plant-eating sea-cows. Cruickshank returned to his Morayshire roots, not just with the aforesaid dicynodont but also with a study of the plesiosaur remains from the giant Rhaetian erratic at Linksfield near Elgin, and to his Gondwanaland roots with the support of the Royal Society of London, to study Cretaceous plesiosaurs in Australia, New Zealand and South Africa. The southern continent work came about in part to examine relatives of *Leptocleidus superstes*, from the Wealden of Sussex, which was startlingly similar to the early Jurassic *Rhomaleosaurus* despite being a Lower Cretaceous form; Cruickshank suggested that these Cretaceous pliosaurians had been displaced into near-shore and estuarine environments by the rise of competitors. He also examined other southern forms, co-describing the new *Kaiwhekea* from New Zealand with Ewan Fordyce.

Figure 5. Arthur Cruickshank at his "retirement" party, at the Strode Theatre, Street, Somerset, in July 2009. The cake is an accurate model of the holotype specimen of the Triassic–Jurassic boundary plesiosaur Thalassiodracon hawkinsi *(Owen, 1840), found at Street. (Photo by Mike Taylor.)*

Cruickshank's work on plesiosaurs took place when this important group was almost completely neglected. The situation is much different today, for his work helped stimulate a younger generation of researchers with whose studies, as well as those of his nearer contemporaries, he was much involved, often working in collaboration. As with his earlier work on Permo–Triassic beasts, he was a mine of information, always on hand to provide friendly support and advice to co-workers, students, amateur collectors (so important in this area of research), and others interested in these fascinating animals. In total, and including the Permo–Triassic work, he supervised at least 11 research students (plus two ongoing), and examined eight others. In this and in many other ways he was a deeply appreciated friend and colleague, perhaps more so than he realised, and his memory will live long in the minds of those who knew and loved him. A colleague accurately recalled that "he was the most urbane of palaeontologists, with one of the driest and quickest senses of humour I have known". Cruickshank's modesty shone through when he was amazed by the numbers in attendance at a special session held in his honour, preceding a Palaeontological Association conference on the Triassic/Jurassic boundary fossils of the West Country in Street, Somerset, in 2009 – an appropriate location for its plesiosaurs of world class importance, as well as its views of the Isle of Avalon of, indeed, *Arthurian* legend (see *Palaeontology Newsletter* **73**, 40–46). The Street plesiosaur *Avalonnectes arturi* Benson, Evans & Druckenmiller, 2012 has now been named for Cruickshank, as was the dicynodont *Angonisaurus cruickshanki* Cox & Li, 1983, whose type specimen he helped to collect on the 1963 expedition, and also prepared.

Cruickshank was a long-standing member of the Palaeontological Association, and served on its Council as Institutional Membership Treasurer from 1990 to 1992. For many years he was a Fellow of the Geological Society, and also a member of the Institute of Geologists, taking C. Geol. status. He served variously on the councils and committees of the Zoological Society of Southern Africa, the Geological Society of South Africa, South African Society for Quaternary Research, and the University of the Witwatersrand Faculty of Science. He was on the Museum of Man and Science Board of Governors in South Africa, was Chairman of the Dinosaur Society (UK), and sat on the Tutorial and Counselling Staff Committee of the Open University in Scotland.

Cruickshank gave up solo gliding after a heart bypass operation in 2001. However, he continued to enjoy flying in two-seater gliders, paying as if a trainee under instruction, though the instructor would simply let him do all the flying (especially if a former trainee of his). He always enjoyed visiting aircraft museums and air shows, sniffing them out wherever he travelled at home and abroad. His regular favourites included the veteran and vintage planes at Old Warden near Bedford, Scotland's National Museum of Flight at East Fortune, and the Fleet Air Arm Museum at Yeovilton in Somerset where he often helped his cousin-in-law with volunteer work. He also relaxed by making model aircraft – his collection left behind on moving to South Africa was long on show in the Royal Scottish Museum.

In 2006, the Cruickshanks moved back to the Borders and lived first in Denholm and then in Hawick. Late in life he suffered, with remarkable resolve and cheerfulness, from bowel cancer, and died in the Borders General Hospital at Melrose following a fall at home. A dedicated family man, Arthur Cruickshank is survived by his wife Enid, their children Peter, Susan, and David, and three grandchildren.

Acknowledgements

We thank Enid and Peter Cruickshank and many friends and colleagues for supplying information and photos. We acknowledge kind permission of the respective editors to publish variants of this obituary in both *Palaeontological Association Newsletter* and *Palaeontologia africana* (**46**, pp. 93–98, which last also includes a full listing of Arthur's scientific publications). We have individually or severally published other obituaries but those are briefer and cover much the same ground, except for that in the *Southern Reporter* of 22nd December 2011, p. 12, which has more on Arthur's Borders life, and his activities with local museums, *etc*. It is hoped to place links and/or pdfs of some of those other obituaries on the NMS Research Repository in due course, at <**http://repository.nms.ac.uk/**>.

Michael A. Taylor
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The Palaeontology of Pop

At last year's Annual Meeting in Plymouth, an idea was touted of holding a palaeo-themed musical event. In the end it didn't happen, but there was a fair bit of interest, so maybe it will be resurrected in Dublin in December. It also got me thinking.

A couple of weeks into the New Year, I read that a new species of Cretaceous hermit crab had been named for Michael Jackson. His death had been announced the day the fossil was discovered, so the research team (Fraaije *et al*. 2012) decided to immortalize the King of Pop.

It's not the first time such a thing has happened, of course, with *Australopithecus afarensis* being better-known as Lucy, thanks to the Beatles' "Lucy In The Sky With Diamonds", which was played repeatedly during her excavation.

Dire Straits even made it into *Nature* in 2001, when frontman Mark Knopfler was immortalized as a species of *Masiakasaurus*. *M. knopfleri* Sampson *et al.*, (2001) was a true dinosaur of rock.

But whilst palaeontologists are obviously interested in popular music, is there any evidence of the reverse, I wondered? Have fossils ever made their way into the song-writer's pantheon?

In my formative years, the only fossiliferous pop song I knew of was "Walk The Dinosaur" by Was (Not Was), and that was pretty tenuous. An opening line of

It was a night like this
40 million years ago

didn't indicate a detailed grasp of Mesozoic geochronology.

As an undergraduate, therefore, I wrote my own. When I say 'wrote my own', I actually mean 'butchered other peoples' ". The only one I am proud of is "I Will Survive", the Gloria Gaynor disco classic, the fossiliferous version of which begins:

At first I just decayed,
Then I petrified.
Kept thinking I would never crop out
On some mountain side.
But then I spent ten million years
Sinking down till I was gone
And I grew strong
*And I turned into silicon**

*dioxide.

Countless others, from 'Permian Rhapsody' to 'Paranoid Echinoid', were just rubbish, but I wasn't the only numpty doing it. A cursory search online reveals like-minded souls (*cf*. 'Daddy Why Are There No Pop Songs About Fossils?' – <**http://lastdjango.blogspot.com/2009/03/daddy-why-are-there-no-pop-songs-about.html**>).

Having thought that might be as far as palaeo-pop got, however, the last few years have shown signs of traffic coming the other way. Genuine musicians are writing great songs that actually include geological and palaeontological themes. The times they might be a-changing.

New York band They Might Be Giants have always been experimental. Best known for their 1990 Top Ten single 'Birdhouse In Your Soul', they've written tracks about James K. Polk, metal detectors, and palindromes. In 2009, though, they came up with *Here Comes Science*, a rather novel rock album.

Aimed at children (but far too accomplished and amusing to be wasted on them alone), *Here Comes Science* features such gems as 'Why Does The Sun Shine?' (The sun is a mass / of incandescent gas./ A gigantic nuclear furnace), and 'Photosynthesis' (does not involve a camera / or a synthesizer). And, best of all, 'I Am A Paleontologist'.

OK, so it makes the assumption that all palaeontologists dig for dinosaurs, but it's such a catchy record I'm prepared to forgive them. It was written for band member Danny Weinkauf, "who likes to pretend he is one," and name-checks evolution, mass extinctions, stratigraphy and taxonomy:

It's like pieces of a puzzle
That I love to try and solve
It's so fun to think about
How a species has evolved.

The accompanying video is rather splendid too:

<**http://www.youtube.com/watch?v=B7zo2zY1Zqg&feature=rellist&playnext=1&list=PL44C7ADBD6A22FF0B**>

It even caused a hard rock colleague of mine to express a wish that he was a palaeontologist.

On this side of the Atlantic, vertebrate palaeontology has been interpreted in a slightly different way. 2011 saw indie-rock monsters Kasabian release *Velociraptor!* "We just loved the word, that was the initial attraction," singer Serge Pizzorno told the *Daily Telegraph* <**http://www.telegraph.co.uk/culture/8773196/Kasabian-love-the-glam-rock-of-dinosaurs.html**>.

"Then we found out that they were hunting in packs of four," Pizzorno continued. "They were like a band and that's how they survived, they stuck together. And we found out they had feathers, they were obviously like a glam-rock band with feather boas, so it was perfect."

Dinosaur palaeoecology and the phylogeny of feathers. Who'd have thought such things could make it to the top of the British album charts?

As if to prove this wasn't a one-off, singer-songwriter Emma-Lee Moss (aka Emmy The Great) released her own take on the subject. Her rather more subdued album *Virtue* was apparently inspired by the futility of dinosaur sex. "Someone just said it out loud once," Moss said, "and it made me laugh. The point of the song is 'What did it do?'"

Beginning the song with some weird primaeval squawking, Moss notes apocalyptically that:

Dinosaur sex led to nothing
And maybe we will lead to nothing

As we – and perhaps even Kasabian too – now know, dinosaur sex was not quite as futile as Moss would have it. It did, for the theropods at least, lead to birds.

