The Palaeontology Newsletter

Contents

Reminder: The deadline for copy for Issue no. 95 is 5th June 2017.

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

ISSN: 0954-9900

Editorial

Welcome to the first issue of the PalAss Newsletter for 2017, and what a historic year this is: the 60th anniversary of the Association. From humble beginnings as an informal dining club, the Association has evolved into one of the premier global organisations for promoting palaeontology and its allied sciences. Of particular note is how the Association's initial activities – the establishment of the journal *Palaeontology*, the *Newsletter* and a 'Discussion Meeting' – have expanded into a substantial portfolio of activities that, in addition to these early bastions of the Association, include an impressive array of grant programmes, awards and honours, support of palaeontology-themed sessions at meetings of other bodies, and a strong presence at key public outreach events for palaeontology, all of which can be explored via the newsletter or the Association's website. Reading Prof. Holland's piece on page 24 of this *Newsletter*, it strikes me that palaeontology as a discipline has also come a long way from the 1950s; far from being a rather marginalised aspect of the geosciences, it now occupies a prominent place within the disciplines of geology, earth science, and evolutionary biology and within the public consciousness. Even so, we should not be complacent, but rather take inspiration from Prof. Holland and the other founding members of the Association. These researchers had the vision and determination to create an association promoting palaeontology, and it is our duty to strive to continue to develop both the Association and the discipline of palaeontology, by adapting to changing landscapes in funding policy and society, by continuing to seek to answer the 'big questions', and by furthering efforts to make our science accessible to all.

Maria McNamara
Newsletter Editor
<newsletter@palass.org>

@ThePalAss

<**https://www.facebook.com/groups/palass/**>

Association Business

Annual Meeting 2017

Notification of the 2017 Annual Meeting, AGM and Annual Address

The 2017 Annual Meeting of the Palaeontological Association will be held at Imperial College London, UK, on 17 – 19 December, organized by Dr Mark Sutton and colleagues.

Nominations for Council

At the AGM in December 2017, the following vacancies will occur on Council:

- Vice President
- Editor Trustee
- Book Review Editor
- Meetings Co-ordinator
- Newsletter Editor
- Ordinary Members (2 vacancies)

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. Each nomination must be accompanied by the candidate's written agreement to stand for election, and a short personal statement (less than 200 words) describing their interests.

All potential Council Members are asked to consider the following:

> '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.'

Further information on the responsibilities of Trustees can be obtained from <**secretary@palass.org**>.

The closing date for nominations is **4th October 2017**. They should be sent to the Secretary: Dr Crispin Little, School of Earth and Environment, University of Leeds, Woodhouse Lane, Leeds LS2 9JT; e-mail <**secretary@palass.org**>.

Council vacancies: 'job descriptions'

Vice-President (two-year term)

The Vice-President is one of the more loosely defined Council offices. Vice-Presidents are normally long-serving Council members who have previously held one of the other offices. They have no formal portfolio or duties other than to deputize for the President if and when required, but are present on Council to provide independent input on all matters, backed up by experience arising from their long service. They are also expected to lead or at least participate in important subcommittees, particularly those tasked with making recommendations for the awards of grants.

Editor Trustee (three-year term)

The Editor Trustees are on the Editorial Board of *Palaeontology* but also serve on the PalAss Council. Their role is: to advise the Editor-in-Chief about policy issues that might arise in the running of the journal; to attend the annual review meeting with the publisher, Wiley; to advise the Editor-in-Chief about the suitability for peer-review of articles submitted to *Palaeontology* and *Papers in Palaeontology*; to select the article to be awarded Best Paper in each journal annually; and to hold a watching brief with respect to the management and well-being of the journals and inform Council of issues arising.

Newsletter Editor (three-year term)

Editing the *Newsletter* is an intense role three times a year with relatively little in between apart from collating some content and attending Council meetings. The main responsibilities are approaching people and commissioning content, ensuring that permission for all reproduced images and content has been sourced, editing all content in the *Palaeontology* style, and reminding contributors of deadlines as necessary.

Book Review Editor (three-year term)

The main duty of the Book Review Editor is to provide a range of new and recently-published scientific book titles for members to review. Books available span all areas of palaeontological and evolutionary research and, as such, it is necessary to establish and maintain contact with a broad range of publishers, search for new titles, and request review copies from publishers. For each *Newsletter*, a list of recently-acquired titles is prepared and, as requests come in from members to review the books, each copy must be sent to the prospective reviewer. Reviews recently received from members must be edited in time for each *Newsletter* deadline. It is often necessary to remind reviewers when their text is required so records must be kept monitoring movement of books and receipt of reviews.

Education Officer (three-year term)

Together the Publicity Officer, Outreach Officer and Education Officer comprise the Public Engagement Group (PEG). These posts have responsibility for all the Palaeontological Association outreach activities. Currently they include organizing the Association's presence at Lyme Regis Fossil Festival and the Yorkshire Fossil Festival, co-coordinating the Engagement Grants, answering relevant inquiries, and initiating other activities that promote and develop palaeontological outreach and education for the Association. The members of PEG work closely together and their roles often overlap, but responsibilities associated with the Education Officer post include leading the Association's educational activities, *e.g.* delivering dedicated activities at schools' days associated with fossil festivals and communication with ESTA.

Meetings Coordinator (three-year term)

The Association's Meetings Coordinator ensures the PalAss is present at most of the major international meetings in the wider Earth Sciences domain, mainly by soliciting and/or organizing symposia that are hosted or sponsored by the Association, and via other initiatives. He/she interacts with the Annual Meeting organizers regarding the topic of the symposium at the Annual Meeting, and with other conveners of PalAss-sponsored symposia to avoid overlaps and enhance the visibility of a wide range of palaeontological topics. The Meetings Coordinator also is responsible for the evaluation of applications to and the administration of the Association's Postgraduate Travel Fund.

Ordinary Members (two vacancies, all three-year terms)
Ordinary members do not have a formal portfolio. They attend Council meetings and contribute to discussion, decision making, and future planning. They often participate in important subcommittees, such as those tasked with reviewing and making decisions upon grant applications.

Awards and Prizes

The Palaeontological Association recognizes excellence in our profession by the award of medals and other prizes. The Association sees its lists of medal and award winners as a record of the very best palaeontologists worldwide, at different career stages, and offering different kinds of contributions to the field. The Association stresses the importance of nominations, and encourages all members to make nominations.

Lapworth Medal

The Lapworth Medal is the most prestigious award made by the Association. It is awarded by Council to a palaeontologist who has made a significant contribution to the science by means of a substantial body of research; it is not normally awarded on the basis of a few good papers. Council will look for some breadth as well as depth in the contributions, as well as evidence that they have made a significant impact, in choosing suitable candidates.

The medal is normally awarded each year. Candidates must be nominated by at least two members of the Association. Nominations should include a single page that summarizes the candidate's career, and further supported by a brief statement from the nominators. A list of ten principal publications should accompany the nomination. Letters of support by others may also be submitted. Council reserves the right not to make an award in any one year.

The career summary, statements of support and publication list should be submitted in MS Word or PDF format, ideally as a single document if possible. Nominations should be sent to <**secretary@palass.org**> by **31st March**.

The Lapworth Medal is presented at the Annual Meeting.

President's Medal

The President's Medal is a mid-career award given by Council to a palaeontologist who has had between 15 and 25 years of full-time experience after their PhD, in recognition of outstanding contributions in his/her earlier career, coupled with an expectation that they will continue to contribute significantly to the subject in their further work.

The medal is normally awarded each year. The candidate must be nominated by at least two members of the Association. Nominations should include a single page that summarizes the candidate's career, and further supported by a brief statement from the two nominators. A list of ten principal publications should accompany the nomination. Letters of support by others may also

be submitted. Council will reserve the right not to make an award in any one year. If a candidate has taken time out from their professional career for family and other purposes, this should be highlighted.

The career summary, statements of support and publication lists should be attached in MS Word or PDF format, ideally as a single document if possible. Nominations should be sent to <**secretary@palass.org**> by **31st March**.

The President's Medal is presented at the Annual Meeting.

Hodson Award

The Hodson Award is conferred on a palaeontologist who has had no more than ten years of full-time experience after their PhD, excluding periods of parental or other leave, but not excluding periods spent working in industry, and who has made a notable contribution to the science.

The candidate must be nominated by at least two members of the Association and the application must be supported by an appropriate academic case, namely a single page of details on the candidate's career, and a brief statement from each of the two nominators. A list of principal publications should accompany the nomination. Letters of support by others may also be submitted. If a candidate has taken time out from their professional career for family and other reasons, this should be highlighted.

The academic case, statements of support and publication list should be attached in MS Word or PDF format, ideally as a single document if possible. Nominations should be sent to <**secretary@palass.org**> by **31st March**.

The award will comprise a fund of £1,000, and is presented at the Annual Meeting.

Mary Anning Award

The award is open to all those who are not professionally employed within palaeontology but who have made an outstanding contribution to the subject. Such contributions may range from the compilation of fossil collections, and their care and conservation, to published studies in recognized journals.

The candidate must be nominated by at least one member of the Association. Nominations should comprise a short statement (up to one page of A4) outlining the candidate's principal achievements, as well as one or more letters of support. Members putting forward candidates should also be prepared, if requested, to write an illustrated profile in support of their nominee for inclusion in the *Newsletter*.

Nominations should be attached in MS Word or PDF format, ideally as a single document, and should include the full contact details of the candidate. Nominations should be sent to <**secretary@palass.org**> by **31st March**.

The award comprises a cash prize of £1,000 plus a framed scroll, and is presented at the Annual Meeting.

Golden Trilobite Award

Golden Trilobite Awards are made at the discretion of Council for high-quality websites that promote the charitable aims of the Association. Nominations for websites should consist of a link to the site and a brief supporting case from a member of the Association. Nominations should be sent to <**secretary@palass.org**> by **31st March**.

The award comprises a 'Golden Trilobite banner' and links to the Association's own website. Awards will be announced in the *Newsletter* and on the Association website.

Honorary Life Membership

To be awarded to individuals whom Council deem to have been significant benefactors and/or supporters of the Association. Recipients will receive free membership. Nominations should be sent to <**secretary@palass.org**> by **31st March**.

Honorary Life memberships are announced at the Annual Meeting.

Annual Meeting President's Prize

This is awarded for the best talk at the Annual Meeting. All student members of the Palaeontological Association, and all members of the Association who are early-career researchers within one year of the award of a higher degree (PhD or MSc), excluding periods of parental or other leave, are eligible for consideration for this award. Individuals may nominate themselves for consideration when submitting abstracts for the meeting. The prize consists of a cash award of £200, and is announced immediately after the oral sessions at the end of the Annual Meeting.

Annual Meeting Council Poster Prize

This is awarded for the best poster at the Annual Meeting. All student members of the Palaeontological Association and all members of the Association who are early-career researchers within one year of the award of a higher degree (PhD or MSc), excluding periods of parental or other leave, are eligible for consideration for this award. Individuals may nominate themselves for consideration when submitting abstracts for the meeting. The prize consists of a cash award of £200, and is announced immediately after the oral sessions at the end of the Annual Meeting.

Grants

Palaeontological Association grants are offered to encourage research, education and outreach through different means. Undergraduates, early-stage researchers, and otherwise unfunded persons are given special encouragement to apply. All of these awards and grants are core to the charitable aims of the Palaeontological Association. A full list of the Association's grants may be found on the Association's website (<**www.palass.org**>). Those with deadlines in the next six months are detailed over the page.

Grants-in-aid: meetings, workshops and short courses

The Association is happy to receive applications for loans or grants from the organizers of scientific meetings, workshops and 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 using the online application form. Such requests will be considered by Council at the March and the October Council Meetings each year. If the application is successful, we will require that the support of the Association is acknowledged, preferably with reproduction of the Association's logo, in the meeting/workshop/short course literature and other media. Inquiries may be made to the Secretary (e-mail <**secretary@palass.org**>).

Applications should be made through online submission via the appropriate page on the Association's website, for which you will need the following information:

- Title of meeting/ workshop/ short course
- Date and Place proposed
- Name, position and affiliation of the organizer(s)
- Brief description (not more than ten lines) of the rationale behind the meeting / workshop / short course
- Anticipated number of attendees
- Amount requested (also whether request is for a loan or a grant)
- Other sources of funding applied for
- Specific use to which requested funds will be put

Note: If funds are requested to support one or more keynote speakers, then full details of their names, affiliations and titles of presentations should be included. The application will be strengthened if the keynote speaker agrees to submit their paper as a review article for possible publication in *Palaeontology*.

The deadlines are **1st March** and **1st September** each year.

Outreach and Engagement Grants

Awards are made to encourage educational outreach, public engagement, and related initiatives with palaeontological themes. Normally, the budget for an individual grant would be less than £5,000. Under exceptional circumstances, a budget of up to £15,000 for an individual application will be considered. Grants can support either stand-alone complete projects, or they can be 'proof of concept' case studies that have their own outcomes but that form the groundwork for a larger bid elsewhere. The award is open to both amateur and professional palaeontologists and the principal applicant must be a member of the Association. Preference will normally be given to candidates who have not previously received a grant.

Proposals must fit with the charitable aims of the Association and preference is given to applications for a single purpose (rather than top-ups of grants for existing projects). We particularly encourage

applications with an innovative aspect, such as engaging with new media, and especially cases that will disseminate good practice. Successful applicants must produce a report for the Palaeontological Association *Newsletter*, and any publicity associated with the activity should mention the support of the Association. Full details of application procedures, terms and conditions are available on the Association's website at <**www.palass.org**>.

For more information please contact the Association's Outreach Officer, Dr Lucy McCobb, The Department of Geology, National Museum Cardiff, Cathays Park, Cardiff CF10 3NP, UK; e-mail <**outreach@palass.org**>.

The deadline is **1st October** each year. The awards will be announced at the AGM, and funds will normally be available from 1st January.

AGM 2016: Awards and Prizes

Lapworth Medal: Dr Adrian W. A. Rushton

Stephen Donovan and Nigel Hughes write: Adrian Rushton's name is synonymous with meticulous systematic work of the very highest standards. He has an astonishing command of the global literature and invariably pays great attention to detail with exacting illustrative standards, enforced with the most deft and gentlemanly of touches. Adrian has been instrumental in maintaining the quality of descriptive palaeontological work in the UK, both in his own work and in his role as an editor for the Palaeontographical Society. Adrian's career was one of dedicated service to the British Geological Survey, where he always put his position as a team member first. As a consequence of this, his consistent focus has been refining our knowledge of British Lower Palaeozoic stratigraphy, with a particular emphasis on the Cambrian of the British Isles, of which he is undoubtedly the world's leading authority.

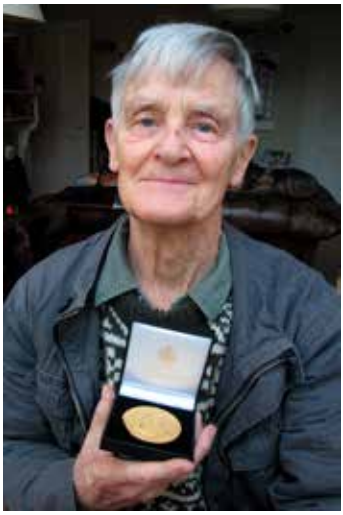


Photo: Jo Rushton

He has written a stream of high-quality papers, both in Survey publications, but also, notably, in top discipline specific journals, on British Lower Palaeozoic palaeontology and stratigraphy, spanning the widest array of taxa. Although these are often collaborative ventures, no paper on which Adrian's name appears deviates from his high standards. Virtually all projects that he has worked on have been published – he has been particularly effective and dedicated in this regard. Although always grounded in his professional focus on British Lower Palaeozoic stratigraphy, Adrian has consistently looked outward in order to more fully contextualize and interpret British material. His systematic papers display comprehensive mastery of the global literature, and he has published a host of papers based on specimens collected from abroad. Examples include publications on faunas

from Jordan, Sweden, Arctic Russia and the Falkland Islands. It is for this reason that Adrian has an outstanding international reputation.

His focus on British Lower Palaeozoic stratigraphy has meant that he has had to work in localities and with material that stratigraphic geologists from other parts of the world would not give a second glance. His ability to collect, prepare and interpret critical information from the most unpromising localities is legendary. This has resulted in substantial novel contributions to British stratigraphy. Unlike some Survey geologists of his generation, Adrian has been an active member of the wider palaeontological community, both nationally and internationally. He is held in the highest regard internationally in matters of Cambrian stratigraphy and palaeontology for the scholarly quality of his work.

He has spoken quite frequently at major national and international meetings. Adrian has always seen his work of equal potential import to both knowledge of the evolution of particular groups (most particularly trilobites and graptolites), and to stratigraphic and tectonic geology. His careful palaeontological work both in the Southern Uplands and in Wales is testament to his abilities in the application of detailed chronostratigraphic constraints to tectonic evolution. Although Adrian is master of classical techniques of specimen preparation and illustration, he has been remarkably active in applying new methods to further improve understanding of fossil form and relationships. His work was among the first phylogenetic analyses of trilobites to employ dedicated software (in this case PAUP) and he also was innovative in the application of computer-based approaches to the retro-deformation of tectonically strained specimens. In addition to his exceptional personal scholarship, Adrian has been a leading force in several compilations of knowledge, such as his two works on the Cambrian geology of the UK and the Atlas of Graptolite Types. His editorship and extensive authorship of *A Revised Correlation of the Cambrian Rocks in the British Isles* provides the definitive account of these rocks that will endure as the standard for years to come.

Although he never worked as a teacher, he has a devoted cadre of apprentices who consider him as their principal guide in systematic palaeontology. Adrian has been an outstanding mentor to younger geologists, guiding them through their earliest publications.

President's Medal: Prof Paul M. Barrett

Richard Butler and Susannah Maidment write: Paul Barrett is the UK's leading dinosaur palaeontologist, having worked on every major dinosaur group from their origin through to their extinction, and also on a number of other fossil reptile groups (*e.g.* turtles, lizards). He has particular expertise in the taxonomy and evolution of ornithischian and sauropodomorph dinosaurs, and has worked extensively on dinosaur palaeobiology and macroevolution. In addition to his academic work, Paul has also had a leading role in the development of vertebrate palaeontology in the UK and internationally through his postgraduate and doctoral training, his heavy involvement in scientific citizenship and his role as a preeminent public communicator.

Paul was trained at the University of Cambridge, where he gained a First Class degree in Natural Sciences (Zoology: 1993) prior to undertaking a PhD in Earth Sciences (under David Norman) on the functional morphology and evolution of dinosaur herbivory (1998). This partially overlapped with and was followed by a Junior Research Fellowship at Trinity College (1996–1999), where he continued and expanded this work. Paul left Cambridge for a Departmental Lectureship in Zoology

at the University of Oxford (1999–2003), where he remained for three years before his appointment as a Researcher in the Department of Palaeontology (now Earth Sciences) in the Natural History Museum, London (2003–present). Since joining the Museum, Paul has had three promotions and is now an RCUK Individual Merit Researcher, the equivalent of a personal Chair. He is one of the youngest people to be promoted to this UK-wide and multidisciplinary scheme. While at the Museum, Paul has served in several managerial roles, most recently as Head of Fossil Vertebrates and Anthropology.

Photo ©Natural History Museum

In terms of publications, Paul is the one of the most prolific authors in his field internationally, having published >140 papers in peer-reviewed journals and books in a 20-year period, as well as a number of award-winning popular books and numerous shorter scientific and popular articles. His range of interests and expertise encompass fundamental monographic work, functional morphology and biomechanics (with particular interests in feeding, soft tissue systems and locomotion) and evolutionary palaeobiology (dinosaur/plant co-evolution, the quality of the fossil record, long-term species-richness patterns and their drivers). His research work is based on collections, databases, various analytical methods and fieldwork. Paul has built extensive international collaborative networks both in the UK and internationally, with particularly strong ties to China, South Africa, Australia, Canada and Japan. His publication list includes contributions in *Nature*, *Science*, *PNAS*, *Proceedings of the Royal Society B*, *Biology Letters* and several other high impact venues. Several of these publications are citation classics, with over 200, and in one case, over 500 citations. His lab has trained and nurtured a large number of undergraduates, graduate students and postdocs, many of whom have gone on to establish prominent positions within the field (*e.g.* Emily Rayfield, Stig Walsh, Roger Benson, Richard Butler, Susannah Maidment, Philip Mannion). As former PhD students and postdocs of Paul's, we can attest to his dedicated and inspiring mentoring of students and postdocs, which has been enormously important (and continues to be important) in our own career development.

Paul's early career contributions to the subject were recognized by the conferral of the Hodson Award of the Palaeontological Association (2006) and the Bicentenary Medal of The Linnean Society (2011). His current standing is reflected by his Presidency of The Palaeontographical Society and the award of several international honours including an Honorary Research Professorship at the University of the Witwatersrand, Johannesburg. Paul is active in several scientific societies at home and abroad and has been Editor or Senior Editor of several key journals (*e.g. Palaeontology*, *Journal of Vertebrate Paleontology*, *Biology Letters*) and currently serves on the Executive Committee of the Society of Vertebrate Paleontology, as well as heading The Palaeontographical Society. Finally, Paul is one of the most publicly visible palaeontologists in Europe, frequently communicating science and raising its profile with diverse audiences though his public role at the Museum and through regular high-profile appearances in the national and international media.

Hodson Award: Dr Susannah C. R. Maidment

Photo courtesy of S. Maidment

Richard Butler and Paul Upchurch write: Susannah Maidment is an outstanding early career palaeontologist who has made several highly significant and substantial novel research contributions. She has developed a strong international research reputation, generated significant external grant funding, and played an important role in promoting palaeontology through her outreach and media activities.

Susie completed her PhD at the University of Cambridge on the systematics of the dinosaur group Stegosauria. She is the acknowledged world leader on this group, having published a string of detailed, comprehensive and well-cited revisions of their anatomy, taxonomy and phylogenetic relationships. In recognition of this, she has recently led the Stegosauria chapter of the forthcoming third edition of The Dinosauria, the leading technical review volume on dinosaurs aimed at graduate students and professional researchers. In addition to her systematic work, she has carried out broader analyses of the musculature, locomotion and functional morphology of quadrupedal dinosaurs, applying a highly integrative and novel combination of biomechanical and anatomical techniques. Most recently, Susie has also been involved in exceptionally exciting work focused on soft tissue preservation in dinosaur fossils. Her co-discovery of collagen fibres and red blood cells in 75 million-year-old dinosaur specimens that are not associated with other soft tissues is potentially paradigm-shifting, and opens up entirely new research directions and opportunities that Susie is beginning to develop and exploit. Her research to date has led to important publications in journals such as *Nature Communications* and *Proceedings of the Royal Society B*.

Susie's current research is focused on refining the stratigraphy of the Late Jurassic Morrison Formation of the western USA, using approaches such as sequence stratigraphy and magnetostratigraphy. The Morrison is an exceptionally important rock sequence that has yielded many of the most important specimens and species of dinosaur from the 19th century through to the present day, but its stratigraphy (particularly correlations between different parts of its huge outcrop) has long been poorly constrained. Susie is an outstanding field geologist, and her work is providing greatly improved stratigraphic controls for the Morrison, with the aim of being able to better understand spatial and temporal changes in biodiversity through this intensely sampled rock sequence.

Susie is an accomplished teacher, with extensive experience in lecturing, supervising and mentoring undergraduate and M-level students. She is also highly committed to public outreach and education, regularly giving talks to schools, specialist interest groups and at popular science events, as well as running a citizen science project excavating microvertebrate remains from the Wealden.

Hodson Award: Dr Robert S. Sansom

Photo: Joe Keating.

Philip Donoghue and Sarah Gabbott write: Robert Sansom graduated with a BSc in Zoology from Oxford University and worked in a biotech company for a year before starting a PhD at the University of Bristol. Here, Robert revolutionized understanding of the evolutionary relationships both among osteostracans, and of osteostracans among their fossil and living relatives. Osteostracans are an extinct group of jawless vertebrates that are key to understanding the evolutionary emergence of jawed vertebrates – one of the most fundamental events in animal evolutionary history. Hitherto, understanding of relationships was based on special pleading, but he lifted debate to the level of objective analysis using rigorous phylogenetic methods and his works serve as the foundation for attempts to understand character evolution in the assembly of the gnathostome bodyplan. Robert published four single-author papers and two first-author papers from his PhD, justifying his recognition as the world authority on osteostracan systematics and evolution.

While maintaining his interests in gnathostome evolution, Robert subsequently expanded his research expertise into experimental taphonomy through his role as a postdoctoral research assistant at the University of Leicester. Working with Mark Purnell and Sarah Gabbott, Robert developed a rigorous statistical and character-based approach to experimental taphonomy that has set the research agenda – in terms of both experimental design and theories on the relationship between decay and estimation of phylogenetic affinity. In particular, Sansom and colleagues showed that invertebrate chordates and jawless vertebrates lose characters through decay in reverse phylogenetic order. This phenomenon, coined 'stemward slippage', results in fossils appearing more primitive than they are, distorting the interpretation of fossil Lagerstätten. The research community is now exploring the general relevance and implications of this fundamental discovery. This work yielded seminal publications in *Nature*, *Proceedings of the Royal Society B*, and *Palaeontology*.

Robert's research served as the foundation for his third current research strand, which is in exploring the impact of non-random data on phylogeny and divergence time estimation through computer simulations and empirical data. The results thus far have been presented in two important papers in *Nature Scientific Reports* and the discipline-leading journal *Systematic Biology*. The role of missing data in phylogeny estimation is an exhaustively studied avenue of research – yet previous research has always assumed that missing data is random. Robert's laboratory and computational studies have shown that missing data is usually non-random, calling into question the results of all previous studies, but also highlighting methods for avoiding such biases in the future. Robert's research in this area has very broad implications for evolutionary biology, including the analysis of both morphological and molecular data.

Robert was awarded a prestigious NERC Independent Research Fellowship which he held initially at the University of Bath, before moving to a proleptic position at the University of Manchester. In

both of these institutions he has been based in life science faculties and departments, evidencing the broad appeal and significance of his research, but also allowing him to serve as an effective champion of palaeontology within the UK Life Sciences community. Robert now holds a lectureship in the School of Earth and Environmental Sciences at the University of Manchester.

Robert has been active in science outreach, including a Royal Society Summer Exhibition (2010), The Big Bang: UK Young Scientists and Engineers Fair (2011, 2012), and his work has attracted significant press coverage ranging from *The Guardian* to CBeebies. Rob has also been in demand to give invited presentations at international conferences including the European Society for Evolutionary Developmental Biology (Paris, France), the International Palaeontological Congress (Mendoza, Argentina), the Committee on Evolutionary Biology (Chicago, USA), the Geological Society of America (Vancouver, Canada), and the Systematics Association Biennial (Oxford, UK).

Mary Anning Award: Dugald A. Ross

Neil Clark and Stephen Brusatte write: Dugie started collecting fossils on Skye as a child, long before academic research teams from Bristol, London, and Oxford (and later Glasgow and Edinburgh) started to work on the island. He has amassed a collection of thousands of fossils, most importantly of dinosaur footprints, dinosaur and marine reptile bones, and ammonites. Two decades ago Dugie opened the Staffin Museum near the village of Staffin. He built the Museum himself, using stones from a ruined 19th century schoolhouse. The Museum houses much of his collection and is a popular tourist site, has hosted thousands of local school children, and been visited by many researchers over the years.

Dugie has been involved in nearly every major discovery of dinosaurs in the Trotternish Peninsula of the Isle of Skye and has been co-author on many of the resulting research papers. These include papers on theropod and sauropod footprints from the Duntulm and Kilmaluag Formations, the first named Middle Jurassic ichthyosaur, an atoposaurid crocodylomorph, as well as many popular articles in the local press in both Gaelic and English promoting responsible collecting and the latest discoveries on the Isle of Skye. He has also featured on many television and radio programmes both locally and globally, speaking about the Isle of Skye and promoting its culture and palaeontology. He has been involved in most of the other discoveries by negotiating with collectors to encourage donations, helping to remove finds that collectors have informed him of, and informing the relevant researchers and landowners of the specimens. He is also concerned with the conservation and protection of the discoveries for future generations against the ravages of winter storms and indiscriminate or irresponsible collectors.

Photo: Sarah Bain

Dugie has been a constant source of all information regarding palaeontological events on the Isle of Skye over the years and liaises with Scottish Natural Heritage, land owners, museums and researchers so that the value of the palaeontology of the Isle of Skye is better recognized and that his own thirst for knowledge is satisfied. This knowledge that he collects is shared with the public through his Museum and he also frequently provides talks and leads field-trips to the various localities for schools, the local community and tourists at the same time as holding down a full-time job as a builder and crofter. He is an honest and modest man without whom the rare and important Middle Jurassic faunas of the Trotternish Peninsula would have remained mostly unknown or destroyed by the frequent severe coastal weather.

Unfortunately, Dugie was unable to attend the 60th Annual Meeting in Lyon to receive the Mary Anning Award in person during the Annual Dinner. However, he will be presented with a certificate during the next stint of fieldwork on the Isle of Skye for the University of Edinburgh this spring.

Best Paper Awards 2016

Since 2015, the Palaeontological Association has awarded annual prizes to the best papers published in *Palaeontology* and *Papers in Palaeontology*. These are to recognize and reward excellence in our field of science and also to encourage the submission of high-quality papers to our journals.

The prize is open to all authors irrespective of age and nationality; membership of the Association is not needed. Frontiers reviews, rapid communications and regular research articles are all eligible. The corresponding author of the winning paper is offered 'open access', paid for by the Association, for one nominated paper submitted by her/him (or one of her/his nominated co-authors) to *Palaeontology* or *Papers in Palaeontology* within the following 18 months (subject to standard peer review process).

So how does it work? At the end of the year, when we know all of the papers that are going to be published in the annual volume, I ask the science editors (who have had the task of steering these papers through the review process) to nominate any papers that they feel stand out as particularly noteworthy. What we are looking for are papers that have scientific breadth and impact, high quality of writing and illustration, and novelty. For *Papers in Palaeontology* it is novelty, breadth, quality of the description and importance of the fauna or flora that we are seeking, while for *Palaeontology* we are looking for those papers that have a wide impact and shape future research directions in palaeontology. The nominated papers are then circulated around the editorial board and voted on.

We again had strong competition for 2016 with plenty of nominations, but the two papers that won are exemplary.

For *Papers in Palaeontology* the best paper prize went to:

Ewa Świerczewska-Gładysz 2016. Early Campanian (Late Cretaceous) Pleromidae and Isoraphiniidae (lithistid Demospongiae) from the Łodź-Miechów Synclinorium (central and southern Poland): new data and taxonomic revision. *Papers in Palaeontology*, **2** (**2**), 189–234. DOI: 10.1002/spp2.1037.

This paper reports a new fauna of sponges in which the microstructure is beautifully preserved and thus adds significantly to our knowledge of the morphology of a number of different genera. The illustrations are of the highest quality.

For *Palaeontology* the best paper prize went to:

Axelle Zacaï, Arnaud Brayard, Jean-Louis Dommergues, Christian Meister, Gilles Escarguel, Rémi Laffont, Bruno Vrielynck & Emmanuel Fara 2016. Gauging scale effects and biogeographical signals in similarity distance decay analyses: an Early Jurassic ammonite case study. *Palaeontology*, **59(5)**, 671–687. DOI: 10.1111/pala.12250.

This presents an analytical study of how best to measure biogeographical similarity explored using a case study of Jurassic ammonites. While it is thoroughly grounded in empirical data, the broader implications that emerge are of interest whatever group of organisms you work on.

The prizes were awarded at the Annual Meeting of the Palaeontological Association in Lyon in December, 2016, and my congratulations go to the prize winners.

Andrew B. Smith
Editor in chief

AGM 2016: Small Grant Awards

The small grants awarded by the Association for funding in 2016 include the Sylvester-Bradley, Callomon, Whittington and Stan Wood awards. Council agreed that the following applicants should receive Sylvester-Bradley awards: Julie De Weirdt (£1,500), Dr Caitlin R. Keating-Bitonti (£1,286), Dr James C. Lamsdell (£450) and Hanwen Zhang (£1,500). The Callomon Award was awarded to Lukáš Laibl (£1,500), the Whittington Award to Zuzanna Wawrzyniak (£1,494), and Stan Wood awards to Michela M. Johnson (£1,457) and Emma Randle (£1,428). Details of the proposed research are given below.

Testing global oceanic anoxia as an alternative cause for the Hirnantian (latest Ordovician) mass extinction

Julie De Weirdt
Ghent University, Belgium

Cooling and glacial episodes have long been considered the main driver of Late Ordovician–Silurian (mass) extinction events that coincide with $\delta^{13}C_{carb}$ excursions. Over the last decade however, emerging palaeontological and geochemical evidence has suggested a more complex relationship between glaciations and extinctions. Emsbo *et al*. (2010) demonstrated dramatic enrichments in redox sensitive metals during the early Wenlock Ireviken extinction event and suggested ocean anoxia as an alternative global kill mechanism. Vandenbroucke *et al*. (2015) built on this idea and recorded a similar increase of redox-sensitive metals at the onset of a mid-Pridoli extinction event, coinciding with peak abundances of malformed (teratological) fossil microplankton. By analogy with metal-induced malformations in modern marine plankton, teratology might serve as an independent proxy for monitoring changes in the metal concentration of the Palaeozoic oceans. The data from the Ireviken and Pridoli events are the foundation for the hypothesis that many, if not all, of the Late Ordovician–Silurian extinctions are caused by large-scale oceanic anoxic events

(OAEs). Using the emerging teratology proxy in Anticosti Island, this project will test the hypothesis that OAE-related kill mechanisms are also applicable to the notorious Hirnantian (latest Ordovician) mass extinction, one of the 'Big Five'.

Physicochemical importance of seawater carbonate saturation

Caitlin R. Keating-Bitonti

Smithsonian Institute, USA

Calcareous marine organisms require metabolic energy to secrete skeletal hardparts, but the total cost of calcification may be quite small relative to the physiological constraints imposed by other physical and chemical oceanographic parameters. Because metabolic rate cannot be directly measured in the fossil record, organism size is often used as a proxy for metabolic rate. However, the overall size of the carbonate skeleton of an organism might not accurately reflect the influence of seawater calcite saturation (Ω_{cal}) on organismal physiology and growth. I propose to use chamber thickness of modern benthic foraminifera to better understand how Ω_{cal} influences the degree of test calcification and growth. Modern oxygen minimum zones (OMZ) are environments of low Ω_{cal} and are, thus, ideal environments to test the hypothesis that foraminiferal test thickness decreases with decreasing Ω_{cal}. Using high-resolution microCT scans, I will quantify within- and among-species patterns of test thicknesses in four representative species that span an OMZ located off southern California. The results of this study could have important implications for palaeophysiological interpretations of the fossil record based on organism size and the degree of calcification. For example, the end-Permian marks the extinction of fusulinidoidean foraminiferans and both acidification and anoxia are documented during this event. Should the results of this study show a positive correlation between Ω_{cal} and chamber thickness, it may motivate a re-examination of patterns of fusulinid morphological change during the end-Permian to elucidate the relative contributions of acidification versus anoxia on the extinction of these large, heavily calcified foraminifera.

Breathing life into an extinct sea scorpion: revealing the gill structure of a three-dimensionally preserved eurypterid

James C. Lamsdell

West Virginia University, USA

Exceptionally-preserved fossils provide unique windows into how extinct organisms lived. Through revealing interactions between species, catching behaviours frozen in time, or showing parts of an animal previously unseen, these fossils allow us to reconstruct long dead animals as living creatures and place them on the tree of life. Applying new technologies to fossils, such as MicroCT scanning, allows us to make new discoveries among established collections and highlights the importance of taking a new look at old fossils. I will be using MicroCT to reconstruct the internal structures of one such fossil, a unique three-dimensionally preserved eurypterid, or sea scorpion, from the Hunterian Museum in Glasgow, UK. Eurypterids were important members of Palaeozoic ecosystems 465–255 million years ago, filling a variety of ecological roles in a manner similar to

modern decapod crustaceans. While we know a lot about the external morphology of eurypterids, we know very little about their internal anatomy, largely due to the fact that almost all specimens are compressed into flattened impressions. The Glasgow specimen is fully three-dimensional and preserves internal organs such as the gills, study of which will allow us to tell whether eurypterids were active predators like scorpions or scavengers, like modern horseshoe crabs. The gills may also hold the key to discovering whether eurypterids are more closely related to horseshoe crabs or arachnids (scorpions, spiders, ticks, *etc*.). This fossil is a unique opportunity to breathe life into a 335-million-year-old arthropod, and is only possible through the combination of new technology and the invaluable resource of museum collections.

Revising mammoth evolution in Eurasia

Hanwen Zhang

University of Bristol, UK

The key aim of my PhD is to achieve a comprehensive revision of the classification and evolution of the Elephantidae, the taxonomic family which includes modern elephants and their close extinct relatives, such as mammoths. Some crucial advancements have recently been made to understand mammoth evolution in Eurasia, but the *dramatis personae* of the ancestral mammoth species in Eurasia which preceded the renowned woolly mammoth are still being debated. My Sylvester-Bradley Award will be used for research visits to institutions that curate some of the most crucial early mammoth fossils: the Naturhistorisches Museum in Basel, the Zoological Institute in St Petersburg, and the Paleontological Institute in Moscow. The fossils span more than 2 million years of mammoth evolution, and consist of rare, exceptionally-preserved skull and jaw material with important diagnostic anatomical features regarding the classification and evolutionary stage of the mammoths. As there remains uncertainty about whether some of the more primitive material in these institutions represents early forerunners of mammoths or other elephant lineages, I will aim to combine anatomical data from fossils curated in these institutions with data collection from key elephant fossils from other institutions such as the Natural History Museum, London and the American Museum of Natural History. A complete overhaul is much needed for up-to-date knowledge of the evolutionary history of the elephants.

Postembryonic development of the olenelline trilobites from the Cambrian Series 2 strata of Newfoundland

Lukáš Laibl

Charles University in Prague, Czech Republic

Trilobites of the suborder Olenellina were a major component of the Cambrian Series 2 ecosystems and are characterized by the absence of dorsal ecdysial sutures and calcified protaspid stage. The complete ontogenetic sequence based on abundant material is, however, known only for a few species from this group. The proposed project aims to investigate postembryonic development and intraspecific variability of the olenelline trilobite *Fritzolenellus lapworthi* from the Forteau Formation of western Newfoundland. The funding will allow me to visit the Newfoundland sections. The material containing developmental stages of *F. lapworthi* and possibly some other trilobites will then be studied using a digital microscope. The images will subsequently be used for collecting

morphometric data and for comparison with development of other olenellines. Such detailed studies of postembryonic development and intraspecific variability are necessary for better understanding of phylogenetic relationships and life history strategies among these early Cambrian trilobites.

Measuring genome size in the earliest fossil plants

Zuzanna Wawrzyniak
University of Silesia, Poland

Changes in genome size, including whole genome duplication, have consequences in plant reproduction, ecology and evolution. New insights into the evolution of plant genome size from studies of fossils corroborate the importance of polyploidy in plant evolution. A recent literature-based survey suggested the important conclusion that early land plants had exceptionally large genomes. The unique preservation of the 407 Ma Rhynie Chert (Aberdeenshire, UK) provides an extraordinary opportunity to obtain information about the genome size of some of the most ancient extinct land plants and to test the hypothesis of large genomes in early plants. A well-established method of estimating genome size in extant plants can be used that is based on the positive relationship between genome size (GS) and stomata guard cell length (GCL): guard cells tend to be larger in plants with larger genomes. I have applied this approach to the early fossil lycopod *Asteroxylon mackiei* from the Early Devonian Rhynie ecosystem. Measurements of GCL were made (a value that remains constant in open or closed stomata) from historical slide collections at the Natural History Museum, London, the University of Aberdeen and the University of Münster (Germany). Unexpectedly, this analysis of *Asteroxylon* showed a large range of GCL (39 µm – 92 µm); this early fossil plant spans over 90% of the known range of GCL for all extant plant species. To understand this phenomenon I am comparing data from fossils to close modern analogues of some living Lycophyta. By investigating fossils of *Asteroxylon* from the minimum and maximum GCL ranges we aim to trace morphological/anatomical differences (*e.g.*, are they perhaps different species?) and give new insight into the palaeogenomic research.

A comprehensive anatomical, taxonomic and phylogenetic analysis of Teleosauridae, and a look into macroevolutionary trends

Michela Johnson
University of Edinburgh, UK

Teleosaurids were a unique group of ancient crocodylomorphs. Resembling modern gharials, teleosaurids were one group of Thalattosuchia, the major Mesozoic crocodylomorph clade that transitioned from land to sea. Teleosaurids ranged from the Early Jurassic to Early Cretaceous (~199–125 Ma), and evolved large body sizes (some exceeding 7 m), diverse feeding and post-cranial morphologies, and a near-global distribution. Teleosaurids are well represented throughout Europe. Despite being one of the oldest groups recognized by scientists (first described in the 18th century), they are poorly understood and very under-studied. The aim of this project is to create an up-to-date, comprehensive morphological and phylogenetic analysis of Teleosauridae, and to examine their macroevolutionary trends including body size evolution and land-sea transition – how the

skeletons, evolutionary rates, and senses changed over time. This will be done in part by, and cannot be completed without, examination of key specimens in German collections, most notably *Steneosaurus bollensis* (a 'grab-bag', predominately German, taxon) and *Machimosaurus*. As the genus *Steneosaurus* may not be a natural group (but specimens lumped together due to superficial similarity), studying these specimens is critical for elucidating teleosaurid evolutionary relationships, and for quantifying their morphological trends through time.

Evaluating bite marks and predation of heterostracan ostracoderms (fossil, jawless vertebrates) during the rise of jawed vertebrates

Emma Randle
University of Manchester, UK

One of the most important events in our evolutionary history is the evolution and rise to dominance of gnathostomes (jawed vertebrates). However, just as important is the decline and subsequent extinction of our jawless relatives (ostracoderms) during the Devonian. There are many hypotheses surrounding this event including the inability of ostracoderms to adapt to changing environments, their limited dispersal capabilities, and competitive displacement or predation by jawed vertebrates. The aim is to investigate the latter of these: does ostracoderm predation trace diversity increase through time and how does this relate to the rise to dominance of jawed vertebrates. This will be achieved by identifying predation trace marks through time based on heterostracan fossils held in museum collections. The abundance of these will then be systematically compared to diversity indices for ostracoderms and gnathostomes through the Middle Silurian to Upper Devonian.

ASSOCIATION MEETINGS

61st Annual Meeting of the Palaeontological Association
Imperial College, London *17 – 20 December 2017*

Contact email: <**annualmeeting2017@palass.org**>.

The 61st Annual Meeting of the Palaeontological Association will be held at the institution in which the Association was founded 60 years ago – the Royal School of Mines (now Department of Earth Science and Engineering) at Imperial College, London. The organizing committee is chaired by Dr Mark Sutton.

Imperial College's South Kensington Campus is located in the heart of London's museum district, sitting between the Natural History Museum and the Royal Albert Hall. The Royal School of Mines has historical links to the 19th Century palaeontological giants Thomas Henry Huxley and Henry de la Beche; our logo is a reworking of 'Awful Changes', one of de la Beche's famous palaeontological caricatures.

Outline programme:

Sunday 17th:	symposium and reception.
Monday 18th:	main programme day one, AGM, annual address, and annual dinner.
Tuesday 19th:	main programme day two.
Wednesday 20th:	field-trip.

Watch future *Newsletters* and the Palaeontological Association website (<**www.palass.org**>) for full details, including symposium topics, annual address speaker, field-trip destination, travel and accommodation advice, student travel grants, and social venues.

Registration, booking, abstract submission and payment (by credit card) will commence in June 2017, via the Palaeontological Association website. Abstract submission will close in September (date to be confirmed) and abstracts submitted after that date will not be considered. Registration after that date will incur an additional administration charge, with the final deadline for registration in November 2017.

LEICESTER PROGPAL 2017

@ProgPal2017 #progpal2017

Join us for the annual **Progressive Palaeontology** conference on

1st – 3rd June 2017

at the Department of Geology, University of Leicester

Registration is ***free!***

New this year!
Delegates to have their say on field trip localities

Competitive travel grants available
Supported by our Crowdfunder initiative:
www.crowdfunder.co.uk/progpal2017

Icebreaker reception with the 'Rutland dinosaur'

Talks live-streamed and recorded by Palaeocast

Expert-led workshops
Dedicated poster session
Lightning talks
Full talks

Follow @ProgPal2017
www.facebook.com/groups/progpal2017
www.palass.org/meetings-events/progressive-palaeontology

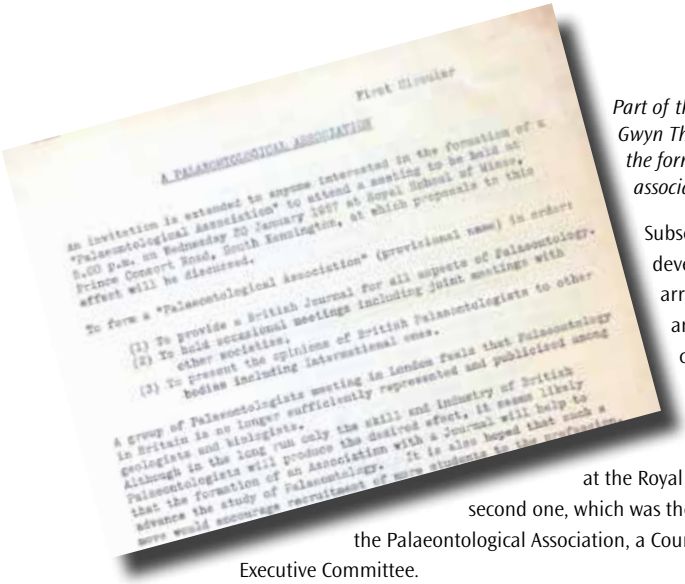
PalAss is 60!!

In the Beginning

This year marks 60 years since the inaugural meeting of the Palaeontological Association. It was in the early 1950s that a number of younger palaeontologists working in London and the south of England became increasingly dissatisfied with the Geological Society's supposed neglect of their needs, particularly in terms of publication of their work. It should be said that they perhaps lacked knowledge that the Society was not rich and was committed to regular publication of the papers presented to it at its regular meetings. Conversations between Frank Hodson, Gwyn Thomas, Bill Ramsbottom and Bill Ball led to the formation of a Palaeontological Dining Club. In a privately circulated account, Frank Hodson gave details of its meetings which took place at the Gardenia restaurant in South Kensington after meetings of the Geological Society. He gave records of the nine younger palaeontologists who attended the first meeting on 15th December 1954; some 23 members eventually were elected. Meetings continued over several years, and they were pleasant occasions. The restaurant charged only a reasonable corkage.

It was at the club that the idea of a palaeontological association began to develop. Hodson records how eventually he and Bill Ramsbottom arranged to meet R. G. S. Hudson on 21st November 1956 before Hudson came, by invitation, to the Club. The purpose was to discuss the possibility of an association and publication. Hudson was a very senior and respected palaeontologist and stratigrapher who had moved from his Chair at the University of Leeds to work for the Iraq Petroleum Company and to continue his research while he was there. He was well known to some also for work as an external examiner at the University of London. The Palaeontological Association must see R. G. S. Hudson as a founding figure who was prepared to take the not inconsiderable risk of underwriting the publication of an expensive journal before subscriptions from members of an association were guaranteed to finance it.

The site of the Gardenia Restaurant, at 36 Gloucester Road, opposite the Gloucester Arms where London palaeontologists are still known to meet for 'Palaeo Drinks'. Photo by J. Hellawell.



First Circular

A PALAEONTOLOGICAL ASSOCIATION

An invitation is extended to anyone interested in the formation of a "Palaeontological Association" to attend a meeting to be held at 5.00 p.m. on Wednesday 29 January 1957 at Royal School of Mines, Prince Consort Road, South Kensington, at which proposals to this effect will be discussed.

To form a "Palaeontological Association" (provisional name) in order

(1) To provide a British Journal for all aspects of Palaeontology.
(2) To hold occasional meetings including joint meetings with other societies.
(3) To present the opinions of British Palaeontologists to other bodies including International ones.

A group of Palaeontologists meeting in London feels that Palaeontology in Britain is no longer sufficiently represented and publicised among geologists and biologists.
Although in the long run only the skill and industry of British Palaeontologists will produce the desired effect, it seems likely that the formation of an Association with a Journal will help to advance the study of Palaeontology. It is also hoped that such a move would encourage recruitment of more students in the

Part of the original circular from Gwyn Thomas to assess support for the formation of a palaeontological association.

Subsequently, amongst other developments, Gwyn Thomas arranged to sound opinion among the British geological community by issuing a circular. The response was good. Two important meetings were arranged at the Royal School of Mines. At the second one, which was the inaugural meeting of the Palaeontological Association, a Council was elected, as was an Executive Committee.

The Association was fortunate in the support given later by distinguished presidents who succeeded Hudson: O. M. B. Bulman, Woodwardian Professor at Cambridge, gave authority and dignity in his conduct of meetings; Professor T. Neville George exposed us to a torrent of complex English with that clarity for which Welshmen are so capable of when speaking English. There was wide support of the new Association. I still remember my old chief Professor Leonard Hawkes who, though himself an igneous petrologist, joined the Association for its first five years to give encouragement and support. Once, seated on a front bench in the Geological Society's meeting room, he was seemingly taking notes of Hudson's Anniversary Address. "I did not know you were so interested in that subject", I said to him afterwards. "I was just counting the ers" he said.

In the early years the Association owed much to the small dedicated group who became the Executive Committee. After Frank Hodson resigned as Secretary to find time to cope with his duties in Southampton, Gwyn Thomas took over from him. He continued to display his ever so capable conduct of business. Stuart McKerrow, a canny Scot at Oxford, provided effective control of our finances. We should certainly remember also Norman Hughes, fellow of Queen's College Cambridge, who brought style to our activities. Some will still remember his particular kind of quiet laughter, which he used to combine sympathy with degradation. When a manuscript arrived in shoddy condition, the author expecting a referee to do the work of correction of error or revision to our expected format, Norman would insist that it be sent back before it was assessed scientifically. Speaking of our development as an association, he once said to me "We must not let it get into the hands of the BM" [1].

My own role in all this was a modest one. Gwyn Thomas became more and more concerned with the development of the all-important journal and its plates, so that eventually I came to succeed him as Secretary. One of my early tasks was to assemble material for our first newsletters. I walked with the copy to a small discreet typing agency near Regent's Park, where two ladies of uncertain age produced a meticulously typed version, which they then posted to the increasing list of members that we provided. I was asked also to arrange the first of a series of so-called

[1] B.M. was our common expression for the then 'British Museum (Natural History)'.

Demonstration Meetings at which a few members would show their work and say a little about it. The first of these took place at Bedford College. Afternoon tea was served. It is interesting that after 60 years this has led to the large and impressive winter meetings of recent years. These have become increasingly international in character. Unlike the present British Establishment, the Palaeontological Association will never turn its back on Europe or the rest of the world. Palaeontology knows no frontiers.

Charles Hepworth Holland
Professor Emeritus, Trinity College Dublin
Member of the Original Palaeontological Dining Club
PalAss Council member 1958–1968 and 1974–1976 (Ordinary Member, Assistant Secretary, Secretary, Vice President, President)
Lapworth Medal winner 2008
Honorary Life Member

The Royal School of Mines, Imperial College London. Photo by J. Hellawell.

news

A new PalAss President

Our new President, Professor Paul Smith, is Director of Oxford University Museum of Natural History. As well as being kept busy with new initiatives in the Museum, he is currently chair of the Oxford University Museums Partnership as well as being co-chair of University Museums Group UK. His research ranges across two main areas of activity: the first relates to the origin and early evolution of major animal groups, particularly the vertebrates and other deuterostomes, and more generally to Earth systems and their interactions during the Cambrian Explosion; the second focuses on the geological evolution of the Scotland – Greenland sector of the Caledonian and ranges from the depositional history, basin analysis and sequence stratigraphy through to the deformation and shortening of the Laurentian margin. Paul is a past President of The Micropalaeontological Society, and we warmly welcome him to his new position as President of the Palaeontological Association.

Richard Twitchett takes the reins as Vice President after serving on Council as Secretary for the past five years and Cris Little takes his place as Secretary. The PalAss Council welcomes new members Dave Bond, Alex Dunhill and Andy Gale as Ordinary Members and Lucy McCobb as Outreach Officer. We are very grateful for the time and efforts of departing Council members Dave Harper, David Ward, Charlie Wellman, Fiona Gill, Martin Munt and Richard Butler.

Jo Hellawell
Executive Officer

Change of charitable status

As announced at the 2016 AGM in Lyon, the changes voted on by members early last year have come to fruition. On 1st January 2017 the Palaeontological Association changed its charitable status from that of an unincorporated association to a charitable incorporated organisation, or CIO. The main benefits of this new status are that the charity has become a legal entity, having limited liability so that members and trustees do not have to contribute in the unlikely event of financial loss. Our new registered charity number is 1168330 (registered with the Charity Commission of England and Wales) and we have transferred all contracts and assets to the new organisation. You are now members of the new charity.

Conversion to a CIO requires us to adopt a new constitution: this was published in *Newsletter* 92 and can be downloaded from the PalAss website at <**http://www.palass.org/association/constitution**>.

The new constitution is much longer than the old one, but many of the additional generic clauses merely formalise Charity Commission regulations and legal requirements that we were already following. For the most part we shall continue to operate exactly as we have done previously and the change should not impact members. However, if you have any questions about this change, please contact me by e-mail to <**executive@palass.org**>.

This year is the 60th anniversary of the Association and we will continue to uphold our charitable aims, promoting palaeontology and publishing high-quality journals and Field Guides, as well as funding a diverse programme of grants and awards. For more about the beginnings of the Association please see the website and page 24 of this *Newsletter*.

Jo Hellawell
Executive Officer

Palaeontology *in the news*

Since the last *Newsletter* there's been a plethora of publicity in the mainstream media for papers in the Association's journals. Part 6 of *Palaeontology* proved a particular hit in the media, with *Proteroctopus ribeti*, a Jurassic octopod, featuring on the BBC Earth website: <**http://www.bbc.com/earth/story/20161102-this-is-a-fossilised-octopus**>; the tail of *Psittacosaurus* gaining coverage that included sound effects in the title: <**http://blogs.discovermagazine.com/crux/2016/12/20/paleontology-lasers-fossils**>; and a *Phys.org* piece on "How sauropods gobbled their way to gigantism": <**https://phys.org/news/2016-12-sauropods-gobbled-gigantism.html**>. The latter article focuses on a study led by David Button, President's Prize winner for best talk at the Annual Meeting in 2014, and his colleagues, addressing the age-old question of how sauropods could eat enough to sustain such a massive body size.

2016 saw the *Lost Worlds Revisited* blog (re)launch on *The Guardian* website, featuring some of our favourite *Newsletter* contributors, including Mark Carnall and Elsa Panciroli. It's fantastic to see our science appear so prominently in the mainstream media on a regular basis. Elsa's article in December featured the "Top fossils of 2016" and included two *Palaeontology* articles out of a total of four articles featured. As Meatloaf didn't say, two out of four ain't bad: <**https://www.theguardian.com/science/2016/dec/28/top-fossils-of-2016**>. One of the *Palaeontology* articles was by PhD student Thomas Clements and his colleagues, presenting work on preservation of coleoid cephalopod soft tissues, and was also featured in Kenneth De Baets' "Favorite Paleontology Articles of 2016", although as Kenneth was third author perhaps this doesn't count: <**https://sites.google.com/site/kennethdebaetswebpage/home/paleontology-news/favoritepaleontologyarticlesof2016**>. Thomas' talk at the Annual Meeting in Lyon on the Mazon Creek Lagerstätte was highly commended and his previous outing at ProgPal won the Best Talk prize; perhaps there's a pattern emerging between talented orators and *Palaeontology* authors in the news?

Just in time for the Chinese Year of the Rooster, PhD student Jennifer Peteya and colleagues published a paper on the plumage and colouration of a fossil bird from the Early Cretaceous of Liaoning. Hanneke Meijer, fossil twitcher, featured the article for *Lost Worlds Revisited* in *The Guardian*, explaining why we should be aflutter with the new feather finds (with ample amounts

of alliteration): <**https://www.theguardian.com/science/2016/dec/14/why-palaeontologists-are-aflutter-over-new-fossil-feather-finds**>; it was also featured on *Sci-News.com*: <**http://www.sci-news.com/paleontology/dinosaur-era-bird-iridescent-feathers-04371.html**>; and Helen Briggs of the BBC explained how, in life, the sparkly feathers would have helped attract mates and that the bird "may have puffed up its feathers like a peacock": <**http://www.bbc.co.uk/news/science-environment-37950166**>. A surprising thing, as well as the evidence of iridescence being preserved, is that these 'flashy' ornate feathers were developed in an animal that was not yet fully grown, though Stig Walsh speculates that it may have been "an adolescent out on its first attempt to 'pull'" – a prehistoric teenage Lothario in the making!

Jo Hellawell (standing in for Liam Herringshaw)
<publicity@palass.org>

Open Access

Most palaeontologists love a fancy new proxy for some aspect of past environment, be it temperature (oxygen isotopes), atmospheric CO_2 (stomatal index), marine redox (pyrite framboids and trace metal concentrations), pH (the promising but as yet unfulfilled boron isotope proxy), or the latest "on trend" tracer for large igneous province (LIP) volcanism, mercury.

New research by several erstwhile PalAss colleagues compares spatial variations in sporomorph chemistry with known latitudinal solar irradiance gradients to develop the first geochemical record of sunshine. The ground-breaking study, led by Phil Jardine in Nature's *Scientific Reports*[1], unpicks the "highly recalcitrant biogeochemistry" (what a great phrase!) of pollen and spores to provide a proxy for incoming UV (particularly UV-B, 280–315 nm) radiation – described as a "key stress factor for the biosphere". Central to Jardine *et al.*'s method is that sporopollenin (which makes up the outer walls of sporomorphs) contains the phenolic compounds para-coumaric acid and ferulic acid. Not only do these phenols convert into vinyl- and ethylphenols that lend distinct notes of "horse sweat", "leather" and "animal" to wine (so I am told), they also provide protection from the harmful effects of UV-B radiation.

Modern plants have been shown to actively control the concentration of these so-called UV absorbing compounds (UACs) in their sporopollenin in response to changes in irradiance. If we assume that ancient plants did so too, their pollen and spore chemistry provides a useful means of monitoring changes in UV flux over geological timescales. Furthermore the great resistance of sporopollenin to the effects of oxidation and thermal maturation means in theory that this technique will work in sediments that cannot yield their secrets to other geochemical proxies. Sounds great, so how is it done?

Jardine *et al.* used non-destructive Fourier Transform Infrared (FTIR) microspectroscopy to quantify UAC concentrations by measuring the height of the 1510 cm^{-1} aromatic peak that records changes in the abundance of UACs. Does it work? Total solar irradiance (TSI) and UV increase towards the equator, so Jardine *et al.* tested for an unequivocal response in UAC contents with latitude by analysing spores from 217 individual *Lycopodium* plants spanning a TSI range of 200 W/m^2. They

[1] Jardine, P.E., Fraser, W.T., Lomax, B.H., Sephton, M.A., Shanahan, T.M., Miller, C.S., and Gosling, W.D., 2016. Pollen and spores as biological recorders of past ultraviolet irradiance. *Scientific Reports* 6:39269. <**dx.doi.org/10.1038/srep39269**>.

found a strong positive relationship between UAC abundance in *Lycopodium* spores and TSI flux. By testing the proxy against a longer, independently dated Poaceae (grass) sporomorph record from Lake Bosumtwi in Ghana, Jardine *et al.* demonstrated that the expected (modelled) TSI signal can be tracked via analysis of small sample sizes (< 30 pollen grains) over orbital precessional cycles (19–21 kyr). Whilst there are confounding factors that have yet to be resolved, such as shading, the proxy has much promise.