Dinosaurs also led to birds for the great Jarvis Cocker. Always a poet of pop, the Pulp singer branched into a new direction with his 2009 solo record *Further Complications*. Living in Paris, he found himself inspired by finding females among the fossils.

"I was in the Museum of Palaeontology on the Jardin des Plantes looking at this dinosaur skeleton," Cocker recalled (<**http://www.acrylicafternoons.com/eurostar.html**>), "and there was an attractive woman there." So he wrote the song 'Leftovers' about the encounter:

I met her in the Museum of Palaeontology
And I make no bones about it
I said,
"If you wish to study dinosaurs,
I know a specimen whose interest is undoubted."

For a gent whose sartorial choices have often been filed under the style sub-group 'palaeontology professor', this seems entirely appropriate.

Talking of which, it would be remiss of me not to mention Greg Graffin at this point. Lead singer of the Los Angeles-based punk band Bad Religion, Graffin is also a lecturer of palaeontology at UCLA. His scientific interests inform his music, and he has often compared evolution with punk rock, recently co-authoring a book called *Anarchy Evolution*.

Rather less aggressive in her approach, but equally geologically grounded, is Portland, Oregon-based singer-songwriter Laura Veirs. After graduating in Earth Sciences with Mandarin, Veirs apparently decided to become a musician during a disappointing field expedition to China (<**http://www.triste.co.uk/lveirs.htm**>).

Such a notion almost sounds impossible, given the Chinese palaeontological finds of recent years, but it worked out for Veirs. Her music career took off, culminating in a beautiful 2010 record *July Flame*, and though fossils are disappointingly absent, Veirs' songs often reference geological terms, from glaciers to magma to spelunking.

I reckon it's the start of a new era: the Anthropopscene. If you don't believe me, just look at the 2012 Grammies. Veirs' Oregonian musical neighbours Bon Iver were nominated in the Best Song category. The song title? 'Holocene'. And even though it lost out, it did so to Adele's 'Rolling In The Deep', which can only be a paean to turbidites.

For further proof, come to the Lyme Regis Fossil Festival in May. There, not only might you be able to see a notable member of Council donning a Mary Anning costume at the PalAss stall[1]*, but you will also have Robyn Hitchcock and John Hegley performing "A Celebration of Time".

Hitchcock is the former lead singer of The Soft Boys, and Hegley a noted performance poet. Their collaboration will launch the 2012 Jurassic Coast Earth Festival, part of the Cultural Olympiad (<**http://www.earthfestival2012.org/events**>).

[1] Subject to the approval of Dr Orr and the Annual Meeting Organizing Committee.

So, if there is a "PalAss Rocks!" event in Dublin, maybe we can invite some of these closet palaeontologists to come along and perform. Kasabian, Bon Iver, Jarvis Cocker, Emmy The Great, Bad Religion, Laura Veirs, They Might Be Giants: it's a line-up Glastonbury would be envious of. I'm sure there must also be others out there: just drop me a line and let me know who they are.

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Sylvester-Bradley REPORTS

Permian–Triassic chondrichthyans from the Oman Mountains

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This study aimed at making a detailed reconstruction of the Permian and Triassic chondrichthyan fossil record on the Arabian Platform and documenting the effects of the Late Permian mass extinction on the chondrichthyan palaeocommunity in the area. This includes sharks, which are predominantly marine top predators and one of the most successful zoological lineages of all time.

The Late Permian mass extinction was the most severe Phanerozoic biotic crisis (Erwin 1994). Fish pose an intriguing paradox, because some authors have stated that they were relatively unaffected by the Late Permian mass extinction event (*e.g.*, Schaeffer 1973; Patterson and Smith 1987), despite the apparent collapse of their supporting ecosystems. Benton (1998) found little effect on chondrichthyan diversity, and also noted particularly high origination rates in fish families in the Early Triassic. In contrast, Compagno (1990) stated that chondrichthyan diversity closely followed fluctuations in other marine and freshwater organisms. Despite a lack of agreement with regard to diversity fluctuations, for which variations in the quality of the chondrichthyan fossil record might be responsible (Twitchett 2001), it is clear that a turnover in the shark community occurred (from Palaeozoic to modern sharks), but the mechanism is not fully understood. An improved understanding of Permian–Triassic shark faunas is required to resolve these issues, which can only be achieved by investigation and sampling of key sections worldwide.

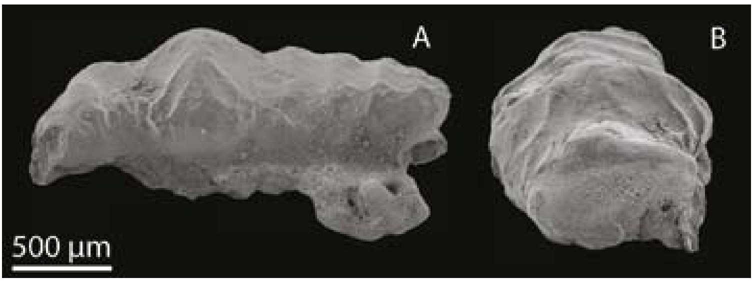
Most of our knowledge of Permian–Triassic chondrichthyan faunas comes from Boreal localities, but there is also potential for lower latitude sites to yield data. The Sultanate of Oman contains a multitude of Permian–Triassic outcrops, including boundary sections (*e.g.*, Glennie *et al.* 1974), but no fossil chondrichthyans have yet been described from these localities. Picking of existing conodont residues nevertheless demonstrated that deposits in the Oman Mountains and the interior of Oman occasionally have a rich yield of well-preserved fossil chondrichthyan remains. One of these deposits was highlighted in preliminary work by Tintori (1998) and Angiolini *et al.* (2003), which showed that Middle Permian (Wordian, Guadalupian) limestones from the Khuff Formation in the interior of Oman are rich in well-preserved chondrichthyan remains, and a comprehensive study of this material has currently been submitted (Koot *et al.* in review). Fieldwork (February–March 2010) was undertaken to investigate the available deposits and to collect samples for a preliminary survey. These studies showed chondrichthyan presence in a number of localities, including the most extensive and continuous boundary section available on the Saiq Plateau. This location was therefore selected for detailed sampling.

View over the Saiq Plateau.

With the aid of the Sylvester-Bradley Award, it was possible to organise fieldwork (February 2011) to the Saiq Plateau in the Jabel Akhdar region of the Oman Mountains to undertake a detailed sampling effort through the Permian/Triassic boundary, as well as obtain a few extra samples from other localities. The deposits on the Saiq Plateau are part of the autochthonous Middle Permian–Upper Cretaceous Arabian Platform (Hajar Unit), a cyclic shallow-water carbonate series deposited along the Neotethys continental margin (Angiolini *et al.* 2003; Richoz *et al.* 2005). The Saiq Formation is >600 m thick (Koehrer *et al.* 2010) and comprises basal conglomerates, bioclastic limestones, coral boundstones and dolostones (Angiolini *et al.* 2003). The basal part was deposited in a transgressive, shallow-marine environment and unconformably overlies pre-Permian basement strata (Glennie 2005). The Saiq Formation is overlain by the >500 m thick Mahil Formation, which covers all of the Triassic (Koehrer *et al.* 2010), and is composed of dolomites representative of a more restricted environment (Glennie *et al.* 1974). Deposition started in the Wordian with a basal layer of clastics, overlain by 120 m of shallow water fossiliferous limestones. From the upper Wordian, later stage dolomitisation affects the rest of the sequence (Richoz *et al.* 2005; Koehrer *et al.* 2010). A minimum of 1 kg per sample was collected at regular intervals throughout most of the deposit (depending on access). Dolomitisation reduces the preservation potential of fossils, so the basal part of the Saiq Formation was sampled at the highest resolution. The samples were processed using buffered acetic acid and buffered formic acid, following the methodologies outlined by Jeppsson *et al.* (1999) and Jeppsson and Anehus (1995), respectively. These methods left the phosphatic elasmobranch microremains intact, which were then picked from the residue and studied and analysed further.

Results

Twenty specimens, including isolated teeth and dermal denticles, were recovered from multiple beds within a 50 m thick section of the basal limestone of the Saiq Formation. The teeth have been identified as belonging to the ctenacanth genus *Glikmanius* and a new hybodont genus, which is in agreement with the fauna described from the Khuff Formation (Koot *et al.* in review). The importance of the material recovered from the Saiq Formation is that it confirms the composition of the Wordian palaeocommunity on the Arabian Platform and widens its geographical and environmental range. Together, these specimens are the first recorded occurrence of Permian chondrichthyans from Oman and also the western Neotethys basin. They are also evidence of a well-established pre-extinction fauna, which can now be used as a foundation for discussions on extinction and recovery patterns using material from Lower Triassic outcrops, the description of which is in preparation.



Hybodont tooth from the Saiq Formation, Jabel al Akhdar, Oman Mountains. A–B, O-16. A, lingual, and B, lateral views. The new hybodont genus that the tooth belongs to is defined using material recovered from the Khuff Formation in central eastern Oman (Koot et al. *in review).*

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Microfacies analysis of the Burgess Shale Tulip Beds locality

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The non-mineralised remains of animals over half a billion years old preserved in Burgess Shale-type deposits all over the world provide key biological and ecological information on the first appearance of most modern phyla in the aftermath of the Cambrian explosion (Briggs and Fortey 2005; Caron and Jackson 2008; Dornbos and Chen 2008). The 505 million-year-old Burgess Shale (Yoho National Park, British Columbia, Canada) is the best known of these exceptionally preserved faunas. Much of our knowledge of the Burgess Shale biota comes from two localities on Fossil Ridge, the Walcott and Raymond quarries. Understanding how representative the Walcott Quarry is of the overall community composition of the various Burgess Shale sites is important when identifying potential ecological factors that may have played a role in the Cambrian Explosion. Less well-known are several new Burgess Shale-type deposits discovered by the Royal Ontario Museum in the 1980s outside the type localities (Collins *et al.* 1983; Caron *et al.* 2010).