What next? For me, the most exciting application of the sporopollenin UV proxy is in deep-time climate studies, particularly in the context of mass extinctions. The Permian–Triassic (PT) and Cretaceous–Paleogene catastrophes have both been linked to the deleterious effects of LIP volcanism, the latter also to the Chicxulub meteorite impact. Whilst the temporal coincidences between these phenomena (particularly the LIP-extinction link) are now well established[2], debate rages over the relative importance of the environmental changes that they induce. In addition to global warming, marine anoxia, ocean acidification, toxic metal poisoning and many others, "vinegar-like acid rain" has been implicated in the PT crisis[3,4], possibly a result of ozone destruction by Siberian Trap-derived halogens[5]. Jardine *et al.*'s new method provides a potential means of evaluating these proposed kill mechanisms. As they write, "extensive sporomorph archives … are available ready-processed in palynological laboratories around the world". Watch this space!

David Bond
University of Hull

Raising Horizons at the Geological Society

Have you ever followed in the footsteps of a pioneering palaeontologist? I would hazard a guess that many, if not most, of us have. For me, it is Dorothea Bate – bold, brave and fond of dynamite, she explored the caves and sea cliffs of various Mediterranean islands at the turn of the 20th Century, discovering fossils of dwarf elephants, hippos and deer. When I climb those same cliffs, or enter those same caves, I always imagine Dorothea doing it first. And I imagine what it would have been like to be her: exploring, shooting and exploding her way to scientific success, hampered by long skirts and a hefty dose of societal disapproval.

PalAss-sponsored *Raising Horizons* is a new portrait exhibition that takes stories of pioneers like Dorothea, and pushes them forwards into the present day. The brainchild of artist Leonora Saunders, and produced in collaboration with *TrowelBlazers*, it depicts fourteen pioneering women in palaeontology, geology and archaeology at imagined moments in their respective careers. The twist? Each of these portraits is posed by a modern-day pioneer in the same field, highlighting how the world has changed in the intervening years: Lorna Steel is Mary Anning (pictured); Jane Francis is palaeobotanist Marie Stopes; Cynthia Burek is Catherine Raisin; Natasha Stephen is Charlotte

[2] Bond, D.P.G. and Grasby, S.E., 2016. On the causes of mass extinctions. *Palaeogeography, Palaeoclimatology, Palaeoecology*. <**dx.doi.org/10.1016/j.palaeo.2016.11.005**>

[3] Visscher, H., Looy, C.V., Collinson, M.E., Brinkhuis, H., van Konijnenburg-Van Cittert, J.H., Kürschner, W.M. and Sephton, M.A., 2004. Environmental mutagenesis during the end-Permian ecological crisis. *Proc. Natl. Acad. Sci. U. S. A.* **101**, 12952–12956.

[4] Sephton, M.A., Jiao, D., Engel, M.H., Looy, C.V. and Visscher, H., 2015. Terrestrial acidification during the end-Permian biosphere crisis? *Geology* **43**, 159–162.

[5] Black, B.A., Lamarque, J.-F., Shields, C.A., Elkins-Tanton, L.T. and Kiehl, J.T., 2014. Acid rain and ozone depletion from pulsed Siberian Traps magmatism. *Geology* **42**, 67–70.

Murchison; Ella al-Shamahi is Mary Leakey. And my heroine Dorothea Bate? She is posed, in fittingly fierce and typically powerful style, by Anjali Goswami.

The portraits are simple, but tell complex stories. Some have evoked very strong opinions – Charlotte Murchison in particular seems to divide the room. All of them make you think: of the women who went before us; of the legacy they have left; and of the diversity of women working in these fields today, pushing at the boundaries of science, making their own discoveries, and paving the way for generations yet to come.

Raising Horizons has been on at the Geological Society for the month of February and will be on tour in the UK. See <**http://raisinghorizons.co.uk**> for more details, including our other sponsors.

Victoria Herridge
Natural History Museum, London

Dr Lorna Steel, Senior Curator of pterosaurs and crocodiles at the Natural History Museum, London, posed as Mary Anning (with dog Tray). Photograph © Leonora Saunders.

Professor Dame Jane Francis

Jane Francis, a past President of the Palaeontological Association and well known researcher in the fields of palaeobotany and palaeoclimatology, was appointed Dame Commander of the Most Distinguished Order of Saint Michael and Saint George (DCMG) in the January 2017 New Year's Honours List. The award specifically mentions Jane's outstanding contributions to both UK polar science and diplomacy.

Jane is the first woman to have chaired the influential Antarctic Treaty Consultative Meeting Working Group on Science and Operations, and only the fourth woman in history to receive the Polar Medal. Since being appointed Director of the British Antarctic Survey in 2013 she has had the dual role of ensuring UK scientific polar excellence and promoting British sovereign interests in Antarctica. To tackle the byzantine complexities of the Antarctic Treaty as well as promote the diverse interests of UK polar science has been a singular achievement, now recognized by this rare and high honour.

But, rest assured, Jane is still just as enthusiastic and energetic for her specific science interests as ever, and she will continue to promote 'palaeo' science wherever she can.

Alistair Crame

Palaeontological giveaway

To celebrate 48 years in business, Stuart Baldwin and Sue Lyman of Baldwin's Scientific Books in Essex are giving away several thousand palaeontological reprints/separates and original articles collected over the last 40 years – including a complete set of *Zoological Record* – **at no charge**. Plants, invertebrates and vertebrates are well represented. A list is currently in preparation and will be emailed on request. For instance, decapod crustaceans are represented by 115 items weighing 4.2 kg. Calling in person to darkest Essex is recommended as visitors will be able to see hundreds of other free items not listed. We are 50 miles north-east of London and 50 miles south of Cambridge. If unable to visit, items can be sent with postage, packing *etc*. charged at cost. The nearest station is Witham (45 minutes from London's Liverpool Street Station).

Baldwin's Scientific Books, 18 School Road, Wickham Bishops, Witham, Essex, UK CM8 3NU
Tel +44 (0) 1621 891526, e-mail <**sbaldwin@fossilbooks.co.uk**>.

Stuart Baldwin

*Friday 28th
Schools Day - not all activities are available to the public

Lyme Regis Fossil Festival

TIME, TIDE & TECTONICS

Fri 28th* – Sun 30th April 2017

LYME REGIS COAST & TOWN VENUES

Free festival ✭ Learn about fossils from top experts ✭ Music
Fossil Walks & Talks ✭ Theatre ✭ Hands-on Science
Hands-on Art ✭ Family activities ✭ Fossil Fair

www.fossilfestival.com

Lyme Regis Development Trust

From our Correspondents

Legends of Rock

Isabel Clifton Cookson: Pioneer in Palynology and Palaeontology

Isabel Clifton Cookson was born in Melbourne, Australia, in 1893. She was one of the country's first palynologists and also one of its first professional female scientists, with a career spanning 58 years. She lived in Melbourne for most of her life, where she made important contributions to our understanding of early plant evolution. Her interest in science began when she attended the Methodist Ladies' College at Kew, where she excelled in anatomy, physiology and botany. Despite the passing of her father when she was young, Cookson excelled at school and went on to study for a BSc in Zoology and Botany at the University of Melbourne.

Following graduation Cookson continued her studies at Melbourne, completing an MSc on modern fungi and plants while also working part time as a demonstrator. She published her first scientific paper in 1921 on abnormalities in the flowers of two angiosperms. Though her studies were originally centred on extant organisms, both plants and fungi, her research became increasingly based in palaeontology, despite a lack of formal geological training. Cookson's interest in palaeontology was cultivated on several visits to England, in particular, to the University of Manchester, where she worked with William H. Lang. Lang influenced her greatly and is thought to have been her primary inspiration for the study of palaeobiotany.

Cookson had originally intended to work on samples of fungi, which she brought with her to England from Australia. However they did not survive the journey, so instead she moved on to examining the fossil flora of the Victoria region, studying early vascular plants from the Devonian and Silurian. Her first fossil description was in 1926 regarding a specimen from this area named *Arthrostigma gracile*, an early vascular plant from Victoria, Australia. Her research on these early vascular plants produced several papers relating to the *Baragwanathia* macroflora, with a landmark paper describing plant evolution which she published with Lang in 1935. Cookson's contributions to this field were recognised when William H. Lang named the fossil plant genus *Cooksonia* in her honour in 1937.

She returned to Melbourne in 1929, where she was appointed a lecturer, and in 1932 she was awarded a DSc based on her contributions to the understanding of early plant evolution, being

only the fourth woman to receive this honour from the University of Melbourne. She was widely considered an excellent lecturer and many of her undergraduate students went on to work in her research lab.

From the 1940s onwards Cookson specialised increasingly in Cenozoic plant fossils and palynology, with much emphasis on the brown coal reserves of Yallourn, Victoria and Moorlands in South Australia. Cookson discovered an incredible wealth of pollen and spores within the Yallourn material using a technique called chlorinationacetolysis. She went on to describe diverse pollen taxa from the deposit and demonstrated their applications in relative dating and stratigraphy. In 1949 the University of Melbourne established the Brown Coal Pollen Research Unit and Cookson was appointed as its head. She collaborated extensively with other notable palynologists, who at the time were all based in Europe, undertaking many self-funded research trips. She also worked on marine deposits, characterizing many fossil plankton and dinoflagallates. As a result of her contributions to the taxonomy of these fossils and to their applications in stratigraphy, her work was of great importance both to our understanding of the evolutionary history of these groups and of the oil industry. Her considerable contribution to dinoflagellate cyst taxonomy was widely recognized and various taxa, for example *Cooksonidium*, *Cooksoniella*, *Isabelia* and *Isabelidinium*, were named in her honour.

Cookson officially retired in 1959 but continued her research on a self-funded basis, producing a further 30 papers post-retirement. Aside from her biological and palaeontological passions she was a keen follower of the stock market and an enthusiastic tennis player. Said to be a good conversationalist by friends, and known by some as Cookie, she was nevertheless devoted to her work and her mind was never far from the research she was conducting at the time. She did not marry. The institutional climate in which Cookson worked was male-dominated and often underfunded. Despite this, she described a significant 557 species during her lifetime, either by herself or in collaboration with others. Palaeobotany clearly owes Cookson a great debt; although not her original field of research, her work in the field has left a lasting legacy.

Women biology students, University of Melbourne, c.1916, University of Melbourne Photographs collection, University of Melbourne Archives, 1993.0181.00002.

Cookson was a pioneer in palaeobotany and for women in palaeontology.

Holly Betts
University of Bristol

REFERENCES

RIDING, J. B. and DETTMANN, M. E. 2014. The first Australian palynologist: Isabel Clifton Cookson (1893–1973) and her scientific work. *Alcheringa: An Australasian Journal of Palaeontology* **38**, 97–129.

TURNER, S. 2007. Invincible but mostly invisible: Australian women's contribution to geology and palaeontology. *Geological Society, London, Special Publications* **281**, 165–202.

Behind the Scenes at the Museum

The New Walk Museum & Art Gallery, Leicester

The New Walk Museum opened in 1849 as one of the first municipal museums in the UK following the Museum Act 1845, which gave town boroughs the power to establish museums funded by local council tax. Joseph Hansom, creator of the eponymous taxicab, designed the original museum building that forms the core of the present museum on Leicester's New Walk promenade, between Victoria Park and the city centre.

The founding collection of the New Walk Museum comprised some several thousand curios amassed by members of the Leicester Literary and Philosophical Society (LLPS) with whom the Museum has maintained a strong connection. The collections of the New Walk Museum & Art Gallery (now combined) have grown in scope and size since 1849, now boasting an eclectic suite of exhibitions including the (Richard) Attenborough Collection of Picasso ceramics, a newly refurbished Egyptian Gallery, and an exhibition of German Expressionism.

Of principal interest to our community is the Natural Sciences Collection which currently comprises upwards of 60,000 geological specimens, the majority of which (*c.*38,000) are palaeontological, alongside about 160,000 zoological specimens. According to the Curator of Natural Sciences, Dr Mark Evans, this is reflected in the "unashamedly palaeontological" displays of the Dinosaur Gallery which was opened in September 2011 by Sir David Attenborough.

The centrepiece of the Dinosaur Gallery is the 'Rutland Dinosaur' *Cetiosaurus oxoniensis*, one of the most complete British sauropods. Discovered in 1968 in an active quarry in Rutland, northeast of Leicestershire, the fossil had been dug out by the time museum staff arrived on scene and was found residing in a corner of the quarry! This ancient giant, now reconstructed using a combination of fossil and replica bones, presides over the goings-on of the gallery.

A clear Jurassic theme runs through the Dinosaur Gallery, with a focus on local specimens. Alongside a new Gloucestershire plesiosaur, which found itself the subject of Mark's PhD research, are displays of the Museum's Hettangian (Early Jurassic) Barrow-upon-Soar and Callovian (Mid Jurassic) Oxford Clay collections.

The New Walk Museum & Art Gallery. Image courtesy of Leicester County Council.

The Dinosaur Gallery. Image courtesy of Leicester City Council.

The first of these collections comes from the mid-19th Century lime pits around Barrow-upon-Soar, ten miles north of Leicester. This includes the 'Barrow Kipper' – a five metre long rhomaleosaurid plesiosaur – discovered in 1851 and still under taxonomic study. The 'Kipper' has been in the possession of the New Walk Museum on display, much as it is now, since the 1850s. Whilst this impressive display has survived the test of time, the Victorian preparatory techniques leave something to be desired. The wall-mounted skull is a cast, with the original occupying an adjacent display cabinet where careful use of a mirror demonstrates the beautifully chiselled underside of the skull. Rock and bone were indiscriminately planed-off in the 1850s to create a flush surface for mounting the specimen. The eagle-eyed observer will also see pits left by six inch nails, originally (we must assume) used to prevent the 'Kipper' making a break

for it! However, this is a nonetheless stunning fossil and an interesting study in how (or how not) to prepare palaeontological specimens. As in life, as on display, this plesiosaur shares its environment with articulated ichthyosaur specimens, complete with body-outlines preserved, and various invertebrates and fishes. These fish include the holotype, and indeed only specimen, of the diminutive *Browneichthys*, discovered by and named for the persistent collector and 19th Century New Walk curator, Montagu Browne.

The 'Barrow Kipper' – a rhomaleosaurid plesiosaur. Image courtesy of Leicester City Council.

Surveying the Dinosaur Gallery from above is *Leedsichthys* – a *c.* 9 m long pachycormid fish from the Middle Jurassic Oxford Clay Formation. This collection has a rather unusual display, whereby the often fragmentary vertebrate fossils are contextualised in metal frame outlines that form the basis for fleshed-out model reconstructions. These models were themselves used to create an animated interactive display where the Jurassic seas are brought to life with creatures swimming right over your head.

Despite the name, the Dinosaur Gallery is not restricted to the Mesozoic Era. Perhaps the most famous specimen in the Natural Sciences collection is the holotype of *Charnia masoni* – the first identified Precambrian macrofossil. Brought to scientific attention in 1957, *Charnia* has been on near-continuous display in the Museum since January 1958. Alongside the holotype are two wall-mounted casts of spectacular Charnwood Forest Ediacaran fossil surfaces, on loan from the British Geological Survey (BGS), which give a sense of the difficulties of studying these organisms, but also of how rewarding that work can be.

The 'lab space' of the Dinosaur Gallery displays items from the geological side of the collection, displayed as a suite of samples just unpacked after a 19th Century expedition. Rocks and minerals sit atop packing crates amongst old museum desks, gazed down upon in sightless curiosity by the 'Bone Zone's' articulated skeletons. In this lab space you can try your hand at microscopy and discover plate tectonics with a seismometer provided by the BGS and LLPS. For the kids jumping up and down, testing their seismic impact, the seismometer provides boundless entertainment, or the feeling of the coming apocalypse if you happen to be studying ice age fossils in the basement collections room below!

Among the currently unseen treasures in these basement collection rooms are many more marine reptiles, the skeleton of the wingless moa alongside many ice age fossils. Although the majority

The holotype of Charnia masoni *at the New Walk Museum. Image courtesy of Leicester City Council.*

of the collections remain out of sight, the New Walk Museum hosts monthly "fossil in focus" events to bring some of these specimens out of the dark. Most recently, the bones of the giant pachycormid *Leedsichthys* were out on show, and before that the focus turned to a suite of large-antlered ice age deer fossils not seen since 1982. Local libraries also benefit from temporary displays on loan from the Museum, including the current "ay up me duck" suite of waterfowl that brings together local dialect and natural history at the New Parks Library.

The entrance of the New Walk Museum and Art Gallery is currently being redeveloped to improve accessibility, with work on a new ammonite-inspired staircase due to be completed in mid-May 2017, and in June the Dinosaur Gallery will play host to the icebreaker reception of the Progressive Palaeontology meeting. The New Walk Museum has successfully navigated the sometimes bumpy road followed by municipal museums by reinventing itself over the years, and it keeps its place as an important repository of British palaeontological collections, especially those from the English midlands.

Thomas Hearing
University of Leicester.

New Walk Museum & Art Gallery, 53 New Walk, Leicester, LE1 7EA
Tel: 0116 225 4900
E-mail: <**museums@leicester.gov.uk**>
Web: <**http://www.visitleicester.info/things-to-see-and-do/arts-museums/leicester-museums/newwalkmuseum/**>

General admission to the New Walk Museum & Art Gallery is free. The Museum is open all year round from 10 am to 5 pm Monday to Saturday and 11 am to 5 pm on Sundays.

Sir David Attenborough opens the Dinosaur Gallery, September 2011:
<**https://www.youtube.com/watch?v=PC9UN46Qr4o**>

The Dinosaur Gallery on YouTube:
<**https://www.youtube.com/playlist?list=PL1D1005066484DD75**>

Brief moments

Urban legends are a fascinating thing. One might wonder quite how they differ from rural legends, but they have a persistence that their quirkiness does little to shake. In fact, it seems that the more quirky, the more persistent, the better; and if they shiver the spine a little – well, that won't harm their longevity, as in the oft-told story that in a city one is always within six feet of a rat. Here, of course, one might protect oneself from the omniproximate rodent by cultivating the company of another urban legend, the Black Dog, that spectral giant pooch with the glowing eyes. That should do the trick.

There are some palaeontological urban legends too. Most, naturally, focus on the dinosaurs. One that I remember well from a tender age was the notion that they had two brains, one in front and one behind. This is nonsense, of course – an expansion of the spinal cord in the pelvic region is not a brain – but this story proved surprisingly persistent, nonetheless. Their scaliness? Now this is a fascinating question, as feathered dinosaurs have been much in the news in recent years. Hence the legend is evolving, and it has become common knowledge that the likes of *Velociraptor* and perhaps even the mighty *T. rex* were be-feathered.

So, do we still await the first cinematic blockbuster where all the dinosaurs have plumage, rendered in glorious technicolour? Alas, it seems that many, if not most, dinosaurs remained resolutely feather-free, so one may have to dash the enthusiasm of those CGI image purveyors eager to sketch out a sauropod-of-paradise to amaze the viewing public with. *Brontosaurus* and its kin seem to have been scale-clad baldies, after all, so that the next dinorama spectacular blockbuster would have to be a *nuanced* blockbuster, a contradiction in terms if ever there was one.

Then, there is their use as symbol of all that is outmoded and doomed to extinction. Well, their longevity outlives ours a thousand times or so, and indeed they are still with us in the form of the sparrow and the crow. But there is one of the dinosaur urban legends that occasionally puzzles me, though this is not so much legend as a pattern consistent with the sum total of recorded observations. This is, that the dinosaurs kept the mammals very firmly in their place, as small, squeaky balls of fur forever scurrying out of the way of the giant saurian overlords, and it was only when the dinosaurs of the non-avian kind disappeared that ecological space opened up for the subsequent appearance of the lions, tigers, elephants, blue whales and so on.

The best part of two hundred million years seems an *awfully* long time to maintain such a power balance – or rather, absolute power imbalance. Yet, that is what the fossil record seems to say. From the late Triassic onwards, mammals were present in some numbers. Admittedly, the squeakiness and furriness do not usually preserve (nor those other mammalian characteristics such as the sweat and mammary glands, parental care of young and so on). But, those very distinct, highly specialised and highly preservable mammalian tooth structures – with incisors, canines, premolars and molars – are not uncommon, and suggest strongly that the rest of the package was there too.

Those packages did come in small sizes, with the usual comparisons being made to shrews and cats, while the very largest – such as the late Cretaceous *Vintana* of Madagascar – weighed in at about badger size (mind, I have seen some of the better-fed cats of my acquaintance, such as

the legendary 'Mr. Six-Twenty'[1], getting close to that level of avoirdupois). Still the point is made. Mesozoic mammals – as far as one knows – were titchy.

Given the length of time they had to grow larger – roughly three times what they had in the Cenozoic (and we all know what they managed in *that* space of time) – this still seems a puzzle. If it was all down to the ability of dinosaurs to instantly scrunch any mammal that dared to exceed badger dimensions … well, hats off to the dinosaurs is all one can say, and it makes those Mesozoic swamps an even more *consistently* scary prospect than one had imagined.

Still, just perhaps, a consideration of palaeogeography might offer wider perspectives. Most hunting for dinosaurs, and for early mammals, has likely taken place in what approximates to the big country – various places on the large continents where the dinosaurs would have roamed far and wide, and where there would be little hiding place for any Mesozoic mammal with scalar ambitions. So, what one might need here are some dinosaur-free sanctuaries that a few mammals might have reached and where they therefore might have begun their own evolutionary experiments. A kind of *Lost World* in reverse, as it were.

Some large-ish ocean islands might fit the bill: large enough to nourish any stray mammals that might have made landfall via a drifting tree or suchlike, so that over time, they might evolve a little larger, and then yet larger. Perhaps such a location might be the place to search for the bones of the odd stray Mesozoic mega-mammal. One should here, though, remember the fate of most ocean islands, which is to be smeared into tectonic oblivion, as they make their final appointment with a subduction zone. Hence, if isolated island populations of larger Mesozoic mammals ever developed, their remains are likely now deep in the mantle. One might imagine that final scene in the inevitable blockbuster (*The Core vs Jurassic Park*) where the tissues of the lost mega-mammal are turned into the diamond that will one day adorn the throat of the imperious heroine who has rescued the dim but handsome palaeontologist who had inadvertently allowed the crucial bone to fall into the hands of the evil fossil-smuggling mogul…

It is all too easy for one's imagination to run away with one, as you can see. It's all the fault of time, really – of which palaeontology has such a surfeit that it does not know quite what to do with it.

Darwin noted the problem of the over-abundance of time while bemoaning geology – as a means, we might hastily add, of providing hard evidence for his theory of descent with modification of organisms through natural selection, which we have come to know as evolution[2]. He was an avid geologist in other respects, with Lyell's *Principles of Geology* being a constant and well-thumbed companion on his voyage on the *Beagle*, and indeed his first major monographic work was focused on the geology of coral atolls. But, even in the absence of radiometric dates to provide a true measure of Earth time, he keenly felt the disparity between planetary and the human measures of time. A century to a million years is – he said, approvingly quoting James Croll's nice analogy – the equivalent of a tenth of a inch marked off on a strip of paper 83 feet and 4 inches long. The abyss of Earth time was nigh-well bottomless, even then.

It is still regarded as such now, given that we know that millions of years are the small change of geological time, and those palaeontologists who work on, say, Archean stromatolites, habitually

[1] It refers to the weight, in the metric scale.

[2] Darwin was simply not aware of just how useful geology could be in support of his dangerous idea, as was explored in an earlier column (vol. 86).

talk in multiples of billions of years. A corollary to that moves us once more decidedly into urban legend territory. This is the view that, as geologists and palaeontologists deal with time in millions and billions of years – then that is the sole currency to be used. And, as a further corollary, one can ignore, or simplify, or conflate, time on a human scale, just as soon as one is faced with the rock or fossil of the day.

That seems to me to be a *decided* over-simplification of the histories that we are faced with. For instance if we are to have one example of an unsung revolution in the study of Earth history – and so a kind of reverse urban legend, as it were – then it would have to be the Ocean Drilling Project in its various versions, which has been mostly well-nigh invisible to the public eye. Latterly it seems to have just now found its moment of fame in drilling the Chicxulub crater in Mexico – and not before time. But following closely is another publicly invisible revolution (one indeed closely related to the ODP saga, which provided many of the raw materials for it). This is the use of preserved astronomical (Milankovitch) cycles in strata as a means of fine-scale correlation – replacing a metre scale with a fine millimetre ruler as some of my cyclostratigrapher colleagues put it. Here, now, the dates put upon stratigraphic boundaries are indeed quoted in millions of years – but to three decimal places, and so here the scientists are reaching towards the nearest millennium. That may be a touch optimistic – I recall the late Nick Shackleton, doyen of these studies, saying that it has been hard to get much better than plus or minus five thousand years of precision, because of the way that the time signal in the sedimentary layers had been chewed up by worms. Nevertheless, the million-year barrier has been well and truly shattered by this field of study.

And once we begin to look around, those ancient strata are stuffed to bursting with examples of real-life[3] time. When one admires some nicely developed cross-stratification, for instance, what is one looking at but successive instants of the flow of a river in spate? And, when one is happy enough to fall upon a petrified example of a *tidal* river or estuary – not so very rare, at that – then counting the mud and sand layers means that you are tracking the way that individual tides succeed each other. And – if you happen to come across one of those examples where the tidal stratal bundles thicken and thin rhythmically, then – with a little statistical checking – one can walk along a cliff face, past the fortnightly cycle of the successive spring and neap tides. If the rocks are sufficiently ancient, then – just to put the icing on the cake – the pace (of the strata, not one's contemporary footsteps) can discernably quicken, from the Earth spinning more quickly beneath a Precambrian moon that then loomed closer and brighter. It was all billions of years ago, perhaps, but the pattern of the passing hours can be imprinted as clearly as if it was yesterday.

If all that sounds just a little too humdrum and regular – why, one can go from the equivalent of a gentle amble in the countryside to taking a white-knuckle ride down an exploding mountainside. And still keep track of time, too, if one can have one's wits about one amid extreme turbulence and an ambient temperature of half a thousand degrees centigrade. It is a little safer to do this when everything has cooled down, mind. My volcanologist colleague Mike Branney has a knack of picking his way through the antique rubble of pyroclastic density currents, and placing within them what he terms entrachrons, time planes which track the

[3] If human lives can be thought to be real, recalling those recent suggestions that we are all characters in some kind of cosmic computer game.

evolution – using the term loosely, of course – of individual examples of those monstrous cascades of magma spray and rock. The entrachrons here might just be a few minutes apart: so much for the imperceptible passage of endless geological time.

Eustochio Molina and colleagues had similar real-time matters on their minds when dealing with even more impressive destructiveness, as they were placing the Global boundary Stratotype Section and Point, aka golden spike, for the Cretaceous–Paleogene boundary at El Kef, in Tunisia in 2006. In placing the golden spike at the base of the meteorite-derived iridium layer, they were careful to note that they regarded the boundary as coincident with the impact of that bolide on the Yucatan Peninsula of Mexico. After all, the outflung debris would have taken some hours or days to travel a few thousand kilometres across the world to what would become the stratotype, and Molina *et al.* were anxious that *all* of the meteoritic layer should be included within the Paleogene – and not to creep down into very latest Cretaceous times. There really are times when a few hours matter in geology – even around a stratigraphic boundary that formed 65 million years ago.

Fossils, of course, are no slouches at day-to-day timekeeping too, and within settings that are generally more familiar and life-friendly. There is something here, that my colleague Mark Williams has recently been delving into, that has pretty well attained urban legend status itself – at least in palaeontological neighbourhoods – and as far as I know has not been transmuted into myth. This is the story of the Silurian and Devonian rugose corals so well-preserved that their exterior surfaces show the finest of growth-ridges – some couple of dozen per millimetre – that can be counted and placed within larger regular patterns of preservation on the coral that seem to show annual or monthly cycles.

Almost half a century back, these fine growth bands were painstakingly counted by John West Wells, the coral specialist whose pacific career nevertheless intertwined with conflict, helping recover taxonomic literature from war-damaged scientific institutes in Germany, and later being part of the scientific team surveying Bikini Atoll, just before those islands were reshaped by thermonuclear explosions. Wells' discernment of daily and annual cycles on the Palaeozoic corals – and his inference of a 400-day year in the Devonian – was the high point in a long and productive career. JBS Haldane was to comment that, in an age of burgeoning big-money research and ever-more complex analytical equipment, it was nice to see that a keen eye together with a hand lens could still produce good science. A year or so later, Colin Scrutton looked at other such corals, and could not clearly recognize the years on the coral skeletons – but found that the months seemed to be present and correct, and these led to the same conclusion: of a faster spinning Earth, way back then.

It is not just corals that tell stories of passing days and tides. James Vanyo and Stanley Awramik, also a few decades ago, communed with some of the fine layering in the classic Bitter Springs stromatolites, which are the best part of a billion years old – though here a little more than a hand lens was needed. The hardworking but clearly sensitive cyanobacteria within the stromatolites complained of even shorter days, with some 435 being crammed into a year.

Back in the present, one can stroll down to the beach, too, and come back with a fine haul of mollusc shells, their fine lines also counting the passing of time – indeed of an enviable amount of time from a human perspective. Take that distinguished representative of the black clam (alias quahog, alias *Arctica islandica*) lineage, christened Ming by the researchers who found it.

Ming was born in 1499 – and hence within that 276-year-long Chinese dynasty that has been described as one of the most stable and orderly phases of human history[4]. Ming the mollusc easily outlasted Ming the dynasty, to eventually succumb at the age of 507 years – frozen, alas, on board the ship that had collected it. Written into the shell layers are stories of good years and bad years lived on the Atlantic sea floor.

Then there are tree rings, which also tell stories of the passing seasons, and these go back into the Permian, and – if one looks hard – to the Devonian. Going back to strata, there are all those exquisitely laminated lake deposits and deep-sea black shales, with their own arrays of finely divided time. And here, for good measure, the patterns tend to get clearer as the rocks get older, with fewer of those disruptive burrowing organisms (and there were none, of course, to tear up the pages of Precambrian time).