Fossils from many of these new localities have yet to be fully enumerated and thoroughly studied. Perhaps the most important (in terms of number of specimens) of the new Burgess Shale-type localities is the Tulip Beds locality (formally known as S7). The Tulip Beds locality was discovered in 1983 by the Royal Ontario Museum on the northwestern shoulder of Mount Stephen, and 2,038 slabs, with ~9,000 specimens, have been collected by subsequent expeditions. The site gets its name from the distinctively tulip-shaped animal *Siphusauctum gregarium*, a stalked filter feeder which is unique to this locality and the most abundant animal in the community (O'Brien and Caron 2012).

A study quantifying the community composition of the Tulip Beds is currently under way to get an understanding of the community structure and to compare with the Walcott Quarry (O'Brien in prep.). A preliminary quantitative analysis indicates a dominance of epifaunal suspension feeders, and suggests that this site has a different taxonomic and ecological composition than previously studied localities on Fossil Ridge. However, confident comparisons of the Tulip Beds locality to other Burgess Shale localities can only be confidently made if we have a good understanding of the mode of deposition. Understanding the sedimentation at this locality is significant for understanding the way in which the fossils at this site have been preserved.

Geological fieldwork was carried out at the Tulip Beds locality in 2010 and the Sylvester-Bradley Award was used to examine two sections, each one metre thick, taken from fossil-bearing rocks in the main Tulips Beds quarry. Subsequent analytical work was carried out at Pomona College, California, in association with Dr Robert Gaines, where the sections were cut polished and examined using x-rays and SEM.

The Tulip Beds locality is one of the oldest Burgess Shale localities, and is situated within the Campsite Cliff Shale Member, 42.5 m above the base of the Burgess Shale ("Thick Stephen") Formation. Investigation of multiple stratigraphic sections on the North side of Mount Stephen reveals that the Tulip Beds locality is more distal to the Cathedral Escarpment, possibly up to 1,500 m away, compared with being just tens of metres distant at the Walcott Quarry on Fossil

Ridge. The Tulip Beds fossil collection is taken from *in situ* exposures (Tulip Beds Quarry) and a talus slope 200–300 m south of the main locality. The fossil-bearing lithofacies comprise homogenized fine-grained calcareous claystones, which are characterized by millimetre-scale event-deposited muds. The lithology here is similar to that of the Walcott Quarry; however the event beds appear to be much thinner, indicating deposition in a more distal setting. Exposure of the fossil-bearing interval is at least 13.5 m thick (the top is not seen) and is laterally continuous for at least ~700 m within the Tulip Beds fault block. The quarry spans the lower 3 m of this interval, while the talus slope samples the entire exposure.

Polished sections show evidence of pyritisation, millimetre-sized pyrite crystals and small pyrite lenses, suggesting reduced oxygen conditions at the time of deposition, at least below the sediment-water interface. X-rays and polished sections show finely laminated beds a few millimetres thick. There is clear evidence of soft sediment deformation with slumping and deformation of bedding on ~10 cm scale (Fig 1). SEM analysis shows randomly-orientated clays, suggesting rapid deposition of the sediment. There is no evidence of any pelagic sedimentation between the event beds, and

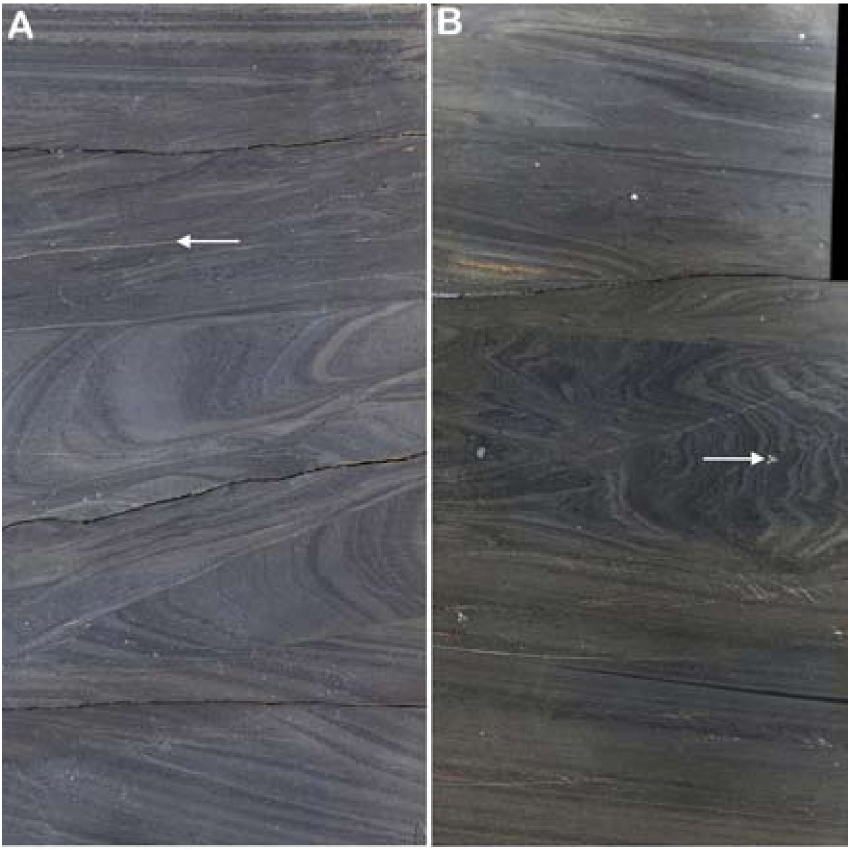

Fig. 1: Polished sections from samples taken at the Tulip Beds quarry. Both show the thinly bedded nature of the rocks and the soft sediment slumping within some of the layers. The arrows indicate areas of pyritisation with A, indicating a pyrite lens and B, indicating a small cluster of cubic pyrite. Section length A = 160 mm, B = 140 mm.

it appears all the beds are derived from clastic sediment delivered during pulsed storm events. No evidence of infaunal actively in any of the material examined from the quarry has been found, indicating a low oxygen environment at the sediment–water interface.

The results of this project show that the deposition of the Tulips Beds is different to that of the Walcott Quarry. The rocks in the Tulips Beds Quarry were deposited by event-driven sedimentation only, with no background sedimentation. Analysis also indicates that there was little or no oxygen at, or below, the sediment–water interface.

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Virtual Palaeontology

I'm not too sure how it started. I'm a keen video gamer and a trained palaeontologist. At first I just made a mental note about the video games that featured prehistoric creatures. That turned into actively researching and digging out video games featuring prehistoric creatures, and that in turn resulted in building up a small collection and eventually a weblog cataloguing them all. I thought I'd put pen to paper (fingers to keyboard?) and give PalAss members an overview of how (mostly) dinosaurs and other extinct creatures end up in video games.

When reading PalAss newsletters my favourite articles are those that reflect on how palaeobiology is viewed in wider society; be it street signs featuring fossils, the criminal lack of crinoid-related press releases or the artistic licence that Hollywood brings to bear on geology and palaeontology on the silver screen. Although we may collectively roll our eyes every time a newspaper gets a binomial name wrong or makes a technical error or a movie reconstructs an animal the wrong size, shape or colour, palaeobiology in popular culture is a useful yardstick for how well we are communicating science. I have a strong suspicion that as much as we may gripe on palaeontological blogs, newsletters and forums indulging in palaeo-popular culture is a guilty pleasure. My evidence for this assertion is that it is rare to visit a palaeontologist's office and not find it decorated (littered is more often an accurate description) with dinosaur toys, dinosaur movie posters, mugs, t-shirts and other paraphernalia.

Unlike popular literature or film, video games may be unfamiliar to many members. This is in part because the medium is still young (although video game icon Mario celebrated his 25th anniversary last year), but in their short history they have grown from seedy arcades to a medium that has infected every appliance that has a screen. Long gone are the days when a definition of 'video game' could accurately and neatly ring-fence a group of products that we confidently assert are video games. They vary from the old arcade machines, to games you play on a home console through to virtual worlds that host millions of players, throwaway experiences you may tap away at on your phone on the bus and even to cross-media alternate reality games (ARGs) that mix interacting with technology and exploring the real world.

The explosion of video games has meant that not only do you have to be a dedicated fan to keep track of the latest developments, but if you were say interested in palaeontologically-inspired video games you have to employ a lot of palaeontological skills. Unlike other forms of media there isn't an international system or library recording when and where video games have been published. The preservation of older video games is very much the responsibility of amateurs, and finding elusive titles requires a lot of detective work and excavating the strata of forum posts and web caches.

So how about those extinct creatures in video games? So far my research has identified at least 150 video games that feature prehistoric critters, but bearing in mind there's an estimated five million video games thought to be in existence (this estimate is probably out of date given that 300 new apps are released every day on the iPhone) this list is by no means exclusive – but it probably gives us a good sample set.

First it might be prudent to assess the palaeodiversity of creatures in video games. It will be no surprise to learn that dinosaurs (excluding modern birds) are by far the favourite group of animals digitally brought back to life, with 89% of the sample set featuring dinosaurs and over 120 different taxa present. Again it won't surprise to find that virtually every game that includes dinosaurs will feature *Tyrannosaurus rex*, making this species the stand-out candidate for inclusion in video games and one of the only dinosaurs regularly referred to by its specific name. A handful of games feature *T. rex* as the only dinosaur, most notably in *Tomb Raider 2* where Lara Croft discovers two adults improbably living at the bottom of a well-hidden featureless box canyon underneath the Great Wall of China. It is not clear how the animals got into the canyon without suffering injury and quite how a population of the dinosaurs was sustained secretly for 65 million years. Presumably, these two represent the last in the line given that until Lara turns up there doesn't appear to be a readily available food source.

The *Jurassic Park* movies have been an overwhelming influence on game developers. Foremost, the *Jurassic Park* franchise itself has been flogged, repackaged and remixed with no less than ten *Jurassic Park* games released on over twice as many formats, ranging from games based closely on the movie, through to a park management simulation (complete with the odd tropical storm and dinosaur break out), a beat 'em up game in which dinosaurs perform improbable feats of aerobatics smacking each other around, and last year's misleadingly titled *Jurassic Park: The Game* telling alternative stories following other characters stranded on Isla Nuba during the same fateful night as the first film.

The influence of *Jurassic Park* on other games is clear because after *Tyrannosaurus rex*, the most common creatures to feature in video games are 'raptors' (52%), then *Pteranodon* (47%) then *Triceratops* and *Stegosaurus* following closely behind with *Parasaurolophus* making up the last of the creatures to appear in more than a third of all video games featuring extinct fauna. 'Raptors', in this case, is used to refer to eudromaeosaurians, as many games don't bother to distinguish which 'raptor' they are referring to and most borrow the disproportioned Jurassic Park *Velociraptor* model – although a handful of games do distinguish between *Deinonychus*, *Velociraptor* and *Utahraptor*.

One reason why eudromaeousarians are popular is due to the influence of *Jurassic Park* and the impact of the giant intelligent predatory Velociraptors of the film. Another reason why they and *Pteranodon* are so often cast may be because with the addition of *Tyrannosaurus rex*, these three fit a common trope amongst shooting video games. *Velociraptor* makes up the common foot soldier enemy type, *Pteranodon* fits the profile for an ever-present threat from the sky, and *T. rex* makes for a nice end-of-level boss type character.

A second tier of dinosaurs featured includes all the usual suspects you'd find in a typical my-first-book-of-dinosaurs. Sauropods are invariably either *Brachiosaurus* or *Apatosaurus* featuring in roughly 10% of games featuring prehistoric animals, *Diplodocus* sadly only appearing in about 5% of games. *Brontosaurus* makes two appearances of note, but before you prepare your tirade about the oft misused synonym, one of the appearances is in the enchanting *Jetpack Brontosaurus* about the jet-fuelled dreams of an *Apatosaurus* called Brontosaurus. The other appearance is in *Peter Jackson's King Kong: The Official Game Of The Movie* (PJKKOGM) and seems to be an inexplicable error given the efforts that were made with the backstory to explain the strange fictional creatures found on Skull Island (more on that later). *Ankylosaurus* and *Pachycephalosaurus* are two other genera that are commonly used to up the roster of dinosaurs in video games and *Iguanodon*, *Spinosaurus*, *Compsognathus* and *Archaeopteryx* follow closely behind, completing the set of dinosaurs that make appearances in a dozen games each. *Spinosaurus* in particular has been modelled more since the movie *Jurassic Park 3*.

The above selection of dinosaurs may seem slightly unimaginative, however, there are a dozen or so games that take the kitchen sink approach when it comes to taxonomic coverage. *Dino Master* includes over 100 genera of dinosaurs and other prehistoric creatures, and SEGA's *Dino King* franchise – which is a video game, television show and collectible card game – features over 70 genera of dinosaurs taking particular care to include obscure taxa such as *Ampelosaurus*, *Pawpawsaurus* and *Zuniceratops* in addition to the usual Hollywood staples. *Carcharadontosaurs* and *Giganotosaurus* also make a few cameos, no doubt off the back of media in the 2000s exploring whether *T. rex* was the biggest carnivore.

Pteranodon has already been mentioned but is by no means the only extinct animal that is not a dinosaur and that can be found in video games. As *Pteranodon* dominates the virtual prehistoric skies, plesiosaurs and ichthyosaurs are to be found in any body of water, sometimes stranded in tiny lakes or swimming along rivers. As with raptors, rarely are they identified beyond plesiosaur. The same is true of mammoths, a staple for games set in 'the ice age', although the excellent games *Syberia* and *Syberia 2* are based around the search for living mammoths and go a little bit deeper with palaeontology than most games. A comparative anatomy museum in the fictional Barrockstadt University is a highlight, with plenty of nice details to spot for the keen-eyed palaeontologist. More obscure vertebrates are a delight when encountered; the gorgonopsid *Inostrancevia* populates a cave system in *Dino Crisis 2*, and in the alternate universe of independent game *Dino D-Day* Nazis employ a *Desmatosuchus* mounting a cannon on the front lines. When encountered, giant flightless birds are almost always *Diatryma* (another junior synonym it seems is hard to shake). *Bothriolepis* makes a very subtle cameo in *Paraworld*; stop for a second to admire the scenery and you may be lucky to spot a shoal of them. The video game of *Disney's Dinosaur* makes the bizarre inclusion of swarms of *Icaronycteris*, the Eocene bat neither appearing in the film nor in the Jurassic when the film and game are set. Filling out the roster of non-dinosaurian vertebrate in video games are non-specific woolly rhinoceroses, sabre-toothed cats and the occasional pterodactyl.

As ever, invertebrates get the short shrift. Trilobites and ammonites, when they feature, are rarely more than 'an ammonite fossil'. In fact it falls to two series to give invertebrate fossils their dues. The massive franchise *Pokémon* (the games alone number 47 including various spin-offs and spanning a number of genres) was inspired by creator Satoshi Taijiri's love of nature, and many of the pocket monsters are inspired by real animals. Fossils are no exception and ammonites, trilobites, crinoids and *Anomalocaris* inspire the Pokémon Omanyte, Kabuto, Lileep and Anorith respectively. Players find fossils via various means and can take them to the museum to have them revived. As an interesting aside, other Pokémon are inspired by *Pachycephalosaurus*, *Archaeopteryx*, *Pterodactylus*, *Torosaurus* and the extinct turtle *Archelon*. A further interesting point of trivia is that there is a fish Pokémon described as a living fossil that can be found in the deep sea and is given the rather telling name of Relicanth in English. Another series that does justice to invertebrates is *Endless Ocean* – a game primarily about exploring the animals of the sea, but if you explore thoroughly you can catch a glimpse of a cryptic *Anomalocaris* and the giant cephalopod *Cameroceros*.

Video games are highly diverse when it comes to extinct animals, more so than popular literature and film. However, they are as guilty as the other media for their common mistakes. Tripod dinosaurs dragging their tails behind them are still common, and despite the idea of feathered dromaeosaurs predating Mario, only a handful of games dress their 3D models accordingly. By far the best example is the excellent browser game by FlashBank Studios, *Off-Road Velociraptor Safari*.

Yes, the game may be about a monocled *Velociraptor* wearing a crash helmet mowing down fellow *Velociraptor*s in a 4 x 4 Sport Utility Vehicle with a spiked ball and chain attached to it, but these do have feathers, which shows they have at least googled *Velociraptor* before they constructed their models. Size and scale are also issues, and once again the influence of *Jurassic Park* is felt in that *Dilophosaurus* is always about half the size it should be and inevitably fills the place of ranged enemies by spitting slime. Other crimes against palaeontology include very vague notions of biogeography, geochronology and chronostratigraphy, often bringing together animals separated by tens of millions of years and whole continents.

The day-to-day work of palaeontology is downplayed for the sake of gameplay, most games trivialise the process of organising fieldwork, excavation, fossil preparation and studying material into games where you tap a rock with a pick axe a couple of times and a fully articulated and prepared fossil falls out of the wall. A few games at least attempt to make working with fossils sexy. *Dino King* on the Nintendo DS uses the console's microphone to make the player blow on the fossil they've been excavating to clear the dust away. *Jurassic Park III: The DNA Factor* is particularly hilarious in its setup: a plane carrying INGEN dinosaur DNA is struck by lightning and the precious load it was carrying is spread all over an island on which the plane eventually crashes. The aim of the game is to run around collecting the DNA, which is not so subtly represented as glowing balls as big as the player avatar's head. Upon completion of a level the player then uses a machine to fire DNA bases at a scrolling double helix in order to reconstruct it. I'm by no means a geneticist but I'm not entirely sure this is exactly as it happens in the lab…

If crimes against biology weren't enough, physicists interested in the nature of time should turn away now. It seems that there are only so many ways to contrive getting your dinosaurs and other prehistoric creatures into games, and these are well worn by the sample of games we're looking at. *Dino Strike*, *Tomb Raider* and *PJKKOGM* invoke the lost valley/island idea that these animals never went extinct but were just blissfully existing in a remote paradise. The origin of that idea can be traced back to Verne's *Journey to the Centre of the Earth*. *World of Warcraft* wears its inspiration on its sleeve; a range of dinosaur-like creatures can be discovered in the Un'Goro crater in the South of the World's westernmost land mass – strikingly analogous to the plateau of South America in Conan Doyle's *The Lost World*. At least *PJKKOGM* makes the extra effort with its cryptic survivors to suggest that these animals might have changed during the millions of years of isolation, inventing the animals *Vastatosaurus rex* and *Terapusmordax*. The *Jurassic Park* model is a regularly occurring trope used to push a scenario and account for reanimated fossils. In *Dino Master*, *Pokémon* and the ridiculously named *Fossil League Dino Tournament Championship*, bringing back extinct animals is as simple as plonking a fossil in a mysterious machine *et voilà*. Other gubbins normally employed in fighting games involve genetic engineering to create the ultimate fighter used to justify the *Velociraptor*-like Riptor in *Killer Instinct* and Alex the boxing/wrestling dinosaur in the *Tekken* series.

Time travel is the last trope employed to justify adventures in deep time, and is used in *Jurassic: The Hunted*, *Dino Crisis* and the *Turok* series. Time travel can be caused by man's foolish tooling with the nature of the Universe as in *Dino Crisis*, or is made possible by a mystical barrier between Earth and an alternate Universe where time holds no meaning. It is best not to dwell on these machinations at the risk of falling through the giant plotholes they create.