It's an embarrassment of days, a profusion of fortnights (those lunar tides) and an absolute cascade of years. Look after these, and the millions and billions of years can look after themselves. Trouble is, to do a half-decent job, we have millennia of work ahead of us…

Jan Zalasiewicz
University of Leicester

R for palaeontologists
6. The tidyverse
Part 1: the ggplot2 package

Introduction

The focus of this series so far has been to cover the basics of programming in R as well how to conduct a range of common analyses. Every function and technique I have covered in the preceding articles can be run in base R; that is, you don't require additional packages or the most up-to-date version of R in order to be able to run these examples. However, all that is about to change as we delve into one of the R language's core strengths, the vast array of packages available to users. At the time of writing there are over 10,000 packages available on the CRAN server (a number that will almost certainly be out of date by the time you read this) that make a wide range of data processing, analytical and plotting techniques available to all users. In the next part of this series I will focus on the packages that have become an important part of the palaeontological toolkit such as conducting phylogenetic analyses.

Introducing the tidyverse

For this and the following article I will focus on a series of packages that are changing the R landscape. The *tidyverse* is a compilation of packages, developed by Hadley Wickham and colleagues, that was designed to make the R environment more intuitive to use, specifically with

[4] Though reading the fine print suggests an impressive catalogue of failed uprisings, successful uprisings, wars, regicides and famine.

regards to the manipulation and processing of datasets which can be one of the trickiest aspects of using R, especially for those new to the language or to programming as a whole. I am going to cover some of the functionality within the *tidyverse*, which has become such an important part of the R world. The *tidyverse* comprises a number of packages, each of which has its own specific use, such as the *stringr* and *lubridate* packages which are used in the manipulation of strings and dates respectively, and the *dplyr* package which is used in the creation and modification of tidy data (more about tidy data in the next article). The package we will cover here is *ggplot2*, which makes the production of high quality figures much easier.

Installing new libraries

Before we can use any packages we first need to install them into R. To install any new packages to the R environment we use the **install.packages** function, using the first argument to specify the package to be installed:

```
install.packages("ggplot2", dependencies=TRUE)
```

It is very common in R packages that one package (A) will use the functions built into one or more packages (B) so we say that package A is dependent on package B. By including the **dependencies** argument as above, R will automatically download and install any additional packages that are required for package A to be run, so it is worth using this when installing new packages. As I mentioned the *tidyverse* is comprised of several packages, and helpfully rather than installing them all separately Hadley Wickam has recently created the *tidyverse* package which installs the entire catalogue of packages in one step.

```
install.packages("tidyverse", dependencies=TRUE)
```

A quick note just to say that if it doesn't work then you may not have the most recent version of R installed; you need at least version 3.0.0 (current version 3.3.2) in order to install the *tidyverse*.

So, now we've installed the *tidyverse* package, in order to use it we need to load it into the R environment using the **library** function:

```
library(tidyverse)
```

This makes the functions and datasets contained in this package, along with any packages that it depends on, available to use in the current R session. It is important to note that you only need to run the **install.packages** function once but you have to run **library** in each new session. Also if you are loading in multiple packages at the same time you need to run the **library** function for each one; you can't include multiple packages as an array, like this:

```
library(c(ggplot2, dplyr))
```

This would give you an error because it expects the package name to be a length of one, so use a new line for each package:

```
library(ggplot2)
library(dplyr)
```

The grammar of graphics and the ggplot2 package

The **ggplot2** package works on the principles of the 'Grammar of graphics'; in the words of Hadley Wickham 'It takes care of many of the fiddly details that make plotting a hassle (like drawing legends) as well as providing a powerful model of graphics that makes it easy to produce complex multi-layered graphics'. In simple terms it works by building up plots layer by layer, starting with a coordinate system. As such there are several things every ggplot requires:

1. A dataset.
2. A set of aesthetic properties that govern how the data points will look.
3. The type of plot to be used (geom).

A basic graph

In order to demonstrate the range of options available in ggplot2 I have created a simple dataset that we will use throughout the examples below. The '*species.csv*' file is available on the PalAss website (see note at the end of this article) and contains information on 52 species including the species, genus and family names as well as the body size, geographic location and geological age.

As always the first step is to load the dataset into the R environment; here I've assigned the data to the new variable **species**. If you are uncertain how to load datasets into the R environment, see the first article in this series. The second line below uses the **tbl_df** function to convert our standard data frame into a *tidy* dataset (or a 'tibble' which is the essence of the *tidyverse;* I'll cover this in more detail next time).

```
species <- read.csv("species.csv", header=TRUE)
species <- tbl_df(species)
```

If you take a quick look at the **species** dataset after you've converted it into a *tidy* dataset you will see that it looks slightly different to a typical data frame. Only the first ten rows of the data are printed to the console along with a short description of the type of data in each variable, such as fctr for factor or int for integer. These *tidy* datasets are designed to give you a reasonable amount of information about your dataset without flooding the console with all of it.

Now we have our data in the correct format let's begin by creating a simple plot as a reminder of the default output of the classic **plot** function, by plotting the age of the species (*age* variable) against the size of each species (*size* variable). This will provide a useful comparison against what can be generated using only a few lines of code in *ggplot2*:

```
plot(species$age, species$size)
```

There is a lot we could do to change the look of the standard R plot, such as changing the size, colour and shape of points, and giving the axes more appropriate names. While these are simple enough to do and will greatly, and quickly, improve the look of this graph, there are other additions we may want to make such as colouring the points according to a specific variable such as family name, or adding a legend. In base R this generally involves a lot of experimentation and can be frustrating at times, especially if you have multiple plots or want to include several plots in the one graphic. However, as I will demonstrate here, *ggplot2* deals with much of the logistics of this and with a couple of lines of code can produce high-quality plots with ease. So to begin, let's look at the default plot generated by *ggplot2* using the **qplot** function (Figure 1):

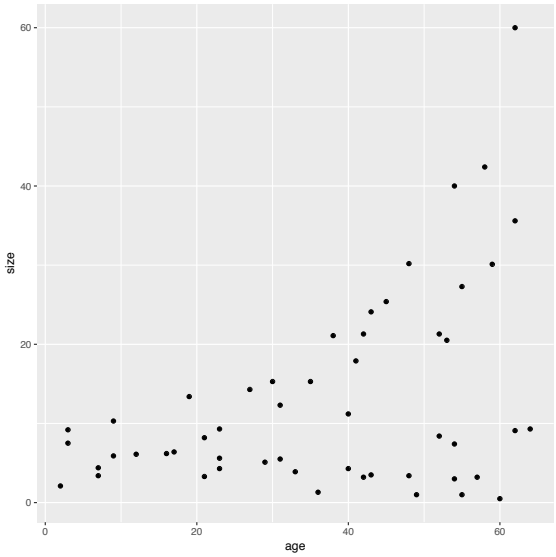


Figure 1. A plot of body size over time as an example of the default output from ggplot2.

qplot(x=age, y=size, data=species)

This is useful for creating a scatterplot that is an improvement over the plot created by base R (Figure 1), already doing some of the work for us such as providing more appropriate axis labels.

Building a chart with ggplot

As mentioned in the introduction one of the fundamentals of *ggplot2* is that it is based on the 'Grammar of Graphics' and requires three things to create a plot: (1) a dataset, (2) information on how we want the plot to look (aesthetics), and (3) the type of graph we want to use (called a *geom*). So we will begin with a simple plot consisting of one continuous variable. Let's say we are interested in seeing the distribution of body size across our 52 species: we could use a histogram. The first thing we need to do is create a new data object that contains the data that we are going to plot. For this we use the **ggplot** function as below. This is the main function in the *ggplot2* package and provides much more control than **qplot**:

sizePlot <- ggplot(species, aes(size))

As well as assigning the dataset we are using, **species**, there is an additional argument here, **aes**. At the moment we've only used it to assign which variables we want to include in the plot, but as you will see it has an important part to play in specifying other aesthetics associated with the plot (we'll skip this step for a moment). The next step is to choose which *geom* (type of plot) we want to use. All geoms built into the package start with a **geom_** prefix and cover a wide range of plots for different kinds of continuous and categorical data; Table 1 (over the page) includes a list of common plot types and the relevant geom and data types they handle. Here we want to create a histogram, so we use the **geom_histogram** function. As I mentioned these functions work in layers so we can simply add the new function to our exisiting dataset, **sizePlot**, using an addition ('+') symbol, as in:

sizePlot + geom_histogram(binwidth=5)

Table 1. Common plot types (geoms) available in *ggplot2*.

Syntax	Plot type	Data required	Data required
geom_hist()	Histogram plots	One continuous	One continuous variable
geom_density()	Density plots	One continuous	
geom_bar	Bar plots	One discrete	One discrete variable
geom_point()	Scatter plots	Two continuous variables	Two continuous variables
geom_line()	Line plots	Two continuous variables	
geom_smooth()	Fitted line plots	Two continuous variables	
geom_text()	Text to plots	Two continuous variables	
geom_bar()	Bar plots	One continuous, one categorical	One continuous and one discrete variable
geom_violin	Violin plots	One continuous, one categorical	
geom_boxplot()	Box plots	One continuous, one categorical	

Figure 2 shows what this will output. As you see we can set the width of the bins; if you leave it blank it will automatically be set to 30, which may not be appropriate for your data.

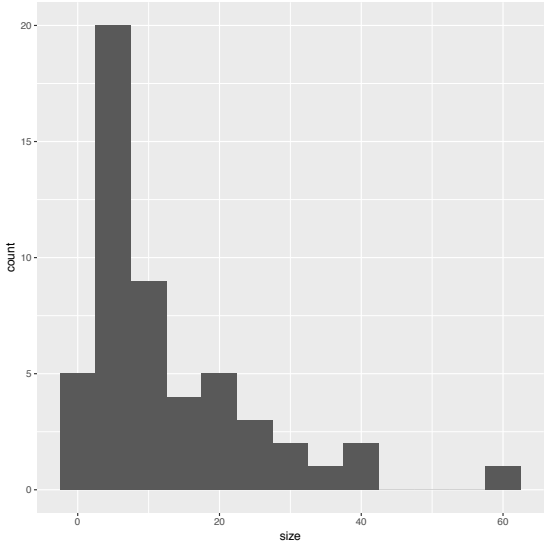


Figure 2. An example of using the histogram geom to show the distribution of body sizes of all species.

It is worth noting that you don't need to assign the data to their own variable, and the same plot can be achieved using the following code, although it is important to note that the '+' symbol must be placed at the end of the first line otherwise R will run this line, and produce a blank graph, rather than wait for the next set of instructions.

```
ggplot(species, aes(size)) +
 geom_histogram(binwidth=5)
```

As I mentioned there are a range of available geoms that you can use for this kind of continuous data, such as:

```
sizePlot + geom_area(stat='bin') # for area plots
sizePlot + geom_density() # for density plots
```

Plotting two continuous variables

Now we have the basics let's examine this *species* dataset in more detail, starting with replicating the plot in Figure 1 using **ggplot**. The first step is to create the dataset we wish to use:

```
sizeagePlot <- ggplot(species, aes(x=age, y=size))
```

Next we need to decide on the kind of plot we want, which in this case of Figure 1 is a typical scatter plot, for which the appropriate geom is called **geom_point**:

```
sizeagePlot + geom_point()
```

What can we tell from this initial plot? Overall within this group of species there is a trend towards smaller size over time (note the axes have the present day to the left with older species to the right, we will fix this in a moment). Using **str(species)** to look at the structure of this dataset we can see that there are four genera (*genusa* to *genusd*), two families (*familya* and *familyb*) and two locations (*north* and *south*) present in this dataset. From this initial observation we may next want to know if this is a consistent trend across all these genera and families or indeed if there is a difference between these two locations. Going back to the step we skipped earlier, the aesthetics, we can tell **geom_point** which variable to use to colour the individual points. In this case let's start by looking at the genera by using the **aes** argument to assign the *genus* variable to **colour** ('color' is also accepted):

```
sizeagePlot + geom_point(aes(colour=genus))
```

With this, ggplot has assigned each genus its own colour (there are ways to change the default range of colours) and has added a legend to the right of the plot with an explanation of the colours used. Not only does this save a lot of effort in getting the legend right but it importantly reduces the chance of making a mistake by assigning a category to the wrong colour. However, we are not done yet – we can assign multiple variables at once, so let's now assign a different shape to species from different locations using the **shape** argument:

```
sizeagePlot + geom_point(aes(colour=genus, shape=location))
```

Now, as well as the distinction between families, the legend helpfully shows that the species from the north location are represented by circles and the south by triangles. Further aesthetic qualities we can modify include the transparency of the points using **alpha**:

```
sizeagePlot + geom_point(aes(colour=genus, alpha=location))
```

and the size of the points using **size**:

```
sizeagePlot + geom_point(aes(colour=genus, size=location))
```

If, rather than select the size, colour or shape of points according to a variable, you want to change all points at once to the same size or colour, place the relevant argument outside of **aes** as in:

```
sizeagePlot + geom_point(aes(colour=genus), size=2)
```

As with the first example there are a range of geoms that you can use for your plot; while I don't have space to go through them all, one I want to highlight is **geom_smooth**, which adds a fitted line to your plot. Rather than replacing the scatterplot we can add this to our existing plot by using the '+' operator at the end of the last statement:

```
sizeagePlot +
 geom_point(aes(colour=genus, shape=location)) +
 geom_smooth()
```

One final point to illustrate the capabilities of this package: try replacing the **geom_smooth()** statement with **geom_smooth(aes(colour=location))**; this automatically adds a separate fitted line for each location (Figure 3).

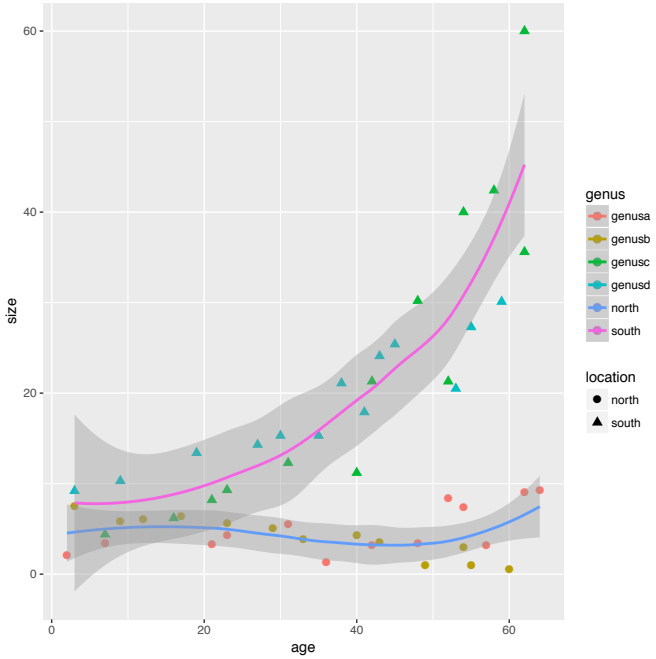


Figure 3. The body size of all species plotted against the age of the species as in Figure 1, with the genus *variable used to select the colour of the points and the* location *variable used to select the shape of the points. Also included is a smooth fitted model for each of the two locations.*

Plotting categorical variables

By using a scatterplot in the above examples we get a good idea of the overall trends in size across all species as well as for genera and different geographical locations, but it doesn't make

it easy to visually compare sizes between genera, families or locations. For that there are more appropriate methods such as boxplots and violin charts. To do this we need to create a different dataset that specifies the categorical variable we want to compare.

```
sizegenusPlot <- ggplot(species, aes(genus, size))
```

There are a couple of differences in this example: firstly we don't specify which variable is on the x and y-coordinates, however it is important that the categorical variable, here the *genus*, is placed before the continuous variable, here the *size* variable. In order to plot a boxplot we use the **geom_boxplot** function:

```
sizegenusPlot +
 geom_boxplot()
```

From this boxplot it shows clearly that genera a and b have a smaller body size distribution than both genera c and d. In addition, as in the previous examples, we can colour this boxplot by another variable, say by location, using the **aes** argument (Figure 4), and the **fill** argument uses the selected variable to colour the individual boxes (the **colour** option is used to select the border colour of each box):

```
sizegenusPlot +
 geom_boxplot(aes(fill=location))
```

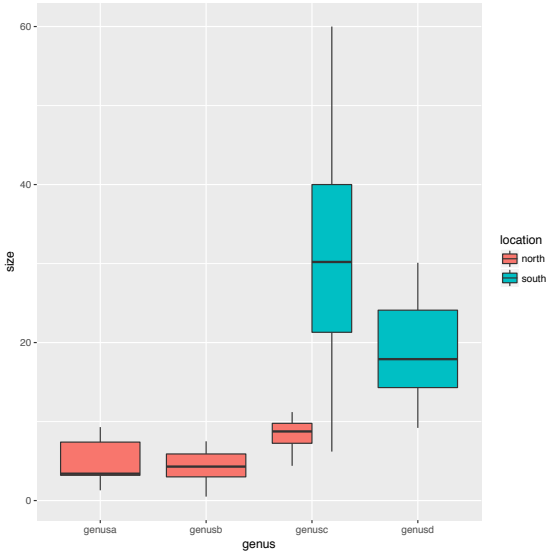


Figure 4. An example of using the boxplot geom to show the distribution of each genus, coloured according to their locations.

You will see that this is largely identical to the previous plot with one important difference, that genus c has been divided into two separate plots. This is because there are species from this genus in both the north and south location so in essence this method allows us to look at the distribution of subsets of the data with ease.

Facets

The last area I want to cover here is *faceting*. Facets allow for multiple plots to be created easily based on subsets of the data. Rather than plotting all species in the one plot as in Figure 1, you may want to create a separate plot for each genus, especially if your dataset is large. To do this we add the **facet_grid** function and specify the variable we want to use to subset the data, in this case *genus*. Using the syntax below it will organize the plots into rows (Figure 5):

```
sizeagePlot +
 geom_point(aes(colour=genus, shape=location)) +
  facet_grid(genus ~ .)
```

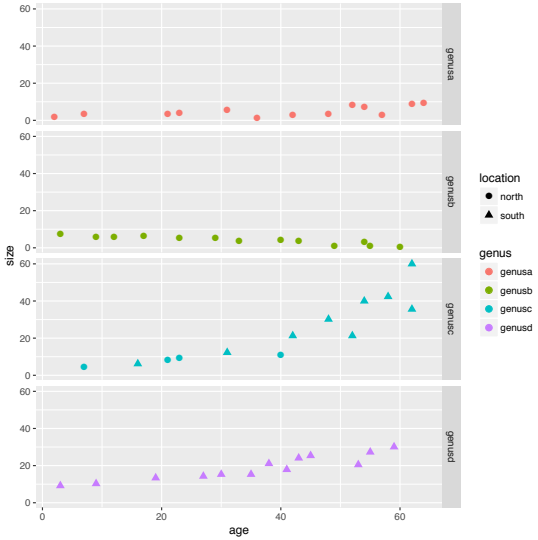


Figure 5. An example of using facets to subset the data by the genus variable and organize the separate plots as rows.

To arrange as columns, place the variable of interest after the '~':

```
facet_grid( ~ genus)
# NOTE the lack of a period (.) when organizing as columns
```

As an exploratory technique, facets are really useful when you have large numbers of categories in the variable you are interested in. However, in this instance it may be better to arrange the plots in a grid rather than in rows or columns; for this we can use **facet_wrap** and specify the layout by using the **ncol** and **nrow** argument, as in:

```
facet_wrap(~genus, nrow=2, ncol=2)
```

Lastly, facets can be used to subset by multiple variables at once using the '~' operator to separate both variables. Say we wanted to compare body size trends by both *location* and *family* at once; we could use the following (Figure 6):

```
sizeagePlot +
 geom_point(aes(colour=genus, shape=location)) +
  facet_grid(family ~ location)
```

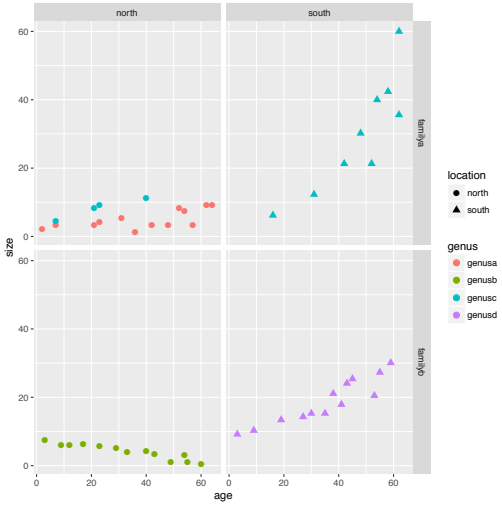


Figure 6. Using facets to subset the data by two variables, here by both family and location.

In summary, you will see that while there is an overall decreasing trend in the data as shown in Figure 1 this is not consistent across all genera, families or locations.

Additional controls

As I mentioned at the outset I wanted to cover the basics of this package rather than provide a walk-through of all its capabilities, however I want quickly to highlight some other controls that are available – 'themes', 'legends and labels' and 'scales' (for a comprehensive and handy guide see Hadley Wickham's cheat sheet for ggplot2 at <**goo.gl/mPPrsy**>).

Themes

Firstly, if you don't like the look of the standard plot you can change it to one of several themes that are built into the package; for example, for a more simplistic look without the grey background:

```
sizeagePlot + geom_point(aes(colour=location)) +
 theme_minimal()
```

In an extreme case you can strip right down to just the basics using **theme_void**:

```
sizeagePlot + geom_point(aes(colour=location)) +
 theme_void()
```

For a wider range of themes follow the examples at the start of this article to install and load the **ggthemes** package. This package provides a range of extra themes that allow you to create the appearance of base graphics in R using **theme_base**, for example to recreate the look of graphics from *The Economist* using **theme_economist**, those of political analytical website *FiveThirtyEight.com* using **theme_fivethirtyeight**, or finally, you can step backwards and use **theme_excel** to make your fantastic data look like they've come out of excel!

Legends and labels

Secondly, you are not restricted as to the location of the legend: using **legend** you can place it on the top, bottom or left of the plot:

```
sizeagePlot + geom_point(aes(colour=location)) +
 theme(legend.position="bottom")
```

You can also give the plot a title and change the axis labels using **ggtitle**, **xlab** and **ylab** separately, or **labs** to save time:

```
sizeagePlot + geom_point(aes(colour=location)) +
 labs(title="Body size over time", x="Size (mm)", y="Age (Ma)")
```

Scales

Finally, as I noted earlier the scale of the x-axis means that the oldest species are plotted to the right and the youngest on the left. The last aesthetic control I cover here is how to change the axes of the plot, using **scale_x_reverse** (**scale_y_reverse** is the equivalent for the y-axis):

```
sizeagePlot + geom_point() +
 scale_x_reverse()
```

We can also transform the nature of the axes; say we wish to show the body size of these species on a logarithmic scale, we can use **scale_y_log10**:

```
sizeagePlot + geom_point() +
scale_y_log10()
```

Summary

I hope you now have an appreciation of the capabilities of the *tidyverse* and the *ggplot2* package in particular. As I said right at the beginning of this series, its graphics capability is one of R's core strengths, and although one can spend hours making amazing graphics, especially if you want to have multiple charts in the one window, *ggplot2* is much more intuitive and easier to use. One thing I haven't been over in much detail is the nature of the datasets that the *tidyverse* employs. If you open the **mpg** data you will see that neither does it display every row of the data (it has 38 and R will display only the first ten) or even all of the variables (depending on how you have the R console set up). This, so-called "tidy" data (hence the *tidyverse*), is designed to give you the most information about your data without flooding the screen with all the variables. Trust me, this is useful when you have dozens of variables and hundreds or more observations. How to create and modify tidy data will be the focus of the next article.

Mark A. Bell
Scottish Government
<**mark.bell521@gmail.com**>

FURTHER READING

CRAWLEY, M. J. 2005. *Statistics: an introduction using R*. John Wiley and Sons, New Jersey. 342 pp.

FIELD, A., MILES, J. and FIELD, Z. 2012. *Discovering statistics using R*. SAGE publications Ltd, New York. 992 pp.

WICKHAM, H. 2009. *ggplot2: Elegant Graphics for Data Analysis (Use R!)*. Springer. 224 pp.

WICKHAM, H. 2014. *Advanced R*. Chapman & Hall/CRC, 478 pp.

You can find the support material for this column, such as the data files *extrinsic.txt, asaphidae.txt* and *species.csv*, in the Newsletter section of the PalAss website, at <**http://www.palass.org/publications/newsletter/r-palaeontologists**>.

Hills of Hame

Experience the TOTAL mountain environment

MOUNTAIN TRAINING ASSOCIATION

Dr Al McGowan: Principal and owner

- Geologist
- Natural historian
- Hill and Moorland Leader
- Wilderness medic

Email: hillsofhame@gmail.com
Phone: 0131 664 7702
Mobile: 0744 3612983
https://hillsofhame.wordpress.com

- **Palaeontological and Geological Tours in Scotland**
- **Training for individuals and groups in navigation (NNAS Bronze and Silver Awards available) and expedition skills**
- **Available to co-lead field courses and trips in British Isles**
- **Fieldwork, statistical analysis and data visualization tasks undertaken as contract research in CGeol capacity**

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

The Rhynie Chert – our earliest terrestrial ecosystem revisited
The Royal Society, London, UK *6 – 7 March 2017*

This scientific discussion meeting is organized by Prof. Dianne Edwards CBE FRS, Prof. Liam Dolan FRS and Dr Paul Kenrick. New discoveries in the fields of developmental and functional biology are shedding light on the origins of land plants; we explore how exceptional fossils from our earliest preserved terrestrial ecosystem – the 400-million-year-old Rhynie Chert – can be integrated into a neobiological understanding of the evolution of plants and their interactions with other organisms and their environment. The schedule of talks and organizer/speaker biographies are available online. Meeting papers will also be published in a future issue of *Philosophical Transactions B*. An evening poster and microscope session with drinks reception will be held following the close of the meeting.

This event is intended for researchers in relevant fields and is free to attend. Places are limited so registration is essential. Please see the website for more details:
<**https://royalsociety.org/science-events-and-lectures/2017/03/rhynie-chert/**>

Lyell Meeting 2017: Sticking Together
Burlington House, London, UK *7 March 2017*

Sedimentology and geomorphology have traditionally been seen as fields in which physical, and sometimes chemical, processes dominate completely. Even in settings where biological processes have long been recognized, for example in marine carbonates, focus has been almost entirely on metazoans. This is curious, because microbial communities since the Pre-Cambrian have suffused all sedimentary environments on Earth, and at least half of global biomass is prokaryotic. Are all these microbes simply bystanders? Recent research has hinted that they are key agents in controlling an impressive range of processes and products in sedimentology, bringing the fields of microbe palaeontology and bio-sedimentology into intimate alignment. The implications are fundamental, and pose the question "are large-scale sedimentological features actually microbial trace fossils?".

This meeting will put the majority of life on Earth back into its proper place within the sedimentary geosciences. It will shed new light on the important roles that microbial life plays in controlling how sediments erode, transport, precipitate, deposit and cement. We will explore whether microbial processes can leave signatures in sedimentary deposits that prove life was there, despite the fact that the majority of global biomass has a negligible preservation potential. Ultimately, we will lift the lid on the exciting field of sedimentary geobiology as we collectively work towards a new paradigm of microbial sedimentology.

For further information about the conference please contact Naomi Newbold (e-mail <**naomi.newbold@geolsoc.org.uk**>) or see the website: <**https://www.geolsoc.org.uk/lyell17**>.

European Geosciences Union (EGU) General Assembly 2017
Vienna, Austria *23 – 28 April 2017*

The EGU General Assembly 2017 will bring together geoscientists from all over the world to one meeting covering all disciplines of the Earth, planetary and space sciences, including palaeontology. The EGU aims to provide a forum where scientists, especially early career researchers, can present their work and discuss their ideas with experts in all fields of geoscience. The PalAss will continue to give its support to sessions under the Division on Stratigraphy, Sedimentology and Palaeontology. This year funding has been awarded to session SSP 4.1 'Experimental and analytical palaeontology' via the Grant-in Aid scheme. Due to other events occurring concurrently in Vienna the organizers encourage booking accommodation well in advance.

Please see the website for more details: <**http://www.egu2017.eu/**>.

Symposium on Molluscan Colour and Vision
Natural History Museum, London, UK *27 April 2017*

The Natural History Museum together with the Malacological Society of London is hosting a symposium on Molluscan Colour and Vision alongside its annual general meeting. The phylum Mollusca is highly speciose and is the largest phylum in the marine realm. Many species are brightly coloured and patterned yet nearly all molluscs are thought to be colour blind. Despite their limitations with colour vision, molluscs showcase a myriad of different eye types, many of which are unique in the animal kingdom. In this Symposium speakers will cover a range of topics that highlight the extraordinary nature of colour and vision in molluscs.

The meeting is free but registration is necessary. Please register by sending an e-mail to the automated account <**MSL-events@nhm.ac.uk**>. You will receive a bounce-back message to say that you have successfully registered. Please do not send queries to this account. Each participant must register in a separate e-mail.

For more information please see <**http://www.nhm.ac.uk/events/symposium-molluscan-colour-and-vision.html**>.

14th International Ichnofabric Workshop
Taipei, Taiwan *29 April – 7 May 2017*

The International Ichnofabric Workshop will take place in Taipei under the auspices of the Department of Geosciences, National Taiwan University and the National Taiwan Museum.
We cordially invite oral and poster presentations dealing with all aspects of ichnofabric, ichnology, and sediment–organism interaction. The workshop will include an intra-workshop field-trip to the north-east coast of Taiwan, where uplifted Cenozoic sandstones offer exquisite exposure of trace fossils and their sedimentary context. The workshop will be followed by a 'round-the-island'

geological excursion of Taiwan, from an ichnological perspective, including a visit to the core repository of CPC in Miaoli.

For more information please see the website: <**http://homepage.ntu.edu.tw/~ludvig/styled-12/**>.