Another simple way to get prehistoric creatures into video games is to make the animals the protagonists. National Geographic's *Sea Monsters: A Prehistoric Adventure* allows the player to play as a selection of marine reptiles from *Tylosaurus* to *Henodus*, and the aim of the game is to explore the ancient seas. Museums feature a lot in video games, and no virtual museum is complete without a dinosaur skeleton or two. Sadly, and perhaps due to the perverse pleasure in destruction, museums are often digitally constructed for no purpose beyond wanton destruction. The game *Stranglehold* presents perhaps one of the most beautiful digital museums, a museum inspired by the Field Museum in Chicago. Such is the fidelity of the reconstruction that digital counterparts of real specimens can be recognised even in the middle of a fire-fight. Paradoxically, you can earn the in-game title of palaeontologist by shooting all the bones off a rather nice sauropod skeleton. Popular franchise *Grand Theft Auto* also pays homage to a famous American Museum, with a version of the AMNH in *Grand Theft Auto 4*'s Liberty City, a pastiche of New York. However, the developers have copped out of rendering the full museum as the in-game version is created in a state of refurbishment work, meaning that only a *Triceratops* and *Tyrannosaurus rex* skeleton are viewable.

This article has been a brief overview of palaeontology in video games, but I hope it gives members a better idea of how palaeontology is represented in the world's fastest growing medium. Unfortunately, far too many of these games have been developed without adequate research or palaeontological consultation, and many of the groan-inducing stereotypes used in other forms of media have made the transition into digital form. Also, given that a lot of palaeontological work is the process of studying fossil remains and then using (informed) imagination to reconstruct organisms and ecosystems for an interactive medium that isn't as constrained as the written word or film, it seems that these games are often about shoehorning dinosaurs and other animals into an existing game mould, be it 'Theme Park with Dinosaurs' (*Jurassic Park: Operation Genesis*), 'Doom with Dinosaurs' (*Turok* series, *Jurassic: The Hunted*, *Dino Stalker*), Resident Evil with dinosaurs (*Dino Crisis*) or Pokémon with dinosaurs (*Fossil League Dino Tournament Championship*, *Dino King*). In each of those examples 'dinosaurs' can easily be replaced with zombies, robots or aliens and still be as mindless. This is potentially worrying, especially as some of the games mentioned above trade on their potential to be educational, but often this translates to your normal mindless (but still fun) games with a 'dinopedia' tacked on somewhere in the menu, filled with facts and information that ten-year-olds love to commit to memory. Far rarer are the games that model prehistoric creatures and employ geological and biological concepts for a uniquely fun and interesting game. The aforementioned *Syberia* is one outstanding example, another is the game *Spore*.

2008's *Spore* is a game that crosses genres, but one that is heavily inspired by palaeontology and goes beyond simply dropping dinosaur models into the game. *Spore* begins with the player controlling a simple cell-like organism living in a hostile fluid environment. Other bigger cells try to engulf you whilst you eat cells smaller than yourself. After eating a number of smaller cells, your organism grows in size, and periodically you can 'evolve' your organism by adding a flagellum or a set of jaw-like appendages allowing you to defend yourself from predators and eat different kinds of zooplankton floating with you. The option to add bits to your organism occurs every generation when your creation lays an egg. Skip a couple of hours of gameplay and your organism no longer represents a cell floating amongst the zooplankton but is a much more complex organism swimming around in the ocean, and depending on how the player has steered the evolution it may represent a fish-like animal, an arthropod or perhaps a creature unlike any creature that has existed. Each environment is populated by other players' creations. Skipping another couple of hours and if the creature is equipped with limbs it can use on land, colonisation of the land can begin.

The genius of *Spore* is that the game procedurally generates the environment and will work out how each creature would navigate its environment. Players build their creatures and the game calculates the biodynamics, giving the look of the creations a realistic feel. At this stage our biological interest in the game ends, but suffice to say the game then continues to the tribal level and then civilisation level; the organisms so meticulously created will now live in cities (also created by the player) and wage war or trade with other civilisations on the planet. After this level, and through development of technology, players can take their organisms into space and visit planets in their own solar system and beyond. Inhabited planets in the Universe are populated by other players' creations, and planets can be invaded, terraformed or colonised. Within just 22 hours of the release of *Spore*'s creature creator, the number of creatures created by players numbered 1.8 million (more than the number of described animal species). The number of player creations today, listed on Sporepedia[1] <**http://www.spore.com/sporepedia**>, is an astonishing 170 million creatures, buildings and vehicles. Unsurprisingly, some players have used the sophisticated tools in *Spore* to model their favourite extinct organisms. What sets *Spore* apart from the other games mentioned here is that the game uses evolution and palaeontology as its inspiration and makes them core to the game experience. Obviously, the way *Spore* creatures evolve is not an accurate model of evolution, but playing through the evolution of at least one civilisation is a powerful experience that allows evolutionary ideas to be experienced and thought through first hand.

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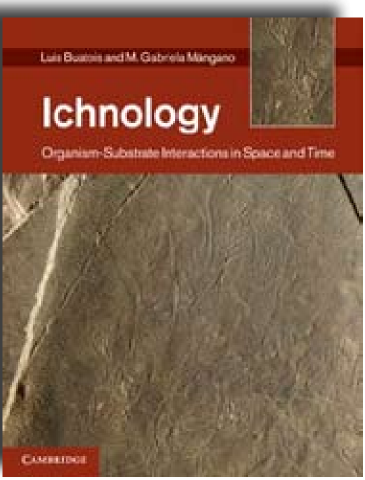
[1] <**http://en.wikipedia.org/wiki/Spore_%282008_video_game%29#Sporepedia**>

Book Reviews

Ichnology: Organism-Substrate Interactions in Space and Time

By Luis Buatois and M. Gabriela Mangano. 2011. Cambridge University Press. 370pp. £50.00. ISBN 978-0-521-85555-6.



Those of us brought up on Lewis Carroll's *Alice in Wonderland* will surely remember the tale of the Cheshire Cat, this mysterious smiling being who has the ability to fade away at will leaving only its grin behind. Alice remarks that she has seen a cat without a grin, but never before a grin without a cat. Be that as it may, there is an entertaining analogy for ichnology here, as I used to teach my students. For trace-fossils record the behaviour of vanished animals, even if it is not always clear what the original trace-maker actually was. The maker, in other words the cat, or the trace producer, has disappeared. But its behaviour, the grin or trace remains behind. So, ichnology is about fossil behaviour. But it is much more than that.

Here we have a new and beautifully produced book on trace fossils, which it has been my real pleasure to review. I would like to say at the outset that not only is this a magnificent treatment of ichnology and its applications, it is also one of the very best scientific treatises that I have read in many a long year. It is not primarily a taxonomic work, though taxonomy is given appropriate coverage, and virtually all the trace fossils mentioned are nicely illustrated. The sub-title refers to 'Organism-Substrate Interactions in Space and Time', and that is exactly what it is about. Such analysis of trace fossils requires a good knowledge of biological, taphonomic and environmental factors, as the authors stress, and these facets are interlinked throughout the book. The 'blurb' advises us that ichnology 'has recently been transformed into a multifaceted science at the crossroads of many disciplines', and this is perfectly true. So let us first enumerate the various chapters, and see how they are arranged.

We have in Part 1 (*Conceptual tools and methods*) five chapters which in order are concerned with (1) the basics of ichnology, (2) taxonomy of trace fossils, (3) palaeobiology of trace fossils, (4) the ichnofacies approach, (5) the ichnofabric approach. Here the ichnofacies concept is clearly distinguished from that of ichnofabrics, and carefully explained. In Part 2 (*Spatial trends*) there are six chapters: (6) trace fossils and palaeoecology, (7) ichnology of shallow marine clastic environments, (8) ichnology of marginal marine environments, (9) ichnology of deep marine clastic environments, (10) ichnology of continental environments, and (11) ichnology of carbonate environments, rocky shorelines and volcanic terranes. Part 3 (*A matter of time*) begins with (12) trace fossils in sequence stratigraphy, (13) follows with trace fossils in biostratigraphy, (14) trace fossils in evolutionary palaeontology, and finally (15) ichnology in palaeoanthropology and archaeology. Is it not evident from this that we have here an extraordinarily comprehensive treatment? For such it is, and above all it demonstrates the range of applications of ichnology to many fields of geological research. There is a comprehenive reference list nearly 50 pages long, and a valuable index.

The layout of each chapter or section is particularly good. Each begins with one or more appropriate quotations, followed by the main text, in which there is a great deal of 'meat'. Despite this 'density', I found none of it hard to read. Whereas the text of each chapter is an elegant synthesis of present knowledge, individual case histories are given in boxes, sometimes three or four per chapter. Examples are (5.2) Composite ichnofacies and ichnoguilds in Cretaceous chalk, (6.2) Thalassinidean shrimps as ecosystem engineers in modern tidal flats of San Salvador Island, Bahamas, (11.2) Volcanic eruption, bioturbation, and ash-layer preservation in the South China Sea. Each of these can be read in just a few minutes, but they make a lasting impression. And then we have the illustrations, which make an excellent text perfect. There are many photographs of trace fossils, from localities all over the world to which the authors have travelled, and where they have worked. But also there are splendid diagrams, likewise all in colour, and beautifully clear. Moreover they are all sparklingly fresh and original; there are no tired old warhorses here. The schematic reconstructions and block diagrams of trace fossils in their varied environments are the work of Patricio Desjardins, and they enable the reader to visualise, instantly, what kinds of trace fossils are found where. There are other diagrams, detailing for example the effects of sea-level changes. I counted about 90 of these marvellous diagrams, which make it so much easier to absorb substantial amounts of information so readily. This is one of the great strengths of this volume, that although it is packed with observations based on the authors' accumulated knowledge in so many parts of the world, it is really very accessible.

Some years ago I had the unforgettable experience of travelling in north-west Argentina with Luis and Gabriela, and separately with Patricio. I had never seen *Cruziana* and *Rusophycus* like those which they showed me, and there were so many other trace fossils also, well exposed because of the scanty vegetation cover. Nor will I ever forget the authors' infectious enthusiasm for their subject, and their erudition. That is conveyed here, superbly.

There are many good books on trace fossils: Seilacher, Bromley, Frey and Pemberton come easily to mind. Yet this is special, and surely destined to become a classic. The authors, illustrators and publishers have done a magnificent job from which we can all benefit. Surely this admirable compendium will stimulate even more interest in ichnology, which has advanced enormously in recent years. And its applications too.

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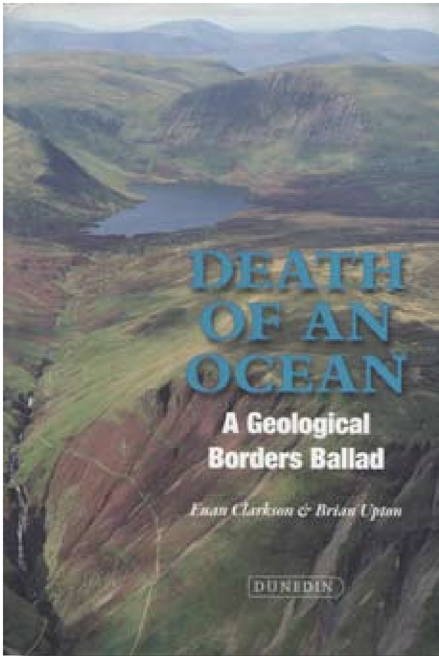
Death of an Ocean: A Geological Borders Ballad

By Euan Clarkson and Brian Upton. Dunedin Academic Press. 210pp. £25.00. ISBN 978-1-903-76540-1.

High standards are expected from Euan and Brian, who delighted us with *Edinburgh Rock: The Geology of Lothian* in 2006. *Death of an Ocean* lives up to these expectations. This excellent book is thoroughly readable and accessible as a popular geological guide, stuffed with golden nuggets of information gleaned from their combined experience – which totals over 100 years of fieldwork!



These two eminent professors from the University of Edinburgh have worked closely for the past forty years, exchanging expertise from their specialised fields, palaeontology and petrology, respectively. They provide a cross-disciplinary approach, linking overviews of ancient ecosystems with sedimentary and volcanic processes in modern tectonic theory. Their effective collaborative writing makes the understanding of complex processes accessible to a wider audience.

The authors claim their book 'is neither a comprehensive field-guide nor a treatise for the professional geologist but an attempt to tell the story of Iapetus, as well as its later Palaeozoic aftermath, for the non-specialist reader'. Nevertheless, the book should create strong interest amongst specialists and would be useful additional reading for introductory geology undergraduates wishing to gain a wider perspective. Useful examples of localities for fieldwork are included.

Beautifully illustrated, with a good choice of colours, the book enhances the understanding of this fascinating area of Scotland. It is clearly organised and styled to appeal to a wide audience; geologists, amateur and professional and anyone interested in extending their scientific knowledge of the Borders.

The structure of the book follows the ancient history of the once great Iapetus Ocean, culminating in its end through the 'inexorable motion' of the tectonic plates, which caused folding, uplift of ocean sediment and the formation of new mountains, the Caledonian mountain range. The book focuses on the demise of the Iapetus through the collision of the Laurentian and Avalonian continents during the mid-Palaeozoic. It tracks the ocean's journey from the southern hemisphere, across the equator, to the remnants preserved today.

In order to comprehend the complex concepts involved in the life-cycle of the Iapetus Ocean, some pre-requisite knowledge is essential. The authors, as experienced teachers of geology, have not shied away from this task and provide thorough explanations for each process in turn. Block diagrams are usefully employed and annotated, although some may have benefited from additional labelling for clarity (*e.g.* the photo-micrograph (fig. 5.3) of a thin section of a coarse-grained Ordovician greywacke). Cross-sections illustrate drifting continents, how plate tectonic theory developed, and how continental pull-apart can give rise to oceans.

'The Time Lords' chapter provides a brief account of the concept of time along with some historical background. Beginning with Copernicus, Galileo and Kepler, following the invention of the telescope, to James Hutton, the 'Father of Geology', the reader is carefully taken through the steps necessary to appreciate how we have developed an understanding of time. As an aside, Hutton had strong ties with Edinburgh and the Scottish borderlands, inheriting his father's farm in Berwickshire in 1750. The beautiful double-page spread of Hutton's unconformity at Siccar Point enables us to repeat his observations, and to catch a glimpse of the insights and thought processes that ultimately led to an understanding of geological timescales. Charles Lyell's contribution to geology, 'the present is the key to the past', explains why modern environments are considered in the book, since modern explanations of today's ocean ecosystems provide a foundation for understanding past environments.

'Death of an Ocean' is dedicated to the authors' late friend Stuart McKerrow, whose 'unquenchable enthusiasm stimulated much of the intensive investigation over the past 40 years'. Euan's and Brian's enthusiasm ensures this legacy will continue for future generations. Thoroughly enjoyable to read, and a handy size, this book represents good value for money.

The cover insert states: "Euan Clarkson and Brian Upton bring their unique blend of enthusiasm, considerable expertise and clarity of style to this popular geological guide". This statement is no exaggeration!

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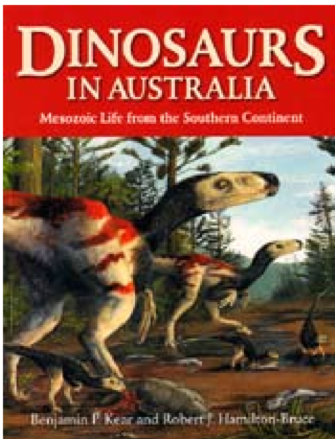
Dinosaurs in Australia: Mesozoic Life from the Southern Continent

By Benjamin P. Kerr & Robert J. Hamilton-Bruce. 2011. CSIRO Publishing, Collingwood. 200 pp. AU$ 79.95. ISBN 978-0-643-10045-9



Australian palaeontologists have a long tradition of publishing large, lavishly illustrated coffee-table volumes about palaeontology, especially their Mesozoic faunas, with titles like *Wildlife of Gondwana* (Vickers-Rich and Rich 1993), *Dinosaurs of Australia and New Zealand* (Long 1998), *The Rise of Fishes* (Long 2010) among the most recent ones. Now we get *Dinosaurs in Australia: Mesozoic Life from the Southern Continent*.

After reading the book, I have to admit that the title *Dinosaurs in Australia* is perhaps a little misleading, as the book covers the entire Mesozoic flora and fauna of Australia, both marine and terrestrial. Dinosaurs actually only appear on 37 of the 180 pages, so a more appropriate title might have been *The Complete Mesozoic Flora and Fauna of Australia*. However, in publishing for the popular and mainstream markets, publishers appear to have developed their own zoological divisions, with only two groups of animals distinguished – dinosaurs and non-dinosaurs. If dinosaurs are mentioned anywhere in the text, however fleetingly, the word "dinosaurs" will be highlighted in the title (a good example is Prothero's (2006) book about Cenozoic mammal evolution, *After the Dinosaurs: the Age of Mammals*. I am sure you can guess which taxon was printed largest on the cover).

But back to *Dinosaurs of Australia*. The book is beautifully illustrated, with large high-quality photographs of the fossils as well as colourful reconstructions of many of the animals. The book is divided into seven chapters, starting with a general introductory chapter that gives a basic introduction to fossils, the geological timescale, plate tectonics and so forth. Chapter two sets the scene for the rest of the book by giving an overview of Australia's palaeogeographical and climate evolution throughout the Mesozoic, along with a map of the present day outcrops of Mesozoic rocks in Australia. The next chapter is devoted to the Triassic period, which is dominated by fish, amphibians and marine reptiles, and the first occurrence of dinosaurs in the form of theropod footprints. Then follows the Jurassic period, which is mostly dominated by marine reptiles, but a few dinosaur finds also make it on to the pages. The Cretaceous Period is, in terms of fossils, by far the most well-represented time period in Australia, and is consequently spread out over the last three chapters of the book. Chapter five deals with the marine fauna from the great inland sea that covered most of the Australian interior during the Early Cretaceous, and had a rich fauna of marine reptiles. Chapter six covers the non-marine Early Cretaceous faunas, and it is here that dinosaurs really begin to make their appearance in the book. The last chapter deals with the Late Cretaceous period when much of the inland sea had retreated, and we get a more terrestrial fauna of dinosaurs and pterosaurs, but still have an extensive record of marine reptiles. The chapter (and the book) ends abruptly with Late Cretaceous pterosaurs. However, because the book presents such a comprehensive overview of the Mesozoic flora and fauna of Australia, a short summary chapter – setting the scene for the Cenozoic evolution of Australia – would have been nice. Perhaps the authors might consider this idea for a second edition.

The language in the book is kept non-technical, which makes the book accessible for non-specialists. A two-page glossary further helps to explain the instances where technical jargon is encountered. There are no bibliographical references within the text, but at the end of the book there is an extensive 20-page bibliography with references to key papers arranged by topic. This provides a good starting point to dig into the technical literature, although I would have preferred references in the text itself, as in the previously published volumes (Long 1998, Vickers-Rich and Rich 1999). This would make it easier to distinguish between the authors' personal interpretations and what is derived from the literature.

So who is this book aimed at? Being the only palaeontologist at the museum I work in, people expect me to know a bit about everything in palaeontology, and despite the Lower Palaeocene marine ecosystem theme of my museum, I still get daily questions about all kinds of dinosaurs from the visiting school kids. As my work hours and family life do not allow me to read up on the technical literature on every palaeontological subject, I find "overview" volumes such as *Dinosaurs in Australia* rather appealing, as they represent the latest updates in their fields in a quickly accessible form, and allow me a reasonable overview of the different faunas around the world. The price of AU$79.95 (approximately £65) is very high for a paperback edition, and many potential buyers will probably be deterred by this. But if you are interested in Australian Mesozoic faunas and want an easily accessible overview (and have plentiful funding to buy books with), then it definitely deserves its place on the coffee table in your office, as lighter, enjoyable reading between the more technical literature.