2nd International Meeting of Early Stage Researchers In Palaeontology (IMERP)
Sigri, Lesvos, Greece *19 – 22 May 2017*

IMERP aims to bring together early career palaeontologists from all over the world. Sigri, the chosen venue, is famous for its Natural History Museum, which was established to conserve, protect and promote the fossils which constitute the Petrified Forest of Lesvos. The Meeting's character is informal and its aim is to create a friendly environment where young researchers can present their work and meet other palaeontologists from many different fields of expertise. The Meeting's sessions will include oral and poster presentations from different fields of palaeontology, such as vertebrate and invertebrate palaeontology, micropalaeontology, palaeobotany, taphonomy, palaeoanthropology, palaeoenvironment, and palaeoclimate studies *etc*.

For more information please see <**http://www.imerp2.upatras.gr/index.php/welcome**>.

1st Geobiology Society Conference
Banff National Park, Canada *11 – 14 June 2017*

Following three very successful International Geobiology Conferences held in Wuhan (2010, 2012, 2014) and the recent Geobiology Gordon Research Conference in Galveston (2016), the newly created Geobiology Society will host a three-day meeting at the Banff Conference Center, Alberta, Canada. "Geobiology 2017" will take a page out of the one-day regional Geobiology meetings held across the United States and Western Canada, emphasizing the work of early career scientists, with three days designed to cover various topics pertaining to how microbial processes affect the modern environment and leave imprints on the rock record. A major goal of the Conference will be to facilitate bridge-building across the disparate fields within geobiology, particularly from the geological and biological ends of the spectrum.

Registration and abstract submission are open until 15th March. For more information please see <**http://cms.eas.ualberta.ca/Geobiology2017/**>.

International Symposium on the Ediacaran–Cambrian Transition (ISECT NL2017)
St. John's, Newfoundland, Canada *20 – 22 June 2017*

The ISECT 2017 meeting will bring together researchers on all aspects of the palaeontology, geochemistry and stratigraphy of the Ediacaran and Cambrian intervals. The meeting will consist of a two-day symposium exploring various topics including the placement of the Ediacaran–Cambrian boundary. It will also provide delegates with the opportunity to visit some of Newfoundland's

spectacular geological and palaeontological sites, including excursions to the Ediacaran–Cambrian boundary at Fortune Head; the Cambrian–Ordovician boundary in western Newfoundland; the trilobite localities at Manuel's River; and the Mistaken Point Ecological Reserve World Heritage Site, home to some of the world's best assemblages of Ediacaran macrofossils.

Registration and abstract submission are now open; the deadline for submitting abstracts is **31st March**. Please see the website for more details: <**http://www.isect2017.org/**>.

4th International Conodont Symposium
University of Valencia, Spain *25 – 30 June 2017*

The Congress follows the decision of the Pander Society in Mendoza, July 2013, to organize the next ICOS meeting in Europe. Subsequently, the International Subcommission on Devonian Stratigraphy (SDS) and the International Subcommission on Silurian Stratigraphy (ISSS) decided to hold the meeting in 2017 in Spain. Therefore, the Congress will be open to all topics on conodonts and on Devonian and Silurian. In addition, it will serve as the venue for the Pander Society and the SDS, ISSS business meetings.

Registration and abstract submission close late February. Please see the website for more details: <**http://www.igcp653.org/2017/01/27/4th-international-conodont-symposium-updates/**>.

6th International Conference on Trilobites and their Relatives
Tallinn, Estonia *7 – 10 July 2017*

The sixth in the highly successful series of international conferences on Trilobites and their Relatives will take place in the picturesque Old Town district of the vibrant city of Tallinn. The Conference provides an opportunity to present and discuss recent progress across a wide range of topics. Planned sessions include: early evolution of the arthropods; Lagerstätten; Cambrian trilobites; the Great Ordovician Biodiversification Event; morphometrics; Devonian and later trilobites; functional morphology; the Trilobite Treatise, systematics, phylogeny & ontogeny; collections and databases, and "other arthropods". Pre- and post-conference field-trips will examine trilobite-bearing rocks from the lower Cambrian to upper Silurian. Especially worth seeing are the olenellid trilobites that are amongst the earliest in the World, and the Baltic asaphid faunas combined with illaenid-cheirurid association in highly stratified nearshore limestones of the temperate climate. The differences between trilobite associations of the late Ordovician and early Silurian reefs in an the equatorial climate can be seen on our islands, with options to pick up some nice eurypterids in addition. Papers from the meeting will be published in a conference volume of Fossils & Strata.

We will have two full days of scientific sessions; accompanying persons are invited to enjoy a parallel programme taking in the history and culture of Estonia. Registration and abstract submission are now open. Please see the conference website for details: <**http://trilobite-conference.com/**>.

Orginized by: Dr Helje Pärnaste. General contact e-mail: <**TriloCo2017@gmail.com**>.

International Workshop on Konservat-Lagerstätten
University College Cork, Ireland *15 – 16 July 2017*

This workshop will explore frontier research on Konservat-Lagerstätten, which are widely recognised as essential archives of palaeobiological information. We invite contributions on any aspect of the palaeobiology, taphonomy, and sedimentological context of Konservat-Lagerstätten, including palaeoecology, geochemistry, morphology, evolution, taphonomic experiments, stratigraphy, sedimentology and new fossil discoveries. The programme includes a full day of talks and posters, with keynote talks, regular talks and 'lightning' talks in addition to dedicated poster sessions. The second day of the programme will include informal discussion-style sessions focusing on key topics, themes and problems in the study of Konservat-Lagerstätten plus group-based workshop sessions on key approaches and tecniques, which will be of particular interest as training opportunities to early career researchers. Keynote speakers include Prof. Derek Briggs, Prof. Phil Donoghue, Prof. Bob Gaines and Prof. Johan Lindgren.

Registration will open in mid-March and abstract submission will end on **31st May**. For further information please see <**http://www.uccconferencing.ie/international-workshop-on-konservat-lagerstaetten-15-16-july-2017/**>.

DINO11: 11th International Conference on Modern and Fossil Dinoflagellates
EPOC Laboratory, Bordeaux University, France *17 – 21 July 2017*

The scientific programme will be devoted to the latest developments in studies of living and fossil dinoflagellates, which are one of the most important groups of planktonic and benthic marine microalgae, and, as such, of interest in both biology and geology. In keeping with the tradition of this conference series, the programme of this meeting (held only every 3–5 years) will consist of oral presentations based on talks and posters selected from the submitted abstracts, supplemented by a small number of invited and keynote talks.

Registration is still open; please see the website for more details:
<**http://www.laplf.org/dino11/calquedino11.htm**>.

7th International Meeting on Mesozoic Fishes
Mahasarakham University, Thailand *1 – 7 August 2017*

The Palaeontological Research and Education Centre in cooperation with the Faculty of Science of the Mahasarakham University (Thailand), the University Claude Bernard Lyon1 (France), and the Natural History Museum of Geneva (Switzerland) are pleased to announce and host the 7th International Meeting on Mesozoic Fishes. The Meeting will reflect progress in Mesozoic fish research during the 24 years since the first meeting in 1993. The Meeting will include discussions of old and new methodologies and will showcase novel information regarding the evolution, diversification and palaeobiogeography of fishes during the Mesozoic. A three-day field-trip is planned to several fish localities of the Khorat plateau in the Isan region in the north-eastern part of Thailand, and will include a visit to the Siridhorn Palaeontological Museum.

Please see the website for more details: <**https://immf7.msu.ac.th/**>.

The Old Red: Hugh Miller's Geological Legacy
Victoria Hall, Cromarty, UK *9 – 10 September 2017*

The Friends of Hugh Miller are organizing a 'legacy' conference aimed at the international geological and palaeontological community, and all who have a general interest in Hugh Miller, fossils and the natural world. A keynote speaker will be John Long, Strategic Professor in Palaeontology, from Flinders University, Australia. The scientific programme includes a three-day field-trip to the north of Scotland Jurassic beds, with special permission to explore the famous fish fossil locality in Caithness. Numbers are limited so please book early.

For further information and booking form please see the website:
<**http://www.thefriendsofhughmiller.org.uk/index.asp?pageid=661915**>.

65th Annual Symposium of Vertebrate Palaeontology and Comparative Anatomy & 26th Symposium of Palaeontological Preparation and Conservation with the Geological Curators' Group (SVPCA and SPPC/GCG)
University of Birmingham, UK *12 – 15 September 2017 (provisional)*

SVPCA is a meeting for current research in vertebrate palaeontology and comparative vertebrate anatomy, and has been held annually in the UK, Ireland or France since 1953. The meeting is held in conjunction with SPPC, a forum for discussion of fossil preparation, conservation, and related topics co-organised with the Geological Curator's Group. The 2017 SVPCA and SPPC meetings will be held at the University of Birmingham, in collaboration with the Lapworth Museum of Geology. The provisional dates for the combined meetings are Tuesday 12th to Thursday 14th September, with a field trip on Friday 15th. This will be the first time in its 65-year history that SVPCA has come to Birmingham, and we are looking forward to welcoming you all.

Please see the website for details: <**https://svpca2017.com/**>.

8th International Meeting on Taphonomy and Fossilization (Taphos2017)
University of Vienna, Austria *14 – 17 September 2017*

Every few years Taphos brings together palaeontologists, archaeologists, biologists and sedimentologists as well as other researchers interested in all of aspects of taphonomy, the study of decay and fossilization of organisms. Previous Taphos meetings have been held in Madrid 1990, Zaragoza 1995, Valencia 2002, Barcelona 2005, Granada 2008, Tübingen 2011 and Ferrara 2014. The upcoming Conference will take place at the University of Vienna (Geocenter, UZA II building). Vienna is the capital of Austria and located in the heart of Europe. It can easily be reached from almost all parts of the world and is famous for its culture and friendly atmosphere. Contributions to all aspects of taphonomy from across the tree of life are welcome and may include biostratinomy, fossil diagenesis, taphofacies, exceptional preservation and fossil Lagerstätten, taphonomy and

sequence stratigraphy, microbial taphonomy, archaeology, historical ecology and conservation palaeobiology.

Registration and abstract submission open in March; see: <**https://taphos2017.univie.ac.at/home/**>.

5th International Palaeontological Congress
Paris, France *9 – 13 July 2018*

The fifth International Palaeontological Congress, IPC5, will be held in Paris. More details will be announced in due course.

See the website at <**http://ipanema.cnrs.fr/spip/news/article/the-5th-international**>.

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

Meeting REPORTS

60th Annual Meeting of the Palaeontological Association
Université Claude Bernard, Lyon, France *14 – 17 December 2016*

The 60th Annual Meeting of the Palaeontologial Association was held in Lyon, the ancient Roman capital of Gaul, from 14th to 17th December 2016. Despite the cold winter weather, the meeting provided a warm welcome to delegates from far and wide. The avant-garde logo captures the French enthusiasm for comic art.

After a couple of pre-conference workshops, the meeting officially began with a symposium on the theme of "Assessing palaeoenvironments and palaeobiology through geochemistry". **Ana-Voica Bojar** delivered the first presentation, about geochemical signals and microstructures of deep-sea barnacle shells, and revealed their ecological niche on the margin of hydrothermal vents. **James Wheeley** presented the first ecological model for Ordovician conodonts based on $\delta^{18}O$ variability across nine taxa and their distribution within host rocks. **Jeremy Martin** reviewed current knowledge regarding different isotopic toolkits and their potential applications in vertebrate palaeobiology. **Robert Eagle** discussed how to use non-traditional isotopic approaches to study the physiology of extinct biomineralizing organisms and their palaeoenvironments.

After the coffee break (which supplied attendees with abundant beverages and nice pastries), **Romain Amiot** continued the thematic symposium with a fascinating talk about isotopic aspects of dinosaur reproduction. **Thomas Tütken** used stable isotope analysis of pterosaur skeletal bioapatite to investigate their potential foraging ecology. **Laura Domingo** closed the symposium with a talk entitled "Carnivoran resource and habitat use in the context of a Late Miocene faunal turnover episode" and proposed that high levels of apex predator sympatry may have been favoured due to high levels of primary productivity.

The symposium was followed by an icebreaker reception, which as always provided a wonderful opportunity to catch up with old friends and colleagues and to make new acquaintances.

The second day of the Annual Meeting started bright and early with an opening speech by **Prof. Marie-France Jouber**. This was followed by discussion of the applications of the Clench equation in palaeodiversity studies to enhance the performance of data acquisition by **Abel Barral**. **Rachel Warnock** taught us about the fossilized birth-death model for the reliable estimation of speciation and extinction rates. **David Bond** explored the links between killers and ultimate drivers during mass extinctions. **Joachim Haug** challenged the adult-centred paradigm and suggested that the immature is the normal condition for many fossil groups while being an adult is something special. **Carolin Haug** presented evidence that the feeding mechanisms in chelicerates are highly diverse and strongly derived when compared to Euarthropods. The last talk of the session was delivered by **Jo Wolfe** who demonstrated the importance of fossils in dating the tree of life.

After the short coffee and poster break, the presentations split into two parallel sessions. The session on Cambrian research began with a review by **Rudy Lerosey-Aubril** of the late Cambrian Weeks Formation. **Robert Sansom** spoke about decay experiments on priapulids, **Cedric Aria**

Coffee break in the Laënnec Building after a busy morning of talks. Photo by Samira Cuny.

introduced a new Burgess Shale bivalved arthropod and its implication for the origin of mandibulates, **Thomas Hearing** spoke about using stable oxygen isotope ($\delta^{18}O$) data from phosphatic microfossils to constrain Cambrian climate, **Ross Anderson** demonstrated an exciting new method using X-ray diffraction to identify specific clay minerals in Burgess Shale fossils, and **Lukáš Laibl** reinvestigated early post-embryonic stages of the Cambrian paradoxidid trilobites.

The second parallel session was focused on palaeobotany. First up was **Victoria McCoy**, investigating variable preservation of fruit flies in resins. **Hendrik Nowak** revealed what spores and pollen can tell us about taphonomic bias at the Permian–Triassic boundary. **Tatsuo Oji** described new ichnological and algal discoveries in a Burgess Shale-type deposit from the late Ediacaran of Mongolia. **Thomas Servais** highlighted the implications of the incomplete fossil record of phytoplankton for our understanding of past marine ecosystems. **Isabel Van Waveren** showed us the effect of climate on equatorial late Palaeozoic floral transitions, and **Bernard Gomez** finished off the session with a description of the earliest aquatic angiosperm, *Montsechia*.

Lunch was at the University Restaurant Rockefeller, and delegates certainly dined in style. No buffet lunch here, but a full three-course meal with wine, in the best tradition of the gastronomic capital of France!

The afternoon again saw two parallel sessions. The first was dominated by Ordovician research. **Greg Edgecombe** stepped in for the original speaker **Nicholas Strausfeld** and kicked off the session with modern arthropod brains and their Cambrian antecedents. **Caroline Buttler** introduced a bryzoan-dominated cave-dwelling fauna and their palaeoecology. **Harriet Drage** talked about freshly-moulted trilobites from the Ordovician Fezouata Lagerstätte of Morocco. **Jorge Esteve** used computer modelling to study enrolment mechanisms in Ordovician trilobites. **Oldřich Fatka** re-examined the Burgess-Shale type fossil *Krejciella* in the Middle Ordovician. **Aaron Hunter**

presented the earliest asterozoan echinoderms from Fezouata Shale. **Björn Kröger** discussed the ecological fitting within sheet-forming skeletal, colonial metazoans from Ordovician. **Enrique Villas** re-examined the biostratigraphic assessment of the uppermost Ordovician in the central Anti-Atlas, Morocco.

The other session was diverse in scope and began with a talk by **Martina Nohejlová** on the morphology of the Cambrian echinoderm *Vyscystis*. **Thomas Clements** discussed the taphonomic model for the Carboniferous Mazon Creek. **Kenneth De Baets** showed us the preferential origin of calcitic cephalopod shell structures during Silurian and Devonian calcite seas. **Michał Jakubowicz** spoke about the ecology of a Devonian fossil reef community. **Leah Nolan** discussed the palaeoecological and palaeoenvironmental significance of brachiopod beds from a Derbyshire Carboniferous carbonate platform. **Jenny Clack** introduced five new tetrapods from the Tournaisian of Scotland and their implications for the early diversification of the tetrapod crown group. **Timothy Smithson** showed us where to find the Carboniferous terrestrial fauna, and **Michael Day** discussed the tetrapod extinction event during the Capitanian and the possible causes.

Delegates at the poster session. Photo by Samira Cuny.

Following tea, coffee, posters and the AGM, delegates were treated to the Annual Address, this year given by **Manolo Gouy**, who introduced many of us to the concept of molecular thermometers, an idea based on molecular markers in modern genomes. Recent findings suggest that the last universal common ancestor (LUCA) was supported by a mesophilic lifestyle, whereas the last common ancestors of the bacterial and archaeal domains were hyperthermophilic.

Delegates were then treated to a complimentary evening visit to the Musée des Confluences, where, somewhat predictably, most gravitated to the history of life section. This was followed by the Annual Dinner, which was held afloat the Restaurant Bellona, a large, double-decker boat. Delegates had ample opportunity to discuss the day's events as the evening meal made its stately

progress through the length of the boat. The following awards were presented: Dr Adrian Rushton received the Lapworth medal for his lifelong achievements in palaeontology; Prof. Paul Barrett received the President's medal for his outstanding contributions to vertebrate palaeontology; the Hodson Award was presented to two recipients, Dr Susannah Maidment and Dr Robert Sansom, and the Mary Anning Award was presented to Dugald Ross. It was then the last tram home for some, an epic walk back for others, or a transfer to the legendary party boat!

The final day of the Meeting started with an early morning poster session followed by two parallel sessions. One session focused on Triassic research, and it was nice to see a sizeable number of vertebrate palaeontologists in attendance. **Sylvie Craquin** spoke about the survival of psychrophilic ostracods during the end-Permian mass extinction. **Richard Butler** demonstrated how mass extinctions significantly increased faunal cosmopolitanism. **Paul Barrett** introduced the enigmatic archosaurs *Mandasuchus* and *Teleocrater* from the Middle Triassic. **David Ware** showed the revised taxonomy and biostratigraphy of the Early Triassic ammonoids from northeastern Greenland. **Andrew Jones** used geometric morphometrics to tease apart and quantify the variation in cranial morphology between phytosaurs and crocodylomorphs.

The other session contained a set of exciting talks on Cambrian fossils. **Joe Keating** discussed the trials and tribulations of total evidence dating with ostracoderms. **Karma Nanglu** introduced a new Burgess Shale polychaete. **Giacinto De Vivo** reconstructed anomalocaridid feeding appendages and their implications for radiodontan ecology. **Peiyun Cong** attracted the audience's attention with the new discovery of gnathobase-like structures in Cambrian Chengjiang radiodontans. **Léa Devaere** presented preliminary stratigraphic data from the Terreneuvian of Iran and Series 2 of Mexico.

After the tea and coffee break, the second session of the morning began with **Emily Mitchell** testing models of community structure in four Ediacaran assemblages. **Frankie Dunn** proposed that *Charnia masoni* is an early member of total-group Metazoa. **Anton Kolesnikov** described the Siberian palaeopascichnids, the oldest known macroorganisms to show an agglutinated skeleton. **Jack Matthews** assessed the depositional setting of the Ediacaran Mistaken Point biota, and **Charlotte Kenchington** concluded the session by describing the palaeobiology of Ediacaran rangeomorphs.

Meanwhile in the parallel session, **Denis Audo** showed that Jurassic polychelidan lobsters had well-developed compound eyes. **Pierre Gueriau** revealed the potential of non-invasive synchrotron X-ray spectroscopy for understanding burial conditions and fossilization. **Christian Klug** asked if the increase of invertebrate defences drove the evolution of jaws in both cephalopods and vertebrates. **Mark Purnell** showed that texture analysis of tooth microwear can discriminate niche partitioning in a guild of modern insectivores. To finish off **Jorge Herrera Flores** described how rhyncocephalians decreased in diversity during the Mesozoic at the expense of squamates, so that today they are only represented by the tuatara of New Zealand.

As with the previous day, delegates ate lunch in style at the University Restaurant Rockefeller.

The afternoon began with the final round of parallel sessions. **Gemma Benevento** revealed that most ecological disparity in mammals after the K–Pg event is found in larger taxa, consistent with ecological release. In a similar vein, **Stephen Brusatte** described the transition from dinosaur-dominated to mammal-dominated communities across the K–Pg of the San Juan Basin.

Morana Mihaljevic identified patterns and drivers of coral diversity in the Central Indo-Pacific, identifying global sea level as a control on available habitat. Moving to the waters of the Caribbean, **Paola Rachello-Dolmen** explored the drivers of ecological and evolutionary turnover since the closing of the Isthmus of Panama. Finally, **Hermione Beckett** described a new fossil, *Bramoides*, from the Eocene London Clay, which she aligned with the enigmatic modern genus *Gasterochisma*.

In the parallel session, **Carlos Martinez Perez** explored the morphological diversity and hydrodynamic performance of extinct jawless vertebrates. **Nidia Álvarez Armada** shared her insights on the origin of colour patterns of insects using trace element chemistry. **Orla Bath Enright** investigated the effects of sediment density flows on soft-bodied polychaete worms. **Christopher Rogers** discussed the use of melanosomes to discriminate between tissues in the vertebrate eye, and finally **Joseph O'Reilly** looked at the influence of taphonomic bias on Bayesian estimation of clade ages using morphological data.

Delegates were reunited for the final session of the Meeting, where **John Cunningham** presented evidence for preservation of cell nuclei in the Ediacaran Weng'an Biota (Doushantuo Formation). **Maria McNamara** explained the importance of the ultrastructure and chemistry of integumentary structures in constraining feather evolution in dinosaurs. **Susannah Maidment** described the ecological separation of two species of *Stegosaurus*. Continuing the dinosaur theme, **Fiona Gill** investigated the diets of the largest land animals ever to exist, the sauropods. **Vincent Beyrand** reappraised the skull anatomy of the small theropod *Compsognathus longipes* using synchrotron imaging and virtual reconstruction. **Graeme Lloyd** finished off the dinosaurs with an investigation into their decline using phylogenetic diversity as a palaeobiodiversity metric.

Following the presentations, delegates were informed about the 2017 Annual Meeting at Imperial College, London, followed by the awarding of the President's Prize to **Joe Keating**, and the Council Poster Prize to **Joseph Moysiuk** for two excellent pieces of work. The session was followed by a wine reception featuring many delicious local products!

The field-trip contingent embarked on a long coach trip to the historic town of Autun, almost 200 km north of what was an eerily fog-shrouded Lyon on the last day of the Meeting. As the sun rose, the fog cleared to reveal the beautiful French countryside. Upon arrival in Autun, we were whisked straight into the Natural History Museum where we were given a great tour in both French and English. The Museum was founded by the Natural History Society of Autun (SHNA) and houses an incredible collection of minerals and fossils from quarries in the local area, including the mineral autunite and the temnospondyl *Onchiodon* (*Actinodon*) *frossardi*. The SHNA actively participated in the early development of the science of palaeontology and under their leadership the Autun basin became a stratotype for the Permian: the Autunian. As well as fossils from the Autunian, the Museum houses a large collection of concretion-hosted fossils from the Late Carboniferous (Stephanian) from Montceau-les-Mines, including thousands of exceptionally preserved specimens, and also houses many Mesozoic fossils including Triassic ichnofauna. There are many type specimens among the collections and the Museum kindly laid out some of them in the basement for us to examine and photograph.

After a fantastic three-course French lunch it was time to get our hiking boots on, although it was difficult to bend down to tie the laces after all the delicious food. Our visit to the Autunian Muse Formation was led by emeritus professor and former president of the SNHA Georges Gand who

gave us a detailed introduction to the area. We visited a small quarry that has been excavated over recent summers and is comprised of oil shales. The oil shales are easy to split along the bedding planes, and although fossil fish were found in these beds as early as 1811 and a temnospondyl in 1873, there were no vertebrate finds during our visit. However, it was very satisfying to split open the shales with our bare hands and we found many plant fronds and a couple of seeds interred inside. Sadly, it wasn't long before our fantastic day out drew to a close and we were back on the coach to Lyon.

Xiaoya Ma
Natural History Museum, London

The PalAss field-trip party visiting a quarry in the Autunian Muse Formation led by Georges Gand. Photo by Gilles Cuny.

There are more photos from the Annual Meeting on the PalAss website at <**www.palass.org/meetings-events/annual-meeting/2016/annual-meeting-2016-lyon-photographs**>

25th International Workshop on Plant Taphonomy
University of Bonn, Germany *25 – 26 November 2016*

For two sunny days in November, a jolly assemblage of students and palaeontologists met in Bonn, Germany for the 25th International Workshop of Plant Taphonomy. The Steinmann Institute of Geology, Mineralogy and Palaeontology at the University of Bonn had the honour of hosting the meeting in the Goldfuß-Museum. Professors Carole Gee and Thomas Litt were the conveners who kept the schedule on track and welcomed guests. The participants came from all corners of Germany, other European nations, and the United States; in total 50 palaeobotanists took part in the meeting. The turnout was large in comparison to that in the past five years. The number of students at the meeting was 24, which was a welcome increase from previous years. The schedule for the two days was packed with tantalizing talks and poster presentations.

On the first day, **Robert Gastaldo** (Colby College, Maine, USA) had the job of breaking the ice and opening the talks. Having flown over just a few days earlier, he battled jet lag and delivered an exciting talk about not only plant taphonomy, but also the importance of combining many disciplines when reconstructing a palaeoenvironment. He was an excellent choice as the keynote speaker and set the tone for a lively and upbeat two days. Following Prof. Gastaldo's talk, the lunch break was abuzz with conversation. The presentations following lunch were met with enthusiastic questions and lively discussion. **Eva-Maria Sadowski** (University of Göttingen, Germany) spoke about her PhD research on insect-trapping plant leaves preserved in amber and left the crowd starry-eyed and full of curiosity. The rest of the day's talks ranged in topic from fossil wood with a possible lightning scar to fossil pollen as a signal for marine sediments. Day one ended with two poster presentations by students, one on the taphonomy of *Acer* leaves and the other on age

Some of the participants at the workshop in Bonn. Photo by Georg Oleschinski, University of Bonn.

determination of the fossilization process in silicified trees using U-Pb dating. Afterwards, many from the meeting went out to see the Christmas market in Bonn's city centre. Glühwein (mulled wine) was enjoyed before dinner at a popular Greek restaurant.

The second day flowed as smoothly as day one. There were five talks from students, followed by a round-table discussion led by **Lutz Kunzmann** (Senckenberg Naturhistorische Sammlungen Dresden, Germany). The theme of the day was fossil cuticle and leaves. The round-table discussion covered a multitude of aspects, from how leaf cuticle is preserved to how it is processed in the lab for study. The meeting concluded with a discussion on next year's host institution. The Department of Geobiology at the University of Göttingen will be welcoming guests for the 26th meeting. The dates of this meeting will be announced in spring 2017.

The atmosphere of the recent plant taphonomy workshops has been very relaxed. Students jump at the chance to give presentations because it is a friendly, relaxed meeting. Even those not completely fluent in English are able to take the first terrifying step in giving a presentation in English and come out unscathed. The professors at the meeting commented on the high quality of the talks given by students; Prof. Gastaldo commented that: "It is promising for the future of our science". Altogether, with 12 different institutions represented at the meeting, there was plenty of networking and sharing of ideas. That being the goal of this international workshop, it can be said that the Bonn meeting – the 25th anniversary of the workshop series – was a great success.

We palaeontologists and especially young taphonomists sincerely thank the Palaeontological Association for the generous Grant-in-Aid (PA-GA201607) given in support of the meeting. The lure of free registration for students definitely contributed to the large turnout. We can look forward to successful meetings in the future and valuable research as a result.

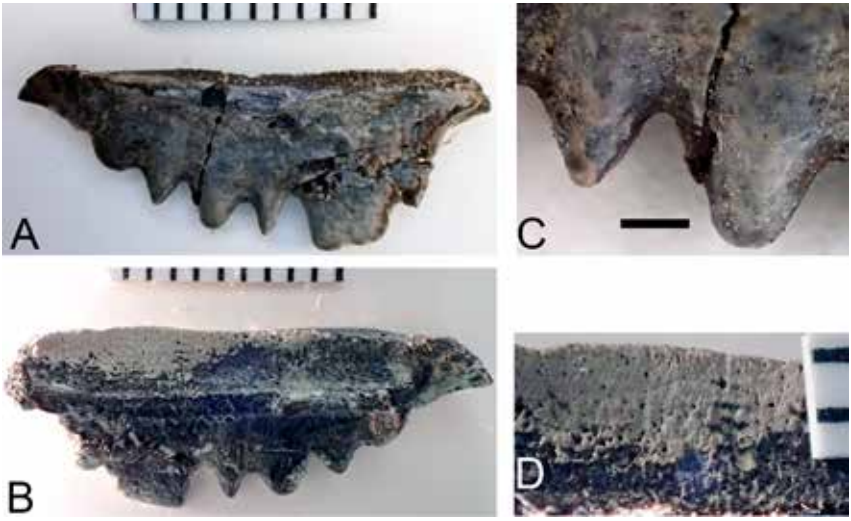
Samantha Moody, Nicole Garten-Dölle,
University of Bonn

MYSTERY FOSSIL 25

Wayne Itano, of the Museum of Natural History of the University of Colorado (Boulder), requests suggestions as to the identity of this fish tooth, found in a marine limestone of the St. Louis Formation (Carboniferous, Visean) of Greencastle, Indiana, USA.

(A) and (B) show opposite views. It is not clear whether the specimen represents the crown or base of a tooth. The irregularity of the sizes of the projections is unusual for cusps; the widest is not truncated but appears to be nearly complete. The pitted surface (C) suggests the presence of tubular dentine, which could be compatible with a chondrichthyan (shark) or dipnoan (lungfish) affinity. The concave region shown in (D) might be an attachment area for a tooth base. The lack of basal ridges is inconsistent with the crown of a petalodont chondrichthyan (Petalodontidae), but could indicate an affinity with the Petalodontiformes. Alternatively the specimen resembles the base of some chondrichthyan teeth, *e.g. Polyrhizodus*. All scale bars have mm divisions.