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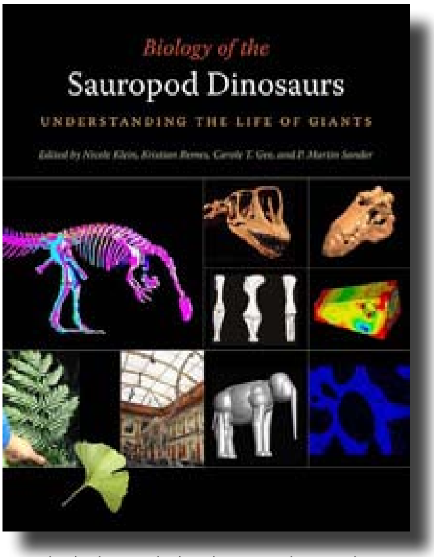
Biology of the Sauropod Dinosaurs: Understanding the Life of Giants

Edited by Nicole Klein, Kristian Remes, Carole T. Gee and P. Martin Sander. 2011. Indiana University Press. 331pp. US$59.95. ISBN 978-0-253-35508-9.



Ask a member of the public to name a dinosaur, and the chances are, if they don't name *Tyrannosaurus rex*, they will say "*Brontosaurus*". The most famous of all junior synonyms (the subjective senior synonym is the less evocative *Apatosaurus*), the enduring public fascination with "*Brontosaurus*" reflects the iconic status of sauropods, which are perhaps *the* stereotypical dinosaurs. With their enormous length (up to 30 metres or more), long necks and tails, and small heads, the sauropod *Bauplan* is among the most recognisable of any extinct organism. Body mass estimates for the largest members of the clade range up to 80 tonnes or more, making them by far the largest animals ever to walk on land, and as much as an order of magnitude larger than most members of other dinosaur clades such as ornithischians. This jaw-dropping and almost implausible size has stimulated endless palaeoecological speculation (sauropods were long portrayed as aquatic animals, unable to support their massive weight on land) as well as much fruitful scientific research addressing the questions of *why* sauropods became so large and *how* they were able to do so.

Since 2004, the German Research Foundation (DFG) has provided extensive support for a research unit coordinated by Martin Sander (University of Bonn) and focused on understanding the *how* and *why* of sauropod gigantism. Currently in its eighth year of funding, the research unit has involved scientists from institutions in Germany and Switzerland covering a broad range of palaeontological and non-palaeontological disciplines. An extraordinary investment from the DFG has been rewarded with more than 100 peer reviewed publications to date, with many of the results summarised in an excellent (and Open Access) review paper published in *Biological Reviews* (Sander *et al.* 2011). *Biology of the Sauropod Dinosaurs: Understanding the Life of Giants* provides a more detailed overview of the work of the research unit, with contributions from 38 researchers.

What strikes one first about the book is the sheer diversity of methodological approaches used to investigate sauropod palaeobiology and evolution, reflecting the truly multidisciplinary nature of the research unit. The 18 chapters of the volume are divided into sections dealing with nutrition, physiology, construction, and growth. In general, the standard of both science and writing are high. I have bemoaned the "Life of the Past" series of Indiana University Press in past book reviews, but my previous criticisms are resolved here: the book is carefully edited with well laid out text, figure reproduction is good, and there are plentiful colour images (covering 22 pages).

I found much of the content of this volume interesting but, reflecting my own personal biases, a number of chapters in particular caught my attention. Hummel & Clauss (Chapter 2) discuss sauropod digestive physiology, concluding that they likely used hindgut fermentation with long retention times. They also discuss one of the most interesting pieces of work produced by the research unit: data on the digestibility of typical Mesozoic gymnosperm groups, which suggest that horsetails, araucarian conifers and some ferns are comparable in digestibility to modern angiosperms, and thus plausible and nutritious sauropod food sources. Gee (Chapter 3) provides an interesting review from a palaeobotanical perspective of potential sauropod food sources, distribution and digestibility, generally supporting the results of Hummel & Clauss in proposing horsetails, some conifers, *Gingko* and ferns (but not cycads or bennettitaleans) as the most likely components of sauropod diet. In the final part of the nutrition section, Tütken (Chapter 4) provides an excellent summary of the use of carbon isotopes ($\delta^{13}C$) to reconstruct dietary sources for herbivores, concluding from analysis of bones and teeth that sauropods fed on terrestrial C3 plants and that low- and high-browsing sauropod taxa may have utilised different food sources (ferns and conifers, respectively).

The highlight of the physiology section for me was Perry *et al.* (Chapter 5), which reviews sauropod respiration, supporting previous work that suggests sauropods had a bird-like system with a rigid fixed lung and ventilatory air sacs. Other chapters in this section deal with the use of laser-scanning to determine dinosaur body volume and mass (Stoinski *et al.*; Chapter 6), and cardiovascular physiology (Ganse *et al.*; Chapter 7).

The longest section of the book deals with "construction", containing eight chapters using a diverse range of approaches. Rauhut *et al.* (Chapter 8) provide one of the few chapters in the volume that examines sauropod palaeobiology in an explicitly phylogenetic framework: they map changes in body proportions, morphology and size on to a sauropod cladogram, drawing out broad conclusions about the sequence and timing of major anatomical changes. Mallison (Chapters 13 and 14) reviews and provides new results from his highly innovative CAD approach to reconstructing and modelling dinosaur skeletons and locomotion. He provides compelling evidence that the classic basal sauropodomorph *Plateosaurus* was an obligate biped (Chapter 13), and that some sauropods were able to use tripodal rearing postures to browse at higher levels (Chapter 14). Other chapters in this section deal with bone structure (Dumont *et al.*; Chapter 9), finite element analysis (Witzel *et al.*; Chapter 10), biomechanics (Hohn, Preuschoft *et al.*; Chapters 11 and 12) and the eternally thorny problem of neck posture (Christian & Dzemski; Chapter 15).

The final section deals with life history, and is notable for an excellent review of sauropod bone histology by Sander *et al*. (Chapter 17), one of the areas of the research unit that has generated the most novel insights. Sander *et al.* conclude that histology indicates that sauropods were tachymetabolic endotherms, and discuss the evolution of growth strategies (including dwarfing on islands) within the clade. The other chapter in this section reviews sauropod eggs and life history (Griebeler & Werner; Chapter 16).

Although this is primarily a technical volume, many chapters are written as reviews – making the volume relatively accessible to a broad range of readers. One potential criticism is that each chapter is a relatively discrete entity, with no single and comprehensive overarching synthesis (such a synthesis was provided by Sander *et al.* 2011, but a similar chapter would perhaps have been useful here). Readers looking for a truly comprehensive overview of current sauropod research would be recommended to pair *Biology of the Sauropod Dinosaurs* with the highly recommended *The Sauropods* (Curry Rogers & Wilson 2005) in order better to reflect the full breadth of research being carried out internationally, and to get a better handle on phylogenetic aspects of sauropod evolution. Overall though, this is an interesting, useful and attractive book with a reasonably accessible price tag.

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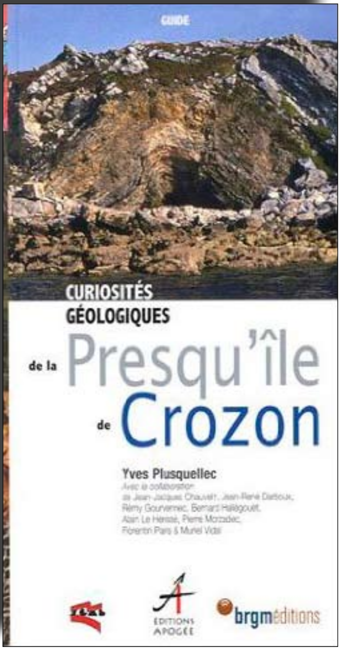
Curiosités géologiques de la presqu'île de Crozon

Yves Plusquellec, avec la collaboration de Jean-Jacques Chauvel, Jean-René Darboux, Rémy Gourvennec, Bernard Hallégouët, Alain Le Hérissé, Pierre Morzadec, Florentin Paris and Muriel Vidal. 2010. 110 pages. BRGM Éditions – Éditions Apogée – SGMB. ISBN 978-2-84398-373-3,. €19, in French. [Available from Amazon.co.uk: under £16.]

This guidebook is part of a series started in 2009 and is produced with the wider audience of amateur geologists in mind. Richly illustrated with maps, drawings and photographs, it is complemented by an authoritative and uncompromising text, qualities which will also draw the attention of professionals who might be looking for a first encounter with the geology and palaeontology of one of the most beautiful parts of the world. A glossary of the technical terms used in this guide helps the non-specialist reader with understanding the text. The main author, Yves Plusquellec (one of my former lecturers in Brest), is a palaeontologist at the Université de



Bretagne Occidentale (UBO), Brest, and specialises in the study of tabulate corals. Throughout his career, he has also contributed to the dissemination of knowledge of the local geology to the general public. Collaborators on this guide include academics from the UBO and the Université de Rennes 1.

Following a short preamble that introduces the reader to the importance of the Crozon Peninsula as a place of focus for painters, writers, artists and geologists, the authors emphasize the geological significance of this peculiarly shaped peninsula in the Armorican Massif. A brief note introduces Fernand Kerforne, who undertook extensive work on the geology of the Armorican Massif, and notably the Crozon Peninsula, in the late 19th and early 20th centuries. Fernand Kerforne is the Breton equivalent, as far as the complex geology of the Armorican Massif is concerned, of the duet formed by Ben Peach and John Horne in Scotland. In much the same way that there is an understanding of the geology of Scotland before and after Peach and Horne's work, there is also an understanding of the geology of the Armorican Massif before and after Kerforne.