Please send suggestions to <**newsletter@palass.org**>.



Outreach REPORT

Fossils for Everyone: Palaeontology Outreach in Children's Hospitals

Being in hospital is not fun. Besides feeling poorly, long hours spent in lonely wards can be boring, making an upsetting situation even worse. For both adults and children, hospitals employ types of entertainment therapy like drawing and music to help pass the time, but why not try science too?

A few years ago, I had the idea to tap into this underserved area of outreach for science and palaeontology – children's hospitals. As palaeontologists, we have the gift of knowledge in a scientific topic that is of interest to people of all ages, but especially children. Although most museums around the world are excellent at outreach, sometimes people who could benefit most from the outreach cannot access museum exhibitions, which is how Dinosaur Doctors was born.

I approached the Palaeontological Association a little over a year ago with my idea to do outreach in children's hospitals; despite never having led this sort of venture before, I was intrigued by the research on arts and music therapy in hospitals and learned that it actually does help patients to heal faster. Taking one's mind off a bad situation can go a long way in recovery. I successfully applied for an Engagement Grant (PA-OE201503) and, after being funded, I formed a partnership with the Royal Hospital for Sick Children in Edinburgh and their partner charity, the Sick Kids Friends Foundation. The Friends Foundation was very pleased to add a scientific event to their regular programme and I had no trouble finding support for this unique venture.

After a few months of development I was able to visit the hospital six times in the summer and autumn of 2016. I spent the months getting ready for Dinosaur Doctors by writing and designing an activity book, buying fossil replicas that could be disinfected for use in the hospital, and creating a

Shaena bringing fossils to the kids in the Royal Hospital for Sick Children in Edinburgh. Photo courtesy of the Sick Kids Friends Foundation.

backpack that I could leave with children at the conclusion of the programme. The interesting thing about an outreach programme like this is that while planning needs to happen, the day of the event is more off-the-cuff than some educators are used to.

Some of the fossil casts used in the Dinosaur Doctors outreach programme. Photo courtesy of the Sick Kids Friends Foundation.

The hours I spent in the hospital were some of the most valuable of my career. With a dinosaur-shaped suitcase full of fossil casts and some small real fossils I bought at Mr Wood's Fossils in Edinburgh, I visited different wards at the Sick Kids, usually three per two-hour session. Every ward presented new challenges, but overall, it wasn't too difficult to get children to look at dinosaur fossils and ask great questions. Another benefit of a programme like this is not only entertainment for the patients, but for the accompanying parents and siblings. Showing the children and their parents fossils and telling them about being a palaeontologist not only let me connect with them, but gave family members a new way in which to connect with each other.

In some instances, I would show a small group of two or three children fossil casts and dinosaur models and discuss palaeontology with them if they wished. In other cases, the child was bed-bound, so I brought materials to them. Mobility on the demonstrator's part is needed – a small fossil kit that can fit in one suitcase is crucial, along with an assistant who can help with the logistics in case the group gets larger than expected. As the facilitator, I needed to be aware of the child and their mood/wellbeing because it is important to have the ability to assess what type and duration of interaction was suitable for each child. When it was time to leave, I left each child with a backpack printed with the Dinosaur Doctors logo containing an activity book that I designed, crayons, stickers, and a plaster cast of a Megalodon tooth that can be painted or coloured. Leaving the children with a 'present' at the end of the session is extremely important; not only does it give them something to do later, but it also leaves them with a happy memory of the Dinosaur Doctors experience.

As science educators we can learn much from programmes outside the classroom or museum. It is a valuable activity for those of us who spend most of our time in an academic environment, as it forces us beyond our comfort zone into settings where we use our skills to reach out to a new sector of the population. Even if the objective of a programme like Dinosaur Doctors is not performance in an exam or memorization of facts, but rather just having fun, I feel it brings one back to the principles of palaeontology that attracted us in the first place – the excitement that comes from learning about our world and what once lived in it.

Going forward, I hope to make Dinosaur Doctors a more permanent venture and turn it into a not-for-profit charity that can be based at a museum or other public institution. I hope an idea like Dinosaur Doctors will inspire other palaeontologists to share their knowledge with other underserved populations and try to seek out other audiences that have been previously overlooked to benefit both the public and we palaeontologists.

Shaena Montanari
University of Edinburgh

Sylvester-Bradley REPORTS

Braincase anatomy, phylogeny and the success of Neoceratopsia

Claire Bullar
School of Earth Sciences, University of Bristol

Introduction

The study of braincase anatomy and palaeoneurology in dinosaurs and other extinct animals has recently been transformed by the use of high-resolution CT scanning and 3D reconstruction. Studies of the neurology of extinct organisms can shed light on their sensory systems, the relative significance and function of different brain regions, and even on the animal's way of life (*e.g.* Walsh *et al*. 2009). My research encompasses 3D braincase reconstruction, phylogeny and macroevolution of the horned dinosaurs, the Ceratopsia.

Recent dinosaur palaeoneurological research has been dominated by studies of non-avian theropods (*e.g.* Witmer and Ridgley 2009; Fiorillo *et al*. 2009). Palaeontologists are seeking to understand the evolution of the brains of these predators, and relationships to the origin of birds and flight (*e.g.* Balanoff *et al*. 2013). There has been no large-scale study, however, on the braincases of ornithischian dinosaurs. My focus is on the ceratopsians, one of the most diverse dinosaurian clades during the Upper Cretaceous. Ceratopsians are among the most abundant dinosaurs in deposits of that age, and are a group for which complex behaviour has been posited. The Ceratopsia range from the bipedal *Psittacosaurus* of the Early Cretaceous in Asia, to large quadrupedal Late Cretaceous ceratopsids such as *Triceratops* and *Chasmosaurus*. Recent phylogenetic studies generally focus on either the Ceratopsidae (Sampson 2010; Xu *et al*. 2010) or the more primitive ceratopsians (Xu *et al*. 2002), but a comprehensive phylogenetic analysis of the whole clade has not been attempted.

North America is famous for its large expanses of Mesozoic strata and consequent wealth of dinosaur remains. The specimens are often three-dimensionally preserved with minimal deformation, making them perfect subjects for study. Ceratopsians from the Late Cretaceous of North America are extremely important in an evolutionary context as they represent the most derived members of the clade.

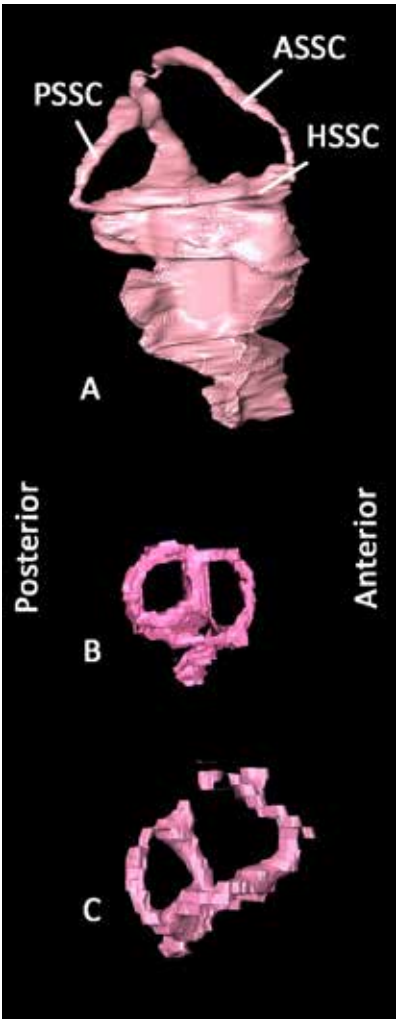
Museum data collection

I spent six weeks collecting data from five institutions in North America. Whilst there, I had access to many ceratopsian skulls spanning most of the Neoceratopsia. At the Royal Ontario Museum I had the chance to examine and photograph many disarticulated *Triceratops* braincases, which will be useful for standardizing the level of intraspecific braincase plasticity. I have secured a future scan of a disarticulated chasmosaur braincase from the Canadian Museum of Nature. The wealth of *Protoceratops* material housed in the American Museum of Natural History permitted the

addition of that taxon to my phylogenetic character matrix. Whilst at the Smithsonian National Museum of Natural History, I was granted access to the medical CT scanner and was able to scan a couple of disarticulated *Triceratops* braincases. I took photos and phylogenetic data from specimens I was unable to scan. I also encountered a number of articulated specimens which permitted phylogenetic coding.

Semi-circular canals and posture

I have now acquired and segmented endocasts of a number of taxa at different stages of ceratopsian evolution. An initial observation was the striking difference between the anterior semi-circular canal of the more basal ceratopsian *Psittacosaurus,* and that of ceratopsids (see Figure). An enlarged, highly arched anterior semi-circular canal is typical of bipeds and the Figure shows how enlarged the *Psittacosaurus* semi-circular canal is compared to the larger quadrupedal ceratopsids.



Semi-circular canals of Psittacosaurus *(A),* Albertaceratops *(B), and* Torosaurus *(C). ASSC, anterior semi-circular canal; HSSC, horizontal semi-circular canal; PSSC, posterior semi-circular canal.*

Future work

The data collected whilst in North America will be analysed over the coming year as I explore the plasticity of the ceratopsian braincase through evolution of the clade. The semi-circular canals will also be segmented in a number of specimens to identify any differences in anterior semi-circular canal morphology throughout Ceratopsia, with particular implications for known transitions in gait style. Any semi-circular canal plasticity seen throughout the evolution of the clade can then be compared to semi-circular canal plasticity observed throughout ontogeny.

Acknowledgements

I would like to thank the Palaeontological Association for awarding me grant number PA-SB201501, without which the travel and data collection would not have been possible. I also thank Kevin Seymour (ROM), Jordan Mallon (CMN), Margaret Currie (CMN), Carl Mehling (AMNH), Michael Brett-Surman (NMNH), Holly Little (NMNH) and Daniel Brinkman (YPM) for making institutional visits possible and assisting me in the collections. Finally, thank you to my supervisors Mike Benton, Michael Ryan and Qi Zhao for their continued support and guidance.

REFERENCES

BALANOFF, A. M., BEVER, G. S., ROWE, T. B. and NORELL, M. A. 2013. Evolutionary origins of the avian brain. *Nature*, **501**, 93–96.

FIORILLO, A. R., TYKOSKI, R. S., CURRIE, P. J., MCCARTHY, P. J. and FLAIG, P. 2009. Description of two partial Troodon braincases from the Prince Creek Formation (Upper Cretaceous), North Slope Alaska. *Journal of Vertebrate Paleontology*, **29**, 178–187.

SAMPSON, S. D., LOEWEN, M. A., FARKE, A. A., ROBERTS, E. M., FORSTER, C. A., WALSH, S. A., BARRETT, P. M., MILNER, A. C., MANLEY, G. and WITMER, L. M. 2009. Inner ear anatomy is a proxy for deducing auditory capability and behaviour in reptiles and birds. *Proceedings of the Royal Society of London B: Biological Sciences*, **276**, 1355–1360.

WITMER, L. M. and RIDGELY, R. C. 2009. New insights into the brain, braincase, and ear region of tyrannosaurs (Dinosauria, Theropoda), with implications for sensory organization and behaviour. *The Anatomical Record*, **292**, 1266–1296.

XU, X., MAKOVICKY, P. J., WANG, X. L., NORELL, M. A. and YOU, H. L. 2002. A ceratopsian dinosaur from China and the early evolution of Ceratopsia. *Nature*, **416**, 314–317.

XU, X., WANG, K., ZHAO, X. and LI, D. 2010. First ceratopsid dinosaur from China and its biogeographical implications. *Chinese Science Bulletin*, **55**, 1631–1635.

Biostratigraphy of the Jurassic continental succession Majunga

Miky Lova Raveloson

Department of Palaeontology and Biological Anthropology, University of Antananarivo

Introduction

The Sylvester-Bradley award which I received in 2013 allowed me to carry out fieldwork in December 2015 in the south-western part of the Majunga Basin, located in the Boeny Region of north-western Madagascar, accompanied by other members of my department. Our aims were to investigate the sedimentology of the basin and to prospect for potential vertebrate fossil sites (including dinosaurs). Fieldwork was carried out at three main localities: Madioroa, Bemokotro and Andranomamy. Plant remains and fragments of vertebrae and femora, representing various dinosaur groups, were collected at all three localities. We identified primitive eusauropods, derived eusauropods and titanosauriforms, which have all been previously reported from the Middle Jurassic (Bathonian) of Majunga. The Bathonian strata of the basin are dominated by continental beds with thin marine bands and thus are considered to represent a lagoonal depositional system. Sediment samples were collected for further investigation of the microvertebrate fauna and the microfauna. The aim of my project was to identify some of the dinosaur bones recovered in the field and place the basin in a broader context.

Materials

The specimens described here are an incomplete left femur and a broken neural spine, thought to be from a dorsal vertebra (Figures 1 and 2). The specimens have not yet been assigned reference numbers, but are deposited in the David Krause collection room at the Department of Palaeontology and Biological Anthropology in the University of Antananarivo.

Figure 1. Left femur in caudal view, with the missing mid-shaft section M.

Figure 2. Posterior view of the neural spine.

Observations and conclusion

Despite some fracturing, the specimens reveal diagnostic features in the distal, proximal and shaft portions of the femur. The neural spine has some diagnostic characters shared with a genus found in the UK. The specimens have not been assigned to any sauropod taxon, but they appear to share some autapomorphies with British taxa. As detailed by Mannion (2010), at least three contemporaneous sauropod taxa occur in the Middle Jurassic of north-western Madagascar, a putative titanosauriform (*Lapparentosaurus madagascariensis*), a basal eusauropod (*Archaeodontosaurus descouensi*), and a derived non-neosauropod eusauropod (*Bothriospondylus madagascariensis*). The specimens studied here may belong to one of the three taxa mentioned above; analysis of contemporaneous taxa in the UK may help resolve this uncertainty. However, more diagnostic material is required for any assignment to family level.

As previously indicated, the presence of cetiosaurid or brachiosaurid dinosaurs is highly likely in the localities where the fossils occur in the Middle Jurassic of the Majunga basin. By considering the characters of *Lapparentosaurus madagascariensis* and the invalid taxon *Bothriospondylus madagascariensis*, we can deduce some significant anatomical features of the femur and also the neural spine. In addition, autapomorphies are identified that are shared with two taxa, *Cetiosaurus* and *Bothriospondylus madagascariensis*: the neural spine from the anterior dorsal vertebrae is pyramid-shaped, and the distal caudal centrum has a tongue-like projection at the dorsal midline at the articular end. Although long bones are not usually diagnostic to genus/family level in sauropods (P. Upchurch, pers. comm.), my observations suggest that we should assign the Madagascan Bathonian finds to the family Cetiosauridae. The femur of *Lapparentosaurus madagascareinsis*

has a short and thick shaft, as well as a broad expansion of the proximal and distal ends, and shares similarities with the following Early–Middle Jurassic species: *Volkheimeria chubutensis* from Patagonia, *Barapasaurus tagorei* from India and *Cetiosaurus oxoniensis* from the UK, suggesting that the Madagascan form may belong to the Cetiosauridae family and could be classified at a similar taxonomic rank. *Lapparentosaurus madagascariensis* could therefore be considered a basal form of the Cetiosauridae, and may have shared ecologically similar conditions to the sauropod dinosaurs encountered in the Middle Jurassic of the Isle of Skye in Scotland. More diagnostic material is required before Cetiosauridae can confidently be reported from the Bathonian of the Majunga Basin.

REFERENCE

MANNION, P. D. 2010. A revision of the sauropod dinosaur genus '*Bothriospondylus*' with a redescription of the type material of the Middle Jurassic form '*B. madagascariensis*'. *Palaeontology*, **53**, 277–296.

Callomon REPORT

Early Pleistocene palaeontology of Westbury Cave, Somerset

Neil F. Adams
Department of Geography, Royal Holloway University of London

Introduction

The Pleistocene sediments in Westbury Quarry on the Mendip Hills in Somerset were discovered by limestone blasting in 1969 (Heal 1970), and it was soon realized that these sediments had infilled an enormous subterranean cave system that became known as Westbury Cave. Excavations at the site between 1972 and 1984 focused on a series of fossiliferous limestone breccias, collectively known as the Calcareous Member (Bishop 1982; Andrews *et al*. 1999). These breccias contained a rich early Middle Pleistocene faunal assemblage and, at the time, yielded some of the earliest purported evidence for hominin occupation in Britain, in the form of disputed flint artefacts (Bishop 1975; Wymer 1988; Andrews *et al*. 1999). The underlying silts, sands and gravels (known as the Siliceous Member) were tentatively dated to the Early Pleistocene based on a very limited fossil assemblage (Andrews *et al*. 1999) and received much less research attention. To address the lack of systematic study and sampling of the Siliceous Member, new excavations began in 2014 (Adams 2015). These excavations have yielded new fossils belonging to at least ten mammalian families, including both small and large mammals (Adams 2015; Adams *et al*. in prep). This new assemblage has been important in refining the biostratigraphical age of the Siliceous Member and in formulating a detailed palaeoenvironmental reconstruction for a poorly-known period within the British Quaternary stratigraphic succession. The 2014 excavations were, however, limited in extent and much of the Siliceous Member remains unexplored. There was therefore great potential to discover more Early Pleistocene fossils from new excavations at the site and to refine further the taphonomic origins of the assemblage.

The Early Pleistocene sediments at Westbury Cave are especially important due to the past discovery of two molars belonging to the extinct water vole *Allophaiomys* (Bishop 1982). The Siliceous Member records the only occurrence of the genus *Allophaiomys* in the British fossil record, while in continental Europe it is a widespread taxon and is present at many Early Pleistocene sites. The majority of British Early Pleistocene fossil sites are located in the East Anglian Crag Basin, but the lack of *Allophaiomys* fossils and the presence of large unconformities in this region led Gibbard *et al*. (1991) to suggest that as much as one million years may be missing from the Crag Basin sequence (*c*.1.7–0.7 Ma). At this time in the European record, *Allophaiomys* becomes a critical taxon for small mammal biostratigraphy. The record of this genus from Westbury Cave thus implies that the Siliceous Member is the only site to date from this hitherto 'missing' period in the British Early Pleistocene. It is therefore a nationally important site for continued research.

The aims and objectives of this new project were:

- To extend the Siliceous Member stratigraphy and depositional history
    - by creating new sections in unexplored areas of the Siliceous Member,
    - by creating detailed sediment section drawings, logs and photographs and taking samples for particle size and clast lithological analysis;
- To identify the full extent of the Early Pleistocene Siliceous Member fauna
    - by laterally extending the fossiliferous deposits identified by Adams (2015),
    - by bulk-sampling sediments to recover stratified vertebrate fossils;
- To determine the age of the Siliceous Member through multi-proxy means
    - by taking samples for independent coupled spin resonance and uranium-series (ESR/U-series) dating,
    - by including new fossils in a refined biostratigraphical analysis.

Methods

The Callomon Award grant funding was used to support three weeks of new excavations through the Early Pleistocene sediments in Westbury Cave during April 2016. The excavations focused on an area immediately to the west of the main 2014 section. This allowed the fossiliferous deposits identified by Adams (2015) to be laterally extended and bulk-sampled. Soil and vegetation were cleared and careful excavation began when *in situ* sediments were reached. A surveyed datum point at the top of the section was used to pinpoint the depths from which samples were taken. Bulk sediment samples were taken from gravel units for clast lithology and to recover vertebrate fossils. These units were systematically sampled in layers 10–30 cm thick. In total, 524 kg of bulk sediment samples were recovered from twelve layers (or spits) through the sediments. After excavation, the bulk samples were wet-sieved through a 500 µm mesh and dried. Residues were graded through nested sieves (8, 4, 2, 1, 0.5 mm) and sorted under a low-power binocular microscope to extract bones and teeth. The sediments were also excavated to produce a vertical section face that could be linked with the main section studied by Adams (2015). Detailed section drawings were made to contribute to the understanding of sediment deposition in Westbury Cave. Each depositional unit identified was also sampled for particle size analysis. As part of this project, we returned to the site in May 2016 to take sediment samples and *in situ* dosimetry measurements for ESR/U-series dating with colleagues from the Muséum national d'Histoire naturelle, Paris: these analyses are ongoing.

Preliminary results

While considerable post-excavation work remains to be done on the half-tonne of bulk sediment samples taken during fieldwork, the new sections created through the Siliceous Member sediments have already increased our knowledge of sediment deposition in Westbury Cave and have considerably augmented the Early Pleistocene faunal assemblage.

Sedimentology

As shown in Figure 1, the sediments exposed in the new sections include units of differing grain size and with numerous truncations and unconformities. In the western-most part of the new excavations, features that appear to resemble flame or loading structures were identified, indicative of soft-sediment deformation. Fine-grained silts appear to bulge upwards into the overlying gravel

Figure 1. The new section of cave sediments revealed during excavations at Westbury Cave in April 2016. The fossiliferous gravels can be seen in the lower right of the section and several large, rounded boulders are evident in the centre and left of the section. Ranging pole is 1 m.

Figure 2. A gravel unit exposed during the excavation that has undergone significant deformation. The contact with the underlying fine-grained silt rises from the left to the right of the photograph and then appears to plunge almost vertically downwards on the right side. This folding is likely to relate to soft sediment deformation caused by a reversed density gradient after the gravel was deposited on top of the finer-grained silt. Ranging pole is 1 m.

unit, which is warped and folded near-vertically (Figure 2). Silts are common sediments in caves, are typically deposited after flood events, and are frequently found capping clastic channel sediments (Farrant and Smart 2011). The silts in Figure 2 were probably deposited in low-energy conditions after one such flood event in the Westbury Cave system. The overlying gravel unit likely represents the deposits of a subsequent high-energy flood event, which cut down into the silts in a manner described by van Loon (2009), the first time deformation features on this scale have been observed in these deposits.

Although the area to the west of the main 2014 section was the focus of the new excavations in 2016, a small area to the east was excavated to explore whether Siliceous Member sediments could be located in other parts of Westbury Cave. Unfortunately, after digging a narrow trench of over one vertical metre into the deposits, it became apparent that the gradual collapse of the Calcareous Member over many years has covered the deposits of the Siliceous Member with a considerable thickness of slumped, younger sediment. Much more time, and excavation of a huge volume of sediment, would be required to expose and study any underlying Early Pleistocene sediments in this area.

Palaeontology

The majority of fossils recovered in the field were from the westward lateral extension of the fossiliferous gravels identified by Adams (2015), but several specimens were recovered from other units (notably the western-most gravel shown in Figure 2). Around twenty identifiable fossils were recovered in the field, the majority of which were mammalian teeth. Numerous indeterminate bone fragments were also recovered and measured during the excavation. Detailed taxonomic work on these fossils is ongoing, but they are likely to represent at least seven families of medium- and large-sized mammals, four of which are new records for the Siliceous Member (Adams *et al*. in prep). The new assemblage also includes genera previously unknown from the Early Pleistocene in Britain, supporting the hypothesis that the Siliceous Member in Westbury Cave may record an unknown interval in British Early Pleistocene stratigraphy.

In addition to the larger field finds, the bulk sediment samples hold great palaeontological promise for smaller mammal fossils. Preliminary sorting of the graded residues from bulk sediment samples collected during the excavations in April 2016 has revealed an important small mammal assemblage (*e.g.* Figure 3). The fossils found in this isolated sample show not only diverse taxa and morphologies, but a taphonomic diversity, with relatively complete, near pristine specimens occurring alongside those that are much more fragmentary. When fully revealed, the new small mammal assemblage from the 2016 samples will provide essential information for the interpretation of the taphonomy of the broader faunal assemblage and will contribute to the best biostratigraphical age estimation of the Siliceous Member to date.

Conclusions

The new field excavations through the Siliceous Member in Westbury Cave have improved our understanding of sediment deposition in the cave system during the Early Pleistocene and have added to an already nationally-important mammalian fossil assemblage. Although detailed taxonomic work on the fossils is still in progress, finds made during the new excavations have added at least four new families of medium/large mammals to the Early Pleistocene faunal assemblage in Westbury Cave and have justified the need for continued research at the site. Further additions

Figure 3. Examples of the small mammal fossils, including vole molars, rodent incisors, an insectivore tooth, and several postcranial bones and bone fragments, recovered from the 1-2 mm residues of one bulk sediment sample taken during the April 2016 excavations. Scale bar is 5 mm.

to the site's faunal list will also undoubtedly be made during the sorting of bulk sediment samples for small mammal fossils. The combined study of the sedimentology, palaeontology, taphonomy, biostratigraphy and geochronology of the Siliceous Member has helped Westbury Cave become one of the most important Early Pleistocene sites in Britain, and continued excavation and research at the site will almost certainly reveal new geological and palaeontological data to reinforce this position.

Acknowledgements

I gratefully thank the Palaeontological Association for funding this new season of productive fieldwork at Westbury Cave through Callomon Award small grant PA-CA201501. I also thank Natural England and Alford Technologies Ltd. for permission and access to land to conduct fieldwork in Westbury Quarry. Pierre Schreve, Ian Candy and Danielle Schreve kindly provided assistance in the field.

REFERENCES

ADAMS, N. F. 2015. *A palaeoenvironmental analysis of the Early Pleistocene Siliceous Member at Westbury Cave, Somerset, UK.* Unpublished BSc thesis. Royal Holloway University of London, UK.

ANDREWS, P., COOK, J., CURRANT, A. and STRINGER, C. (eds). 1999. *Westbury Cave: the Natural History Museum Excavations 1976–1984*. Western Academic & Specialist Press, Bristol. 309 pp.

BISHOP, M. J. 1975. Earliest record of man's presence in Britain. *Nature*, **253**, 95–97.

BISHOP, M. J. 1982. The mammal fauna of the early Middle Pleistocene cavern infill site of Westbury-sub-Mendip, Somerset. *Special Papers in Palaeontology*, **28**, 1–108.

FARRANT, A. R. and SMART, P. L. 2011. Role of sediment in speleogenesis; sedimentation and paragenesis. *Geomorphology*, **134**, 79–93.

GIBBARD, P. L., WEST, R. G., ZAGWIJN, W. H., BALSON, P. S., BURGER, A. W., FUNNELL, B. M. *et al*. 1991. Early and early Middle Pleistocene correlations in the southern North Sea basin. *Quaternary Science Reviews*, **10**, 23–52.

HEAL, G. J. 1970. A new Pleistocene mammal site, Mendip Hills, Somerset. *Proceedings of the University of Bristol Spelaeological Society*, **12**, 135–136.

VAN LOON, A. J. 2009. Soft-sediment deformation structures in siliciclastic sediments: an overview. *Geologos*, **15**, 3–55.

WYMER, J. 1988. Palaeolithic archaeology and the British Quaternary sequence. *Quaternary Science Reviews*, **7**, 79–98.

Undergraduate Bursary REPORTS

Depth-related dispersal patterns in 'complex' conodonts

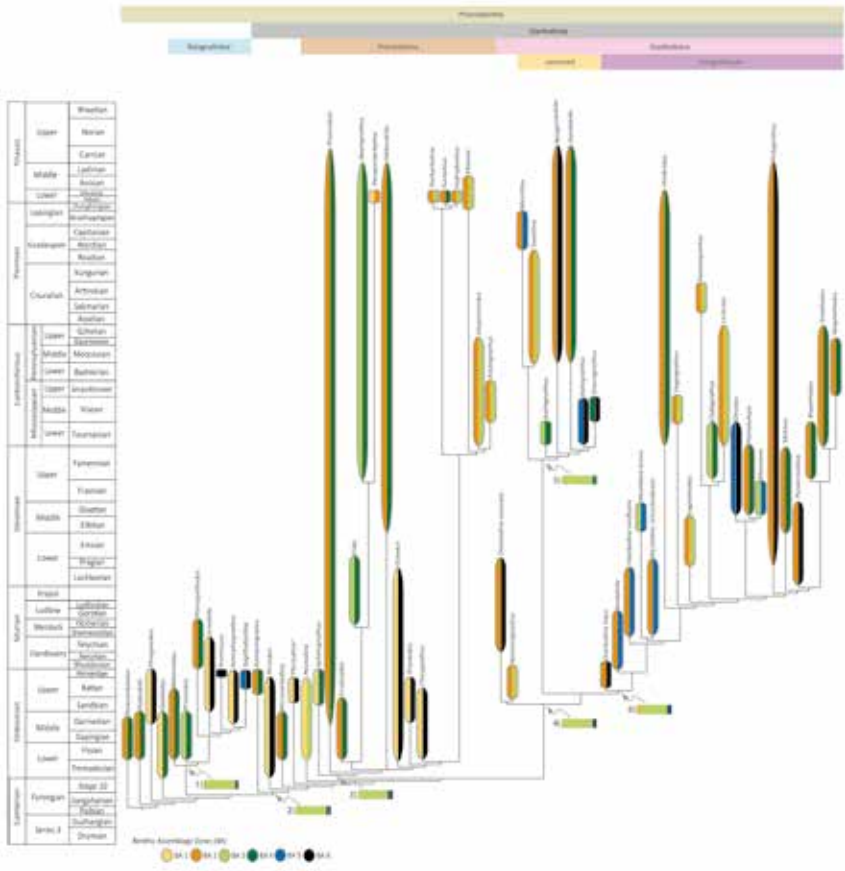
Charlotte Bird
School of Geography, Earth and Environmental Sciences, University of Birmingham

Introduction

Marine invertebrate groups exhibit a preference for originating in nearshore environments and subsequently dispersing offshore, a theory particularly applicable to the Phanerozoic, where it has been suggested that shallow marine settings are cradles of evolution whilst deeper marine settings act as refugia (Jablonski *et al*. 1983). Although research is being undertaken into the applicability of this model to marine vertebrate groups, conodonts have yet to be considered despite having a comprehensive fossil record. The aim of this research was to utilize the abundance of conodont data and the phylogenetic framework of Donoghue *et al*. (2008) through which the onshore-offshore theory could be tested.

Methodology

The Paleobiology Database was utilized as the basis for an extensive literature search to document the global occurrences of complex conodonts and assign a stratigraphic and Benthic Assemblage (BA) zone to as many entries as information was available for, which was aided by further literature mining (in excess of 3,200 occurrences being recorded). BA zones have been previously deployed in analyses of early vertebrate occurrences by Boucot and Janis (1983) in addition to documenting the distribution of invertebrate palaeocommunities (Boucot and Lawson 1999). A phylogenetic tree (see Figure) was constructed in Mesquite based on the topology of Donoghue *et al*. (2008) and time-scaled based on the estimated age of the fauna of the first occurrence for each terminal taxon. We then reconstructed ancestral benthic assemblage zones using the Bayesian function AncThresh (Revell 2013), modelling discrete but ordered states as an expression of values for an underlying continuous trait ('liability', representing the amount of change) that crosses thresholds between states at certain values. To implement this analysis, terminal taxa were assigned prior probabilities for occurrence within each discrete BA zone, based on the distribution of habitat occurrences within the earliest geological stage. We then ran AncThresh for one million generations (200,000 burn-in) under each of three built-in models of trait change: Brownian Motion (BM, random walk), Ornstein-Uhlenbeck (OU, central tendency), and Pagel's lambda (a measure of phylogenetic consistency), which returned both distributions of ancestral zones for each node and estimated threshold values required to exit BA zones. The Deviance Information Criterion (DIC) indicated that an OU model best fit the data, so we re-ran AncThresh under that model for another 10 million generations (two million removed as burn-in).



Complex conodont phylogenetic framework with node analyses for the environment of origin for the major groups Balognathidae (1), Ozarkodinida (2), Prioniodinina (3), Ozarkodinina (4), 'unnamed' (5) and the Polygnathacea (6).

Results

For the species analysed, the AncThresh OU results show that over 80% of occurrences at each tested node fall into BA3 (see Figure), hence suggesting a preference for complex conodonts to originate in subtidal environments. The 'alpha' parameter, indicative of the speed of return towards the ancestral state, was rather weak (peak around 0.3, mean 0.5) but still distinguishable from a random walk. Mean threshold values were tightly clustered across all zones (BA1=1.26; BA2=3.23; BA3=8.14; BA4=8.47; BA5=9.35), indicating that dispersal to deeper (and, to a lesser extent, shallower) environments was possible with relatively little delay, but that leaving BA3 required more time and cost (Sallan pers. comm. 2016). Given that most ancestral nodes fall within BA3, and the tendency to return, this suggests that BA3 may have served as a cradle or magnet for conodont diversity with taxa exhibiting a preference for remaining there.

Conclusions

This work has highlighted some limitations in the Paleobiology Database, particularly with anomalously long ranges recorded for taxa such as *Hibbardella, Prioniodina, Apatognathus* and *Polygnathus* (Golding pers. comm. 2016), in part reflecting artefacts of form taxonomy prevalent in older literature, and thus these entries will need further refinement as part of ongoing work. We also suspect that there is a lithological / palaeoenvironmental sampling bias, as conodont elements tend to be collected from fine grained limestones. Notwithstanding these limitations, this study shows that the major conodont groups typically originate in nearshore subtidal environments but are readily able to disperse into and between offshore environments, apparently with equal opportunity for dispersal between these higher taxonomic groupings. This study also emphasizes the need to revise entries in the Paleobiology Database, and suggests that species-level studies have the potential to enable a more detailed approach to determining evolutionary trends. Future studies will investigate whether dispersal patterns are species-specific or occur in all complex conodont groups.

Acknowledgements

I wish to thank the Palaeontological Association for their support with this study (Undergraduate Research Bursary PA-UB201603), in addition to extending much gratitude to Ivan Sansom (University of Birmingham), Lauren Sallan (University of Pennsylvania) and Martyn Golding (Geological Survey of Canada) for their invaluable contributions to the project.

REFERENCES

BOUCOT, A. J. and JANIS, C. 1983. Environment of the Early Paleozoic vertebrates. *Palaeogeography, Palaeoclimatology and Palaeoecology*, **41**, 251–287.

BOUCOT, A. J. and LAWSON, J. D. (eds.) 1999. *Paleocommunities – a case study from the Silurian and Lower Devonian*. Cambridge University Press, Cambridge. 895pp.

DONOGHUE, P. C. J., PURNELL, M. A., ALDRIDGE, R. J. and ZHANG, S. 2008. The interrelationships of 'complex' conodonts (Vertebrata). *Journal of Systematic Palaeontology*, **6**, 119–153.

JABLONSKI, D., SEPKOSKI, J. J., BOTTJER, D. J. and SHEEHAN, P. M. 1983. Onshore-offshore patterns in the evolution of Phanerozoic shelf communities. *Science*, **222**, 1123–1125.

REVELL, L. J. 2013. Two new graphical methods for mapping trait evolution on phylogenies. *Methods in Ecology and Evolution*, **4**, 754–759.

SALLAN, L. C., FRIEDMAN, M., SANSOM, R. S. and SANSOM, I. J. (in prep) The nearshore realm as the cradle of early vertebrate ecomorphological diversification.

A Silurian bivalve with soft tissues

Hoi Lam Karen Fu
Department of Earth Science & Engineering, Imperial College, London

Introduction

Bivalves are common fossils, but the study of fossil bivalves has always focused on shells. The only specimens preserving soft tissues are all Mesozoic in age and represent only one bivalve subclass (Autobranchia). This project presented me with an exciting opportunity to look at something novel: a much older specimen and probably a more primitive subclass, Protobranchia.

Methods and material

My specimen was from the Herefordshire Lagerstätte (Wenlock, mid Silurian). Fossils from this deposit are preserved in three dimensions with evidence of soft-tissues. Specimens are serially ground and photographed to produce a series of slice images that can be reconstructed as a 'virtual fossil'. My starting materials comprised two sets of slice images, derived from the part and counterpart of the specimen. The first part of the project was to use my supervisor's SPIERS software to edit these slices and pick out the fossil, eliminate noise, interpret ambiguous boundaries, and identify different structures in the material. The results are shown in Figure 1.

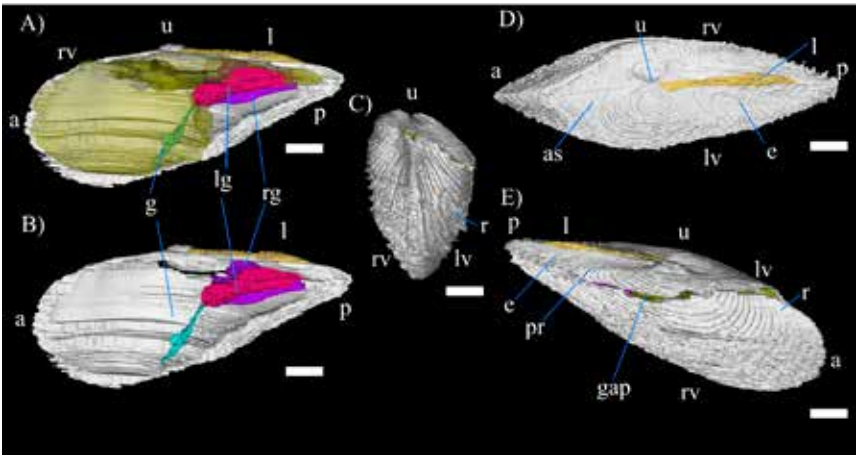


Figure 1. Virtual reconstruction of the three-dimensional anatomy of the specimen. A. lateral view of interior from right with right valve turned off and body mass transparent, showing position of gut and gills; B. same view as A with body mass turn off showing right gill; C. anterior view; D. lateral view of right valve; E. oblique view from left showing 'escutcheon' and posterior ridges. All scale bars represent 2 mm. Abbreviations: a- anterior; p- posterior; d- dorsal; v- ventral; rv- right valve; lv- left valve; u- umbo; e- escutcheon; l- external ligament; as- anterior slope; pr- posterior ridges; r- commarginal ribs; gap- gap due to imperfect combination of the part and counterpart; g- gut; rg- right gill; lg- left gill.

Results

The reconstructed specimen belongs to the species *Praectenodonta ludensis* Reed, 1931. It is a ctenodontid, placed phylogenetically at or near the origin of the crown group of Protobranchia. This phylogenetic position renders the soft tissues of the specimen especially interesting as they could potentially provide information about the ancestral state of the entire subclass. The preserved soft tissues include the body wall and details of the gut (Figure 2A), but the most

significant anatomical structures are the well-preserved gills. These lack gill filaments and show only one demibranch each. This structure differs markedly from the sheet-like gills of autobranchs (Figure 2B, d and e) and, surprisingly, of modern protobranchs (Fig. 2B, a-c).

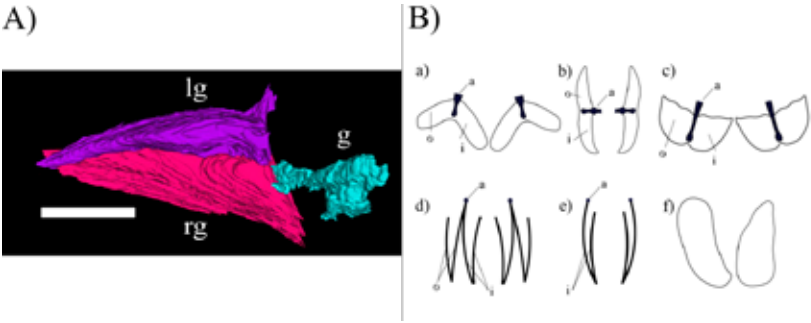


Figure 2. A. Reconstructed gills and gut of the specimen. For scale and abbreviation refer to Figure 1. B. Diagrammatic sections transversely to the axes of the gills of a) Nucula (Nuculida); b) Solenomya (Solemoyida); c) Lembulus pella (Nuculanida); d) the majority of the Lamellibranchia; e) Lucina (Lucinidae) or Montacuta; f) Praectenodonta ludensis. Varying magnification. a, axis; o, outer demibranch; i, inner demibranch.

There are a number of important evolutionary implications. Do these unusual gill structures represent the primitive state for the protobranchs? This may be quite likely as ctenodontids are probably very basal taxa and would suggest that the two-branched gills of protobranchs and autobranchs are not homologous as previously assumed. Secondly, it is possible that the gill structure is an autapomorphy; some living Autobranchia have single demibranch gills, having lost the outer branch through paedomorphosis. The only protobranch for which data are available, however, also develops demibranchs at the same time, excluding heterochrony as a control. Finally, is there a link between a single demibranch gill and chemosynthetic microbial symbiosis? Studies of extant bivalves have shown that species with single demibranchs all belong to families with evidence of a symbiotic relationship, Lucinidae and Thyasiridae (Fig. 2B, e). Problematically, however, only one of the four Thyasiridae species that have symbionts also possesses a single demibranch, and there is only weak support in that taxon for a symbiotic relationship.

Conclusion

This study reports novel respiratory structures in a Silurian bivalve placed phylogenetically very close to the origin of Protobranchia. As a result, the specimen has the potential to rewrite our understanding of the evolution of bivalve gills. I began my project with only a stack of 2D images; after eight weeks of work I can envision making a significant contribution to science, and I have learned an enormous amount about how research and palaeontology works. Above all, I have enjoyed myself – I'm looking forward to getting our paper published, and to doing more research in the future!

Acknowledgements

I would like to thank Dr Mark Sutton for offering this research project to me and providing excellent support. Also many thanks to the Palaeontological Association for funding me with Undergraduate Research Bursary PA-UB201607; without it I would not have been able to afford to live in central London over the summer, or to be near to important resources like the library of the Natural History Museum London.

Coccolithophore cell size and growth rates across the Greenhouse–Icehouse transition

Dominika Nala
School of Geography, Earth and Environmental Sciences, University of Birmingham

Introduction

Coccolithopores are unicellular calcifying algae that are major carbonate producers in the oceans (Gibbs *et al*. 2013). Their spherical shells are made up of calcareous platelets termed coccoliths. As they are highly sensitive to climatic changes, abundant, and widespread, coccoliths can be used as a proxy for palaeoenvironmental conditions (Herrman and Thierstein 2012), especially the structure of the surface ocean and the availability of dissolved inorganic carbon. Changes in these indices can be inferred in the geological record using the size and geometry of the algae. In particular, it has been suggested that there are strong links between available dissolved inorganic carbon in the surface oceans (related to atmospheric carbon dioxide concentrations) and coccolith size (Henderiks *et al*. 2006). Here we seek to test this coupling of atmospheric CO_2 and coccolith size across the Eocene–Oligocene greenhouse to icehouse transition, one of the major global cooling events of the Cenozoic (~40–34 Ma) (Zachos *et al*. 2001)

Methodology

Data were collected from 31 simple smear slides from a core collected from the island of Java, Southeast Asia; the core is dated as middle Eocene to early Oligocene. Cross-polarized light microscope analysis (x1250) provided morphometric data (length, width) as well as coccolith central area type (closed, grill, open) for 350 coccoliths (310 for slide 71–79) of at least 2 µm in length within two dominant genera of the Cenozoic, *Coccolithus* and *Reticulofenestra* (Herrman and Thierstein 2012). Due to the low number of coccospheres present in the slides, the analysis focused on the morphological diversity of the coccoliths, rather than coccospheres. A set of coccosphere images was collected using SEM and is available for further development and analysis.

Size change

In most samples the dominant coccolith size is 2.5–5 µm. One of the highest mean values (5.97 µm) is shown in Figure 1. This difference indicates a shift from warmer environments of ~950 ppm pCO_2 immediately prior to the Antarctic glaciation to ~650 ppm at ~34 Ma (Zhang *et al*. 2013), after which the mean length was generally higher than in the late Eocene. Despite the positive trend in the coccolith size change, reflecting the long-term cooling trend through the middle to late Eocene (Fletcher *et al.*, 2008; Zhang *et al.*, 2013), the increase is not continuous and is marked by some apparently secular variability, especially in maximum coccolith size.

It is true for Java that during the Eocene–Oligocene high-growth-rate coccolithopore populations were favoured during rapid switches to higher productivity conditions (Gibbs *et al*. 2013). The highest mean size of 6.19 µm (slide 39-61) may reflect pCO_2 values of up to ~400 ppm. Subsequent higher pCO_2 values in the late Oligocene caused a decrease in coccolith size. The size changes shown in Figure 1 may reflect minor global extinction events (Rohde and Muller 2005) or more local events (Alves *et al*. 2016). At higher latitudes than that of Java the size and size variability of coccoliths were greater (Herrman and Thierstein 2012).

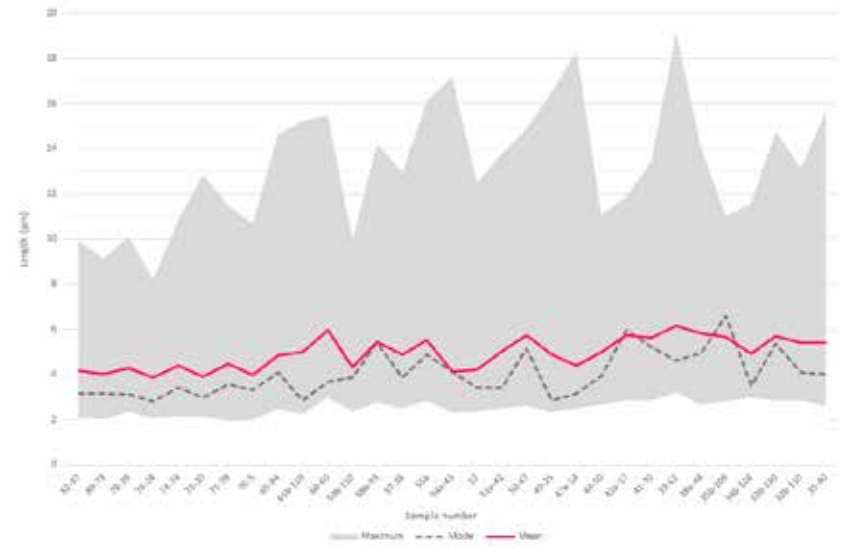


Figure 1. Coccolith size change through the Eocene–Oligocene based on coccolith length. Increase of the maximum length values precedes a sudden rise in the mean length in slide 60-60. This reflects low-latitude CO_2 decline that started 2 million years before Antarctic glaciation, at ~34 Ma (Gibbs et al. *2013; Pagani* et al. *2011). Concurrent maximum size increase and mean size decrease in 54a-43 and 47a-54 suggests the appearance of few very large coccoliths at a time of dominance of very small size.*

Type change

The dominant morphotype throughout the core has an open centre (45–95 % of the coccoliths). Open-centre coccoliths are the smallest and have the highest length to width ratio of 1.18 (mean for all slides), although after 49-25 they become more circular. The biggest sizes are reached by the grill- and closed-centre coccoliths (Figure 2), the latter growing in size from 47a-54 onwards. Both of these types vary greatly in circularity. All coccoliths have similar minimum and maximum length:width ratios and, on average, are broadly elliptical. The ratio is the lowest for grill-centre coccoliths.

Summary

Morphometric analysis of coccoliths retrieved from a core from Java revealed that size fluctuations are related to some environmental changes during the mid-Eocene and Oligocene, especially CO_2 concentrations. Events such as Antarctic glaciation and the rapid Oligocene rise of pCO_2 are reflected, though other fluctuations may have been caused by environmental changes occurring locally rather than globally. The percentages of coccoliths of different morphotypes and their response to environmental changes vary. Despite that, coccolith size change trends through time follow a negative trend in CO_2 availability.

Acknowledgements

I thank the Palaeontological Association for Undergraduate Research Bursary PA-UB201609 that enabled this project, Dr Tom Dunkley Jones for his supervision and guidance, and Amy Jones who was always ready to help me during and after the project.

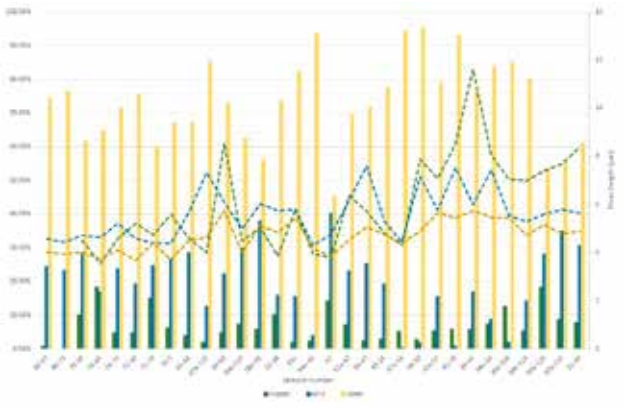


Figure 2. Abundance of different coccolith morphotypes and changes in their mean length. Size increase of the closed-centre coccoliths affects the general mean size value of slide 60-60. Their low abundance and sudden size change suggests the appearance of few very large closed-centre coccoliths at the time of glaciation, ~34 Ma (Gibbs et al. *2013). This group experienced the most drastic size shifts throughout the Eocene–Oligocene. Slide 52 shows low mean length and a high percentage of closed- and grill-centre coccoliths, which suggests that their size decreased significantly during their proliferation.*

REFERENCES

ALVES, T.D., COOPER, M.K.E. and RIOS-NETTO, A. 2016. Paleogene–Neogene calcareous nannofossil biostratigraphy and paleoecological inferences from northern Campos Basin, Brazil (well Campos-01). *Journal of South American Earth Sciences*, **71**, 143–160.

FLETCHER, B.J., BRENTNALL, S.J., ANDERSON, C.W., BERNER, R.A. and BEERLING, D.J. 2008. Atmospheric carbon dioxide linked with Mesozoic and early Cenozoic climate change. *Nature Geoscience*, **1**, 43–48.

GIBBS, S.J., POULTON, A.J., BOWN, P.R., DANIELS, C.J., HOPKINS, J., YOUNG, J.R., JONES, H.L, THIEMANN, G.J., O'DEA, S.A. and NEWSAM, C. 2013. Species-specific growth response of coccolithophores to Palaeocene–Eocene environmental change. *Nature Geoscience*, **6**, 218–222.

HENDERIKS, J., RICKABY, R. and ELDERFIELD, H. 2006. Algal constraints on the Cenozoic history of atmospheric CO2. *Geochimica et Cosmochimica Acta*, **70**, A244–A244.

HENDERIKS, J. 2008. Coccolithophore size rules – Reconstructing ancient cell geometry and cellular calcite quota from fossil coccoliths. *Marine Micropaleontology*, **67**, 143–154.

HERRMAN, S. and THIERSTEIN, H.R. 2012. Cenozoic coccolith size changes – Evolutionary and/or ecological controls? *Palaeoecology*, **333–334**, 92–106.

PAGANI, M., HUBER, M., LIU, Z., BOHATY, S.M., HENDERIKS, J., SIJP, W., KRISHNAN, S. and DECONTO, R.M. 2011. The role of carbon dioxide during the onset of Antarctic glaciation. *Science*, **334**, 1261–1264.

ROHDE, R.A. and MULLER, R.A. 2005. Cycles in fossil diversity. *Nature*, **434**, 208–210.

ZACHOS, J.C., SHACKLETON, N.J., RAVENAUGH, J.S., PALIKE, H. and FLOWER, B.P. 2001. Climate response to orbital forcing across the Oligocene–Miocene boundary. *Science*, **292**, 274–278.

ZHANG, Y.G, PAGANI, M., LIU, Z., BOHATY, S.M. and DECONTO, R. 2013. A 40-million-year history of atmospheric CO_2. *Philosophical transactions of the Royal Society A*, **371**, 20130096.

Survival of the smallest? Trends in brachiopod size across the End-Triassic mass extinction

Fiona Pye
School of Earth and Environment, University of Leeds

Introduction

Body size is a key indicator of an animal's ability to survive and reproduce. In the immediate aftermath of mass extinction events, surviving animals tend to reduce in size (at least temporarily), a term referred to as the 'Lilliput Effect' (Twitchett 2007). Several Phanerozoic extinction events are associated with greenhouse conditions where marine survivors inhabit waters that are relatively warm and deoxygenated. This reduction in oxygen, coupled with the strains of higher temperatures on metabolic rates, causes species to mature faster and to attain smaller sizes whilst placing constraints on resources allocated to essential processes such as biomineralization (Garilli *et al.* 2015). The Lilliput Effect is well recognized in the aftermath of the Late Permian mass extinction (*c.* 252 Ma) (Twitchett 2007), but whether it characterizes recovery following the Late Triassic mass extinction (*c.* 201 Ma) is uncertain. The similarities between the causal mechanisms of the two events, *i.e.* volcanic-induced extreme global warming, suggest that marine shelly macrofaunas will display a similar pattern of size reduction in the immediate aftermath of the Late Triassic mass extinction event. This study uses brachiopods from the collections of the Natural History Museum, London to investigate body volume changes, and thus the presence of a Lilliput Effect, in the order Rhynchonellida across the Triassic–Jurassic boundary.

Methods

Late Triassic–Early Jurassic brachiopod genera were sampled from the Natural History Museum collections. The Rhynchonellida was selected for study as the taxonomy of this group is well understood relative to other Mesozoic brachiopods (Ager 1990). Specimens were measured if they possessed undamaged principal axes and if they fulfilled criteria for appropriate chrono- and/or biostratigraphic resolution. Late Triassic specimens were recorded as either Keuperian (Carnian–Norian) or Rhaetian, and Early Jurassic specimens were recorded to ammonite zones. Specimens were measured with digital callipers along the anteroposterior (A), transverse (T), and dorsoventral (D) axes (Figure 1).

Taxonomic revisions were undertaken using the Paleobiology Database and the *Treatise on Invertebrate Palaeontology* Part H. The revised database includes 409 specimens. Specimen volume was then calculated using the equation from Novack-Gottshall (2008):

$$\text{Volume} = 0.554(\text{ATD})^{0.896}$$

where A = anteroposterior, T = transverse, D = dorsoventral (see Figure 1).

Mean and standard deviations of specimen volume were calculated for each genus per time bin and the significance of changes in mean body size through time were calculated using two-tailed Wilcoxon tests.

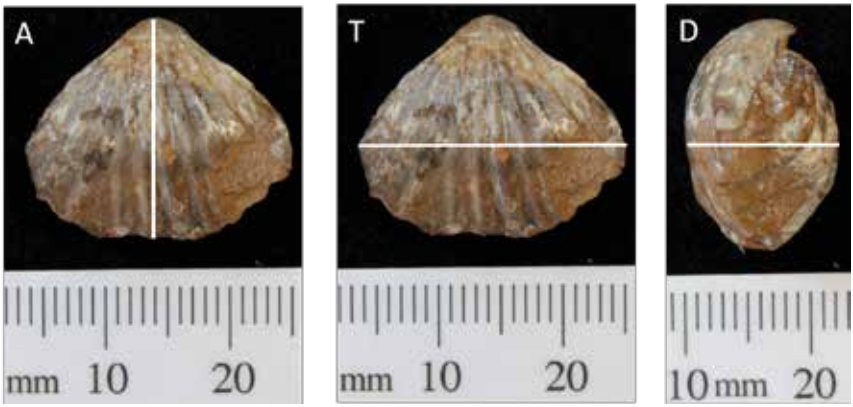


Figure 1. NHM 32415 b with principal axes indicated by white lines. A = anteroposterior; T = transverse; D = dorsoventral.

Results

Mean body size across the entire order of Rhychonellida drops significantly from the Rhaetian to the Hettangian ($W = 1613$, $p < 0.001$) (Figure 2A, over the page). This trend is repeated in two genera that cross the Triassic–Jurassic boundary: *Rhynchonella* ($W = 92$, $p < 0.001$) and *Calcirhynchia* ($W = 128$, $p < 0.001$) (Figure 2BC). In general, genera that are present only in the Triassic (*e.g. Fissirhynchia*) are larger than those genera that are exclusively Jurassic (*e.g. Cuneirhynchia*) (Figure 2D). There are no brachiopod specimens from the *Planorbis* or *Liasicus* ammonite zones, *i.e.* the first two zones of the Hettangian which represent the post-extinction communities; the first Jurassic brachiopods thus post-date the Triassic–Jurassic extinction by roughly one million years. No specimens were found for the *Turneri* zone in the early Sinemurian.

Discussion

The results show that mean Early Jurassic body size was smaller than mean Late Triassic body size in Rhynchonellid brachiopods. This suggests that there may have been a Lilliput Effect associated with the Late Triassic mass extinction event. However, there are a number of limitations that need to be taken into account: (i) certain genera had too low a sample size to calculate statistically meaningful results, an issue related primarily to taxonomic reclassification of groups that is not reflected in the collection; (ii) the genus *Rhynchonella* is widely recognized as a wastebasket taxon and may actually represent order level trends; (iii) the absence of specimens in the collections from the two lowest Jurassic ammonite zones (*Planorbis* and *Liasicus*) makes it difficult to link the discrepancy in body size recorded between Late Triassic and Early Jurassic brachiopods to the Late Triassic extinction event; (iv) no biozones are recorded for Late Triassic specimens and sampling resolution is low (at the level of Stages), potentially masking more subtle temporal trends; (v) fossil localities are geographically and temporally dispersed, and derive from different lithologies; as a result, facies differences cannot be ruled out as drivers of the body size trends. It is therefore possible that any observed Lilliput Effect in the brachiopod communities from Lower Jurassic sediments of the UK is more closely related to the frequent anoxic/dysoxic pulses that occur throughout the Early Jurassic of Western Tethys (Allison *et al.* 2008) rather than the Late Triassic mass extinction.

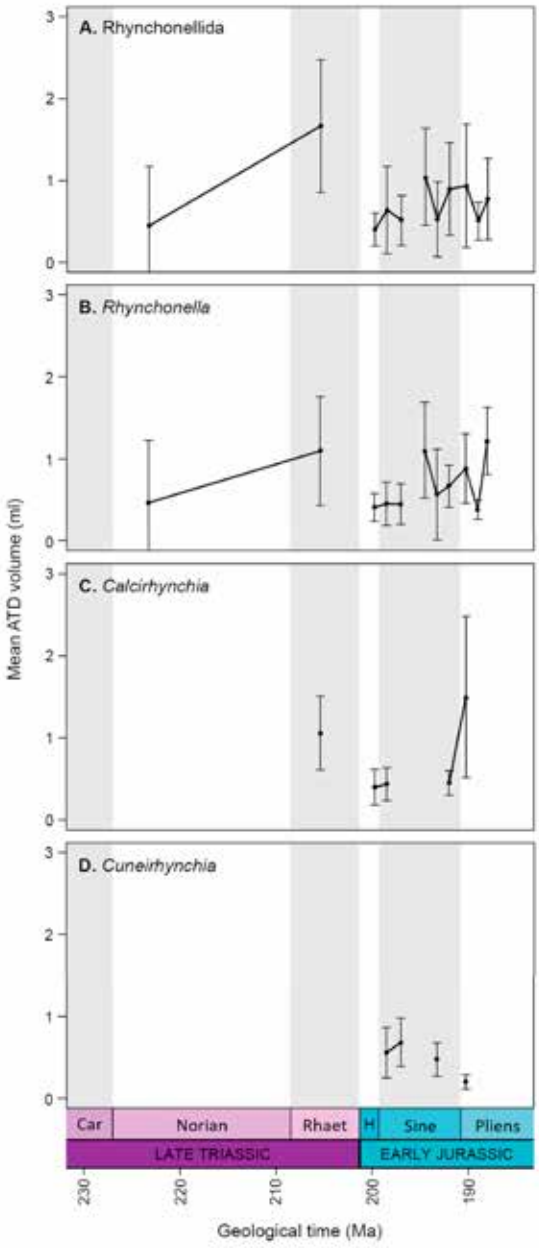


Figure 2. Mean body size (volume) of brachiopods through the Late Triassic–Early Jurassic: (A) order Rhynchonellida; (B) Rhynchonella*; (C)* Calcirhynchia*; (D)* Cuneirhynchia.

Conclusions

Rhynchonellid brachiopods display a statistically significant drop in body volume across the Triassic–Jurassic boundary. This trend is evident at the generic level in *Rhynchonella* and *Calcirhynchia*. This is suggestive of a Lilliput Effect associated with the Late Triassic mass extinction, but further investigation is required in order to rule out confounding influences associated with biogeographic and lithological / palaeoenvironmental factors.