The first two chapters focus on descriptions of the sedimentary rocks and the deformation that shaped the Crozon Peninsula.

In the first chapter, the lithology is explained. The different formations are listed and described in stratigraphic order, from oldest to youngest. The "Phyllades de Douarnenez" open this chapter and constitute the oldest rocks in the Crozon Peninsula, deposited during the Brioverian (650–540 Mya), a term used locally for the Armorican Massif, which corresponds to the end of the Cryogenian and the Ediacaran. This formation is mainly unfossiliferous, but locally some unicellular algae have been found in small colonies. These are clues to the oldest life form in Brittany. The Palaeozoic history of the Crozon Peninsula really starts at the beginning of the Ordovician period (Floian), and continues pretty much uninterrupted until the end of the Devonian period. This represents a succession of rocks 3,000 metres thick. Each formation in the succession is characterised by its geographical, sedimentological, palaeontological and depositional context, enhanced by superb and varied illustrations. From time to time, judiciously positioned inserts focus on a fossil group relevant to the formation described, or explain the formation of some sedimentary structure. Two extended paragraphs summarise the Carboniferous and post-Palaeozoic geological history: not a lot from this interval is preserved in the Crozon Peninsula. The chapter ends with a short history of Quaternary deposits, focusing on the example of Trez Rouz, on the northwest of the peninsula.

In the second chapter, the authors give an overview of the complex tectonic history of the peninsula and, to help the reader, divide the story into two acts: a first act of deformation during the Brioverian, and a second act during the Palaeozoic (Hercynian orogeny). In the succeeding paragraph, the authors summarise the deformational activity after the Hercynian orogeny that led to the complex system of faults and veins scarring the peninsula (look at the geological map provided on the inside back cover; Kerforne's original 1901 geological map of the peninsula is also included, on the inside front cover).

A short cultural interlude with examples of artistic interpretations of geological processes or landscapes reminds the reader that scientific interpretation of geological events is unfortunately devoid of any lyricism.

In the next chapter, seven notable geological sites are described in detail. More illustrations, photographs and maps allow the reader to understand more easily the relationship between the sedimentary rocks, the extrusive/intrusive rocks and the tectonic circumstances that have shaped the landscape we can see today. The sites are not listed in any geological order, but follow the coastline from the south east, to the far west end, to the north east. A short explanation of how to get there completes each site description. All of these sites are easy to access by road (well signposted, just follow the directions given in the guide), and once you have parked your car you do not have to walk for hours.

The chosen sites clearly present the variety of geology that one can encounter in such a small geographic area. From folding to faulting, and from sedimentology to palaeontology, there is something for everyone's taste. I will only stress the importance of Site III, which is the section of Veryarc'h-Lamm Saoz. Veryarc'h means a maerl beach in Breton and Lamm Saoz means the English assault, in reference to an invasion attempt by the English army in 1404 that, thankfully, failed. This section displays a continuous succession without any major tectonic disturbance, and represents the east flank of a large anticline centred between the Pointe de Pen-Hir and Pointe du Toulinguet. Along the beach, starting from the western end and walking about 1,200 metres eastwards, the cliffs open to an easy read for the amateur geologist. The complete succession, from the top beds of the Grès Armoricain (Late Dapingien) to the Grès de Lamm Saoz (Late Hirnantian), comprises over ten interesting fossiliferous beds. The Silurian rocks are not entirely preserved and the Llandovery is missing. The Devonian rocks present here are dipping in the opposite direction (*i.e.* towards the west) due to a major fault. We are here on the eastern flank of a syncline, the axis of which can sometimes be observed in the intertidal zone.

Several appendices end this guide book: a glossary, a list of bibliographical works, a list of useful local addresses, useful maps and websites are completed with a short palaeogeographical interpretation of the area. Finally, a most useful geological map concludes the guidebook, with all the localities and sites described therein.

This guidebook is a useful tool for a first didactic approach to the geology and palaeontology of the area. I believe it will be an 'excuse' for travelling to this beautiful part of the world (have I said that already?) to observe the structural and faunal diversity *in situ*. If you do decide to go, why not take a break and visit the cider museum? – not far from the small town of Crozon, where the visit ends with a tasting session of the cider produced at the farm (along with the opportunity to buy). But let's not digress. As a summary this guide is well written, easy to understand and therefore it is of interest to a wide range of people, from amateurs and students to professionals wishing to 'educate' themselves on the subject. The publishers have done a nice job of combining an aesthetically pleasing layout with an authoritative and accurate text.

Yves Candela
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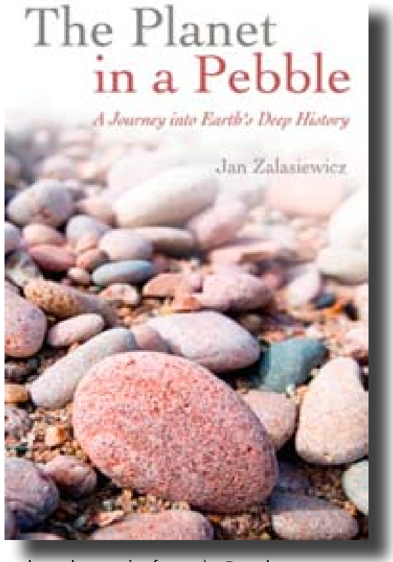
The Planet in a Pebble: a journey into Earth's deep history

Jan Zalasiewicz. 2010. Oxford University Press. 256 pp. £16.99.
ISBN 978-0-199-56970-0.



Books like *The Planet in a Pebble* seem to be more fashionable than ever – a myriad of volumes are available concerning everything from astrophysics and the wonders of the Universe, to native British trees. With such a wide variety of titles that fall under the umbrella of 'Popular Science', there is huge variation in the quality of the content of books in this competitive field. This book could very easily have fallen into the gimmicky, semi-humorous category of the genre – happily, it most certainly does not. Nevertheless, it is by no means dry and boring (I found it quite the opposite) and it still has sound scientific credentials, which are backed up by references to peer-reviewed papers.

In this book, Zalasiewicz's relaxed writing style helps explain immensely complex subjects, succinctly and without fuss. The scope of the book is huge – explaining pretty much everything (the Big Bang, formation of the elements, stars, solar systems and planets, the entire geological history of the earth and even thoughts on its future). But these subjects are not just skimmed over by providing interesting 'facts' – the methodologies behind each topic are explained, along with the limitations of the geochemical techniques involved, as well as summarizing areas that we just aren't sure about (yet). Is this too much for one book to cover in enough detail? No, because of the clever illustrative tool of 'the pebble'; the author miraculously manages this almost entirely descriptively (there are very few pictures and diagrams in this book). There is plenty enough to satisfy readers who like to ask themselves 'how do they know that'. I also like the fact that this book is written by a scientist, who is actively researching this area of geology, instead of a watered-down, half understood, re-working by a professional science writer who is not a professional scientist.

By using one hypothetical pebble (in this case slate from the coast of West Wales – but anywhere would have done), Zalasiewicz ingeniously traces 13 'stories' (the number of chapters in this book) which are unlocked through deduction of evidence, "… of what can be seen, measured, detected, analysed, [and] compared". This brilliantly simple idea allows the author to explore abstract and complicated ideas, spanning incomprehensible numbers of years, whilst still keeping the narrative straightforward and tangible enough for the layperson not to feel lost or confused by jargon and assumed prior knowledge. A good example of the way the author deals with immense numbers, is how he explains how many atoms are in the eponymous pebble: "Our 50-gram pebble therefore contains of the order of one million million million atoms (or thereabouts). If our atoms were sweets—those nice wrapped ones, where every centre is different—then the sack we would need to fit them in would be about the size of the Moon. This is a measure of the enormity of the submicroscopic world that everywhere surrounds us."

As this book is aimed at the general public (*i.e.* it is not intended as a geological textbook), you may be forgiven for thinking that it is of no use or interest to an academic audience. However, I found it very useful as a refresher on the theory behind basic geological techniques, as well as a helpful source of information on newer advances in areas of geology that (as a palaeontologist) I was unaware of. In this respect, *The Planet in a Pebble* would be valuable to anyone, from A-level geologists or geographers, to professors of palaeontology. Because the author is an academic himself, the *Further Reading* section and *Bibliography* are all up-to-date and extremely relevant.

So far I have been very positive about this book, but in order to give a full and unbiased review, I suppose I should point out some of the bad bits (of which, I must admit there are very few). One could argue that because the writing style is so clear, there is little need for illustrations – however, if I were being very (very) picky, the few illustrations that do appear in this book are basic and somewhat uninspired. The one mistake I found in the whole book was that the author states that graptolites' tube-like homes were made from collagen, "the material of which, for example, our fingernails are made" (as I understand it, our fingernails are made from keratin and not collagen). Apart from these trivial points, I really cannot fault this book.

As for format, price and value for money – I also cannot find fault. The chapters are clearly set out in chronological order (starting with the Big Bang) and I found the book easy bedtime reading. At a recommended retail price of £16.99, this is a competitive and affordable price for a hardback of 256 pages. February 2012 also sees the publication of a paperback edition (ISBN 978-0-199-64569-5) at £9.99. Zalasiewicz is an author to look out for, with a style that is in the same league as the great Prof. Richard Fortey's. I look forward to seeing other titles from Zalasiewicz in the future that are equally captivating, ingenious and innovative.

David M. Waterhouse
Norfolk Museums and Archaeology Service

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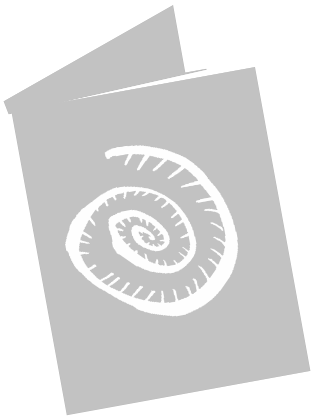

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