Acknowledgements

Thanks to the Palaeontological Association, who funded this research through an Undergraduate Research Bursary (PA-UB201605). Thanks also to Alex Dunhill who supervised this work, Jed Atkinson for methodological advice and Autumn Pugh for assistance with R.

REFERENCES

AGER, D. V. 1990. *British Liassic Terebratulida (Brachiopoda): Part 1*. Monograph of the Palaeontographical Society v. 143, no. 582. Palaeontographical Society, London.

ALLISON, P. A., HESSELBO, S. P. and BRETT, C. E. 2008. Methane seeps on an Early Jurassic dysoxic seafloor. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **270**, 230–238.

GARILLI, V., RODOLFO-METALPA, R., SCUDERI, D., BRUSCA, L., PARRINELLO, D., RASTRICK, S. P. S. *et al*. 2015. Physiological advantages of dwarfing in surviving extinctions in high-CO2 oceans. *Nature Climate Change*, **5**, 678–682.

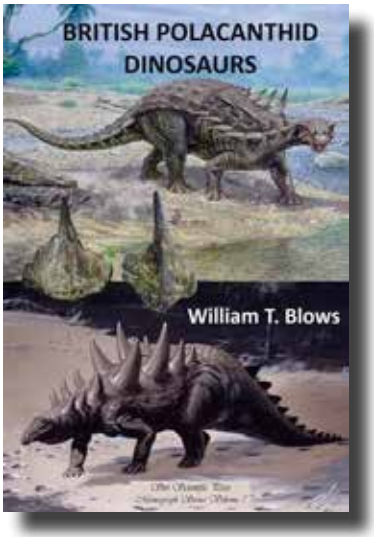
NOVACK-GOTTSHALL, P. M. 2008. Using simple body-size metrics to estimate fossil body volume: empirical validation using diverse Paleozoic invertebrates. *PALAIOS*, **23**, 163–173.

TWITCHETT, R. J. 2007. The Lilliput effect in the aftermath of the end-Permian extinction event. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **252**, 132–144.

Book Reviews

British Polacanthid Dinosaurs

William T. Blows 2015. 224pp. Siri Scientific Press. Hardcover Price £54.99p, ISBN 978-0-9929979-4-6.



Whereas polacanthid dinosaurs are uncommon in the British Lower Cretaceous, they are certainly inspiring beasts. They belong to the Thyreophora, the armoured dinosaurs, along with the stegosaurs and ankylosaurs. Some doubt remains as to the relationship between polacanthids and the other members of the group, though their affinities are clearly with the ankylosaurs. Blows' monograph describes and discusses the dinosaurs *Hylaeosaurus*, *Polacanthus foxii* and *Polacanthus rudgwickensis*; the latter it is proposed belongs in a new genus, *Horshamosaurus*, in this work. The animals are compared with related forms from around the globe, including *Gastonia* and *Mymoorapelta* from the United States and *Dongyangopelta* from China.

The monograph begins with a useful summary and definition of the Polacanthidae, and the geological setting of the essentially Wealden material covered by the work. This is followed by a fascinating chapter on the history of the discovery of the main specimens, beginning with Mantell's original *Hylaeosaurus* material dating from 1832, the type specimen found by the Revd William Fox on the Isle of Wight in 1865, and discoveries made since the 1970s when British dinosaurs were being rediscovered by enthusiasts including the author of this monograph. This account includes notes on missing material, a sad loss, but not without tantalising glimpses of some material surviving the break-up of essentially private collections. There are interesting anecdotes from collectors recording their experiences of finding remains, including the author's diary of the 1979-1980 excavation in Compton Bay on the Isle of Wight.

The bulk of the monograph, chapters 3 to 7, are a description of the skeleton as preserved in individual specimens in museum collections. Contentiously this includes material not in formal accredited museum collections. These chapters are richly illustrated with photographs, mostly in colour, of the bones and teeth, and are the primary reason to get hold of the book: it's an invaluable identification guide. The figures are clear and set against a white background, often with multiple views of individual bones. Throughout these chapters *Hylaeosaurus* and *Polancanthus foxii* are treated together; while this is useful for comparative purposes, it could lead to confusion. Illustrations and captions need to be used well together to avoid mistakes when eye-balling for identifications. Also included is a brief section on natural foot casts which may be assigned to

ankylosaurs. Chapter seven is an account of the dermal bones, the armour, and contains a useful table of the different elements which make up the armour.

It could be argued that if you already have a copy of Martill and Naish (2001) and Lomax and Tamura (2014), you are pretty well covered as both publications (the former a thorough scholarly treatment) provide a wealth of illustrations including the polacanthids. It is my opinion, however, that this monograph adds substantially to the recent literature on British dinosaurs as it fills in the gaps left by the two admirable publications listed above. It ticks the boxes for the dinosaur enthusiast, with a smattering of history and anecdotes and plenty of bones. That said, there is no list of synonyms, which is an essential element of the scientific process, and undoubtedly this would have been present if the treatment was that of a Palaeontographical Society monograph. I believe this monograph to be the life's work of the author; it reveals a man's passion for an enigmatic dinosaur group and the result is an essential part of the library of anyone who shares the love of dinosaurs.

Martin Munt
Dinosaur Isle Museum, Sandown, Isle of Wight

REFERENCES

LOMAX, D. R. and TAMURA, N. 2014. *Dinosaurs of the British Isles*. Siri Scientific Press, Manchester, 416pp.

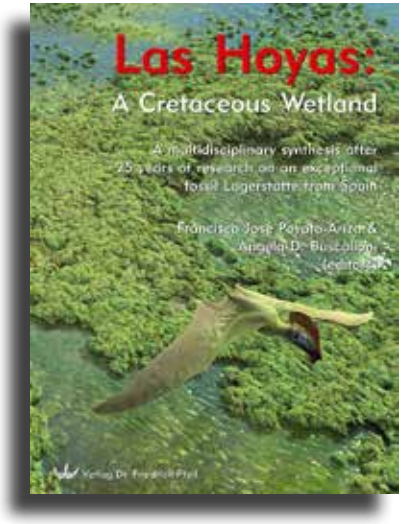
MARTILL, D. M. and NAISH, D. (eds) 2001. *Dinosaurs of the Isle of Wight*. Palaeontological Association Field guides to fossils: No 10. The Palaeontological Association, London. 433pp.

Las Hoyas: A Cretaceous Wetland – A multidisciplinary synthesis after 25 years of research on an exceptional fossil Lagerstätte from Spain

F. José Poyato-Ariza and Á. D. Buscalioni (editors) 2016. [in English] 262 pp. (32.6 x 24.5 cm), 41 coloured and 1 black-and-white plates, 64 coloured and 101 black-and-white figures (altogether 838 photos, drawings and graphics), 13 tables. Verlag Dr. Friedrich Pfeil, Munich. Price €75.
ISBN: 978-3-89937-153-6 (hardback).

The fossil deposits of Las Hoyas from the province of Cuenca, Spain represent a Cretaceous tropical wetland palaeoenvironment. The first fossils were excavated by students in 1985. Following this, three decades of grant-funded research projects have resulted in this locality being recognized as one of the most important Mesozoic Fossil Konservat-Lagerstätten in the world. However, it is relatively poorly known by many academics and fossil enthusiasts alike, because until now the only relevant literature consisted of *c*. 250 academic research papers published in scientific journals, some book chapters and some 13 doctoral theses. The book reviewed here has changed that and has done so in magnificent style!

This is a multi-authored work, with each comprehensive and fully referenced chapter written by leading experts in their respective fields. Fifty-two authors, mainly Spanish but also with contributors from North America, South America, Europe and China, have contributed to 33 chapters as follows: INTRODUCTION – Relevance of Las Hoyas as a Mesozoic Lagerstätte; Environmental reconstruction: a historical review; FOSSIL RECORD: Las Hoyas in the Tree of



Life; Palynomorphs; Plants and their landscapes; Mollusca; Arachnida; Diplopoda; Insecta; Ostracoda; Spelaeogriphacea; Decapoda; Chondrichthyes; Osteichthyan fishes; Albanerpetontidae; Urodela; Salientia; Chelonia; Squamata; Crocodylomorpha; Pterosauria; Dinosauria (Ornithischia); Dinosauria (non-avian Saurischia); Aves; Feathers; Ichnoassemblage (trace fossils); TAPHONOMY – Biostratinomic factors involved in fish preservation; Anuran biostratinomy; Molecular preservation; Microbial mats and preservation; Exceptional preservation; PALAEOECOLOGY – From Taphonomy to Palaeoecology; The wetland of Las Hoyas. There follow a couple of Addenda covering new taxa, including the first mammal to be described from this deposit, a complete systematics list of all taxa identified, and various notes added in proof for each chapter in order to make the volume as up to date as possible.

The book begins with a description of the stratigraphy, palaeogeography and sedimentology of the Las Hoyas system, followed by discussion of the taxonomy and systematics of the abundant and diverse fossil assemblage (with treatment of relevant phylogenetic and palaeoecological implications for the individual groups). Highlights include discussion of actuotaphonomic experiments on fish and frogs to shed light on the fossilization processes, the impact of microbial mats on the preservation process, and even the molecular fidelity of soft tissues of dinosaurs and insects. These have all been woven together to generate a new picture of the palaeoecosystem of Las Hoyas as a regional scale tropical wetland, with two different fossil assemblages corresponding to wetter and drier periods. In contrast to many Lagerstätten, the fossil associations of Las Hoyas are not related to catastrophic events, but merely with alternating hydrological periods that reflect the changing conditions in the palaeoenvironment.

The production standards of this volume are some of the best I have ever seen! The larger than A4 page format uses high quality, silk-coated paper, giving a smooth finish and showing off the many large colour photographs to their best. The non-photographic illustrations are also of exceptionally high quality. In fact, there is very little to fault in this book, beyond the handful of typos I spotted, but these will go unnoticed by many. The publisher and authors should be commended on their production of such a magnificent volume and it would serve well as a template for any future works dedicated specifically to a single fossil locality.

This book will appeal to a broad audience, from academics to those with a more general interest in Mesozoic (especially Cretaceous) ecosystems, Fossil-Lagerstätten or the palaeontology of Europe, especially Spain. Moreover, the range of high-quality photographs and the comprehensive coverage of each taxonomic group (considered in a global context) means that there will be pretty much something of interest for most palaeontologists in this volume. Given the very high production standards and large page size, this volume is very good value at the cover price and it deserves a place in all comprehensive palaeontological libraries for its academic content alone, but I can

envision that the magnificent images it contains will lead to it being regularly taken down from the bookshelves of many personal libraries also.

David Penney
University of Manchester

The Worst of Times – how life survived eighty million years of extinctions

Wignall, P. B. 2015. Princeton University Press, 224 pp.

Mass extinctions in the history of life have always been a topic of great interest to both the public and science. The 'big five' mass extinctions have already been the topic of several popular and scientific books over the years. One thing that immediately struck me while reading this book was how much detail Wignall puts into listing all factors relevant to the extinction events he has devoted his career to studying. Aspects of extinction events that apparently do not fit well within the accepted picture are given fair coverage and he does not shy away from mentioning uncertainties. Working in a museum and with an office located directly beside the famous K/Pg boundary at the UNESCO World Heritage Site at Stevns Klint, I have seen my fair share of biased literature on the topic of the K/Pg boundary, some of which has almost fundamentalistic pro-impact or pro-eruption overtones. As such, reading a well-balanced book dealing with this controversial topic was really a delight.

In this book, Wignall details the cause and effects of small and large extinction events in the roughly 80 million years that Pangea existed, from its formation during the late Permian to the time it finally drifted apart during the Middle Jurassic. During this period of Earth history the Earth experienced no less than six extinction events, including the largest of them all at the end of the Permian and the less severe end Triassic extinction. While the end Permian and end Triassic extinctions are well known among naturalists, the four other extinction events are less commonly known, but no less important as we learn from reading this book.

While the Earth has suffered severe periods of mass extinctions both before and after the time covered in this book there is, however, a common factor linking the extinctions that occurred during the existence of Pangaea – Large Igneous Provinces, commonly referred to as LIPs. The flood basalts from these massive episodes of volcanic eruption can be found around the world today covering vast areas including the Siberian Traps from the end of the Permian, the Central Atlantic Magmatic Province (CAMP) basalts from the end Triassic, as well as traces of flood basalts from the minor extinction phases. While much of the previous literature on mass extinctions has focused on either the marine or the terrestrial realm, Wignall considers both, and explains the different

mechanisms behind the extinctions in both environments and how they could affect each other. At the same time, he is not afraid to admit when some aspect of an extinction event does not fit currently accepted models or when it is hard to explain by the available data. We also learn that not all flood basalts mean an extinction is imminent. Following the breakup of Pangaea there are several flood basalt occurrences that cannot be linked to an extinction event, except for the K/Pg boundary basalts. For a LIP to be really dangerous for life on Earth it has to appear in connection with the unique geographical conditions of a supercontinent, with minimal extent of coastlines and shelf areas. Despite the obvious pun, Wignall deters from naming the book in the vein of something like "The deadly LIPs of Pangaea!", but he does however mention that this combination has been the focus of several amusing titles for publications and presentation titles through time.

The technical level is a bit inconsistent throughout the text. While the majority of the text is a fluid and engaging read, which would catch on well with all who have an interest in natural history and the evolution of life, some parts suddenly require a detailed knowledge of the local fauna to be fully understood. For example, throughout most of the text, there are descriptions of the taxonomy and biology of the animals discussed, which is useful to the non-expert reader. In other parts of the book, however, the reader is offered only a list of Latin names for the non-expert to ponder about.

But this minor quibble aside; this is a very readable, interesting book, which gives a very detailed overview of the complexities of the factors behind many of the Earth's mass extinctions and especially the interplay between Large Igneous Provinces and the presence of a supercontinent. Luckily we still have about another 250 million years before the Earth's continents once again come together to form a single unified landmass.

Jesper Milàn
Geomuseum Faxe, Østervej 2, DK-4640 Faxe, Denmark

Books available to review

The following books are available to review. Please contact the Book Review Editor, Tom Challands (e-mail <**bookreview@palass.org**>), if you are interested in reviewing any of these.

- *The White River Badlands: Geology and Palaeontology*, by Rachel C. Benton, Dennis O. Terry Jr., Emmett Evanoff and H. Gregory McDonald.
- *Acrocanthosaurus inside and out*, by Kenneth Carpenter.
- *Birds of Stone: Chinese avian fossils from the age of dinosaurs*, by Luis M. Chiappe and Meng Qingjin.
- *Dinosaur Tracks: The next steps*, by Peter L. Falkingham, Daniel Marty and Annette Richter.
- *The sauropod dinosaurs*, by Mark Hallet and Matthew J. Weddel.
- *Phylogenomic data acquisition: Principles and approaches*, by W. Bryan Jennings.
- *Dinosaurs: The textbook*. 6th edition, by Spencer G. Lucas.
- *The Princeton Field guide to dinosaurs*, by Gregory S. Paul.
- *Amber Palaeobiology: Research trends and perspectives for the 21st century*, by David Penney.
- *The Princeton Field Guide to Prehistoric animals*, by Donald R. Prothero.
- *Integrated Molecular Evolution*, by Scott. O. Rogers.
- *Earth History and Palaeogeography*, by Trond H. Torsvik, L. Robin and M. Cocks.

Dr Tom Challands
PalAss Book Review Editor,
School of GeoSciences,
The University of Edinburgh,
Grant Institute,
The King's Buildings,
James Hutton Road,
Edinburgh
EH9 3FE
UK

Careering off course!

Inspirational palaeontologists

Byron Blessed, Company Director of *Natural Wonders Ltd*.

After completing a BSc in Geology at the University of Cardiff and an MSc in Palaeobiology at the University of Bristol, Byron set up <**Fossils-UK.com**>, Britain's first online fossil shop, in 1998. In 1999 he opened *Natural Wonders Ltd.*, a fossil and mineral shop in Yorkshire. Byron collects and prepares many of the fossils that are sold in his shop and runs guided fossil hunting trips around the Yorkshire Coast.

1) How did you first become interested in geology and palaeontology?
On a childhood holiday to Lyme Regis, my family bought me a Lower Jurassic *Hildoceras* ammonite after a visit to the Dinosaurland Fossil Museum. This triggered an interest in going to look for my own fossils whenever I could, and this active hobby led me to study Earth Sciences at school and university.

2) Which aspect of your job do you enjoy the most?
In my job I am constantly gaining new experiences and furthering my knowledge on the fossils I work with. I also really enjoy how varied my work can be, often doing something different every day!

3) Have any of your finds ever ended up in a museum?
My collection of crustaceans from the Yorkshire Lias was donated to the Natural History Museum, London and will feature in the upcoming Palaeontological Association guide to the Yorkshire Lias. Work is currently undergoing to establish whether one of the lobsters is a new taxon! I think the hope of finding something that could add to our understanding of past life on Earth is the reason any amateur or professional partakes in fossil collecting.

4) Preparing fossils well takes a lot of skill. How did you learn to be a preparator?
This is something I taught myself to do, with a little advice from other professional

preparators. Finding the right tools and practising a lot really helped. The tool that no one can give you, however, is a lot of patience. Some of the fossils I have worked on have taken thousands of hours to prepare. I wish palaeontologists would talk more about these processes, especially when talking to the general public. This skilled work is sometimes overlooked. Some of the best preparators I know are true artists in their field.

5) What are some of the most interesting fossil finds you have been involved with?
Amateur collectors of all ages and experience regularly bring items into the shop for identification, and I'm happy to do this at no cost. I have therefore been privileged to recognise several important finds. One such exciting fossil was originally brought to my attention when Nick Hannigan showed me some fossil bones he had found on a beach in South Wales. I immediately recognized them as theropod dinosaur bones and he contacted Cindy Howells at the National Museum Wales and Dave Martill at the University of Portsmouth. This turned out to be *Dracoraptor*, the new Welsh dinosaur!

Of course, more often children come in with their fossil finds. Although these finds aren't usually scientifically important, children are always fascinated when I describe what they have found and its age. I like to think that perhaps some of these children may grow up to be future geologists and palaeontologists. It's this aspect of my work that I find the most rewarding. I think more needs to be done to encourage grass roots science, and to recognize the contribution of amateur palaeontologists who dedicate their lives to collecting and preserving fossils.

6) How do your degrees help you with your work on a day-to-day basis?
The knowledge and experience I gained from my degrees was invaluable as it gave me an understanding of where fossils came from, the processes that formed them, and the correct way to collect them so that all relevant data are also recorded. As part of my course I also learnt HTML, which was very useful when I came to design my own website. However, all of the knowledge in the world cannot make up for practical experience in the field or the skills you gain from actually running a business.

7) What advice would you give to someone wishing to pursue a career like yours?
Be passionate, and ensure you have a good knowledge of the fossils you sell. Aside from this, you must learn to manage money effectively, know your competitors and find your niche, adapt quickly to new trends, and foresee new opportunities, especially in technology. Most importantly, be prepared to work hard! I work 7 days a week, 365 days a year, meaning I end up working for a lot less than minimum wage. Any venture into this market would need to be fuelled by passion. I do my job because of job satisfaction, the love of fossils, and because I enjoy being able to promote the science to the next generation of scientists.

World of Wonders, 20 Grape Lane, Whitby YO22 4BA

01947 821363

<**http://www.fossils-uk.com/**>

@fossils_uk

<**https://en-gb.facebook.com/NaturalWondersltd/**>

Gemma Benevento
University of Oxford

Palaeontology

VOLUME 60 • PART 1

CONTENTS

Palaeontology

VOLUME 60 • PART 2

CONTENTS

Papers in Palaeontology

VOLUME 3 | PART 1

CONTENTS

Virtual Palaeontology Issue 6
Annual Symposium – Palaeobiotic interactions

This virtual issue of *Palaeontology* arises from presentations given at the Thematic Symposium of the 59th Annual Meeting of the Palaeontological Association, which considered palaeobiotic interactions in the fossil record.

TAYLOR, P. D. 2016. Competition between encrusters on marine hard substrates and its fossil record. *Palaeontology*, **59** (**4**), 481–497.
<http://dx.doi.org/10.1111/pala.12239>

HARPER, E. M. 2016. Uncovering the holes and cracks: from anecdote to testable hypotheses in predation studies. *Palaeontology*, **59** (**5**), 597–609.
<http://dx.doi.org/10.1111/pala.12255>

WRIGHT, V. P. and CHERNS, L. 2016. How far did feedback between biodiversity and early diagenesis affect the nature of early Palaeozoic sea floors? *Palaeontology*, **59** (**6**), 753–765.
<http://dx.doi.org/10.1111/pala.12258>

Virtual Palaeontology Issue 7
A pageant of Palaeozoic tetrapods

Although Palaeozoic tetrapod papers have not featured all that conspicuously in the journal *Palaeontology* over the decades, some key announcements and descriptions of significant taxa have appeared. The set I have chosen neatly encapsulates the thrust of my research effort and includes contributions by some of the foremost and most influential researchers in this area. The earliest of these papers represents the latest direction that my interest has taken. The tetrapods covered in this set range from the Late Devonian to the Late Mississippian. From my own work, I published some of my first papers drawn from my PhD thesis in this journal, and later, it was the venue for my papers on Devonian, Pennsylvanian and even Early Permian taxa. (I always remember Christine Janis asking whether I 'might get decompression sickness' when thinking about tetrapods younger than the Carboniferous.) Recently our TW:eed project (Tetrapod World: early evolution and diversification) has published a couple of papers showing that the earliest Carboniferous was not as disastrous for some vertebrates as had been thought, but that some of them rapidly diversified following the end-Devonian Hangenberg event, with the recovery of lungfish (Smithson *et al*. 2015; Clack *et al*. 2016) adopting many new feeding strategies. I envisage more papers to come from that project with future publications in *Palaeontology*.

Jenny Clack
University Museum of Zoology, Cambridge
2015 Lapworth Medallist

CARROLL, R. L. 1969. A new family of Carboniferous amphibians. *Palaeontology*, **12**, 537–548. <http://tinyurl.com/hnx4lca>

Bob Carroll was one of the most influential palaeontologists to study Palaeozoic tetrapods following Alfred Sherwood Romer, whose student he was. His prolific output included the massive textbook *Vertebrate Paleontology and Evolution*, which showed the range and depth of his knowledge. This paper describes a little creature from Scotland that unfortunately had no associated locality data, but Carroll's investigations suggested a late Visean or early Namurian age. It consists of a skull about 10 mm long and an elongate vertebral column, and it was apparently limbless. It could not be associated with any known taxonomic group, but he suggested it belonged within the Lepospondyli. Difficult to interpret, the skull was shown to lack the characteristic 'notch' at the back of the skull that was usually present in early tetrapods. This specimen has recently become of interest for a number of reasons. The 'lepospondyls' are being split up and are no longer considered a natural group; other apparently limbless 'lepospondyls' with elongate columns from the Visean–Namurian are more primitive than previously thought and may be related to *Acherontiscus*; micro-CT techniques are now available that can reveal previously invisible features. Early results suggest a highly specialized dentition for *Acherontiscus* unlike that of any other early tetrapod. Watch this space.

PANCHEN, A. L. 1973. On *Crassigyrinus scoticus* Watson, a primitive amphibian from the Lower Carboniferous of Scotland. *Palaeontology*, **16**, 179–193. <http://tinyurl.com/hd3eaak>

Alec Panchen was the leader in Carboniferous tetrapod palaeontology in the UK during the 1960s and 1980s, and influenced a stream of PhD students, of whom I was one. By working on Carboniferous tetrapods in the Hancock Museum and Edinburgh, he reawoke interest in the subject among British workers, and many of his students became key figures in UK palaeontology. This paper redescribed the holotype specimen of *Crassigyrinus*, first described by D. M. S. Watson, and confirmed the lower jaw of '*Macromerion*' as belonging to *Crassigyrinus*. This early work paved the way for the identification and description of the almost complete, articulated specimen from the Dora Bone Bed at Cowdenbeath. This Stan Wood discovery was described in detail by Alec (Panchen 1985) (it was nearly named *Cowdenbeathia* until its true identity was recognized). This enigmatic species, with its formidable tooth array, elongate vertebral column and minute forelimb, continues to produce surprises and consistently appears near the base of the tetrapod family tree.

LOMBARD, R. E and BOLT, J. R. 1995. A new primitive tetrapod, *Whatcheeria deltae*, from the Lower Carboniferous of Iowa. *Palaeontology*, **38**, 471–494. <http://tinyurl.com/hlclc4w>

Eric Lombard and John Bolt in Chicago were two of the most influential workers on early tetrapods in the USA. Eric came from a background in the neurophysiology of hearing, but 'saw the light' and turned to palaeontology. John Bolt and Eric Lombard have subsequently been partners in a wide range of studies on early tetrapods. This paper marks more or less the beginning of a new generation of discoveries of tetrapods from the Mississippian. The locality of Delta has produced other tetrapod taxa as well, but *Whatcheeria deltae* is the most spectacular. It is known from several semi-articulated individuals and many isolated bones. This paper was the first describing the taxon. Although relatively brief, the paper showed it to have remarkable features of the skull and postcranium. Later work on the whatcheeriid *Pederpes finneyae* (Clack 2002; Clack & Finney 2005) showed that this was probably a family that ranged widely in time and space during the late Palaeozoic. A paper on the lower jaw of *Whatcheeria* was published more recently (Lombard & Bolt 2006), but we are still waiting for details of the palate, skull roof and postcranium.

AHLBERG, P. E., LUKŠEVIČS, E. and MARK-KURIK, E. 2000. A near-tetrapod from the Baltic Middle Devonian. *Palaeontology*, **43**, 533–548. <https://doi.org/10.1111/j.0031-0239.2000.00138.x>

Per E. Ahlberg was my first graduate student, who immediately made his mark in the field of Devonian tetrapods, and has gone on to be a pioneer in the use of synchrotron-CT scanning applied to fossils. This paper described two partial lower jaw fragments from the Baltic Middle Devonian that showed unique dental morphology with multiple rows of teeth on the dentary: *Livoniana multidentata*. The jaws showed characters that he and I had earlier described as unique to tetrapods with limbs, although *Livoniana* did not have not the full suite. Thus the species rested between taxa like the limbed *Elginerpeton* and the tetrapod-like fish known as elpistostegids in a cladistic analysis. The find alerted us to the fact that there could be unexpected and highly specialized features among these transitional tetrapodomorphs that might otherwise have been considered to be rather conservative in morphology. The find provides a new search image for tetrapodomorphs.

WARREN, A. and TURNER, S. 2004. The first stem tetrapod from the Lower Carboniferous of Gondwana. *Palaeontology*, **47**, 151–184. <http://dx.doi.org/10.1111/j.0031-0239.2004.00353.x>

Anne Warren, one of Rex Parrington's students, has been a major figure in Australian vertebrate palaeontology, working on temnospondyls. Sue Turner has concentrated on drawing attention to the significance of microfossil 'ichthyoliths'. This paper builds on an earlier one that introduced the only Mississippian tetrapod fossils from Australia (Thulborn *et al*. 1996). Initially distributed among a number of taxa, this paper ascribed them all to the same one, adding crucial parts of the anatomy and placing them in a cladistic analysis. *Ossinodus pueri* clustered with the whatcheeriids *Whatcheeria* and *Pederpes*. It showed several elements that were very similar to those taxa; in particular the maxilla, the interclavicle and the clavicle were very similar to those of *Pederpes*. Other aspects of the anatomy, however, were quite different. The skull table was unusual in its breadth and overall shape, and the dermal ornament was unlike the other whatcheeriids. Whereas the ilium was unlike that of the whatcheeriids, the humerus, described in a later paper (Bishop 2014), was similar to that of *Pederpes*, but not that of *Whatcheeria*. All in all this is a very unusual animal. It showed us two important things: that there were and are Mississipian tetrapod fossils to be found in Australia; and that (assuming *Ossinodus* really is a whatcheeriid) whatcheeriids ranged widely geographically at that time. Isolated elements like those of whatcheeriids have subsequently been found in Devonian deposits (Daeschler *et al*. 2009; Olive *et al*. 2016), suggesting a long range in time as well.

AHLBERG, P. E. 2011. Humeral homology and the origin of the tetrapod elbow: a reinterpretation of the enigmatic specimens ANSP 21350 and GSM 104536. *Special Papers in Palaeontology*, **86**, 17–29. <http://tinyurl.com/gq57tlf>

This paper was presented at the Festschrift meeting for Angela Milner held in London. The main discussion centres around the isolated humerus from the Late Devonian Red Hill Formation

in Pennsylvanian, ANSP 21350. Initially described by Shubin *et al*. (2004), Per noted that new information on other tetrapod humeri required a reassessment of the interpretation of this bone. His conclusion was that, compared to other tetrapodomorph humeri, ANSP 21350 was 'stretched' along the proximodistal axis, and the distal end correspondingly compressed and turned ventrally. Thus the radius and ulna would have been orientated almost dorsoventrally to form an elbow in a weight-bearing appendage. However, this had been achieved in quite a different manner from that of more derived tetrapods. In the early tetrapod *Acanthostega*, for example, the radial and ulnar facets are distally-facing, suggesting that they were held in line with the long axis of the humerus, and set at a low angle to its plane (Coates 1996). Nonetheless, Per also pointed out that, contrary to previous interpretations, the ulna of *Acanthostega* did have a small olecranon process: its small size was probably related to the fact that the specimen from which it came was a juvenile. He suggested that the difference was between an appendage adapted simply for lifting the body in ANSP 21350, and one adapted for extension and flexion in a stride cycle in *Acanthostega* and other tetrapods. This paper also carries a graceful rebuttal of some of his own work on a supposed humerus from the Late Devonian of Scat Craig (Ahlberg 1998) showing that, if a humerus at all, it is not that of a primitive tetrapod.

REFERENCES

AHLBERG, P. E. 1998. Postcranial stem tetrapod remains from the Devonian of Scat Craig, Morayshire, Scotland. *Zoological Journal of the Linnean Society*, **122**, 99–141.

BISHOP, P. J. 2014. The humerus of *Ossinodus pueri*, a stem tetrapod from the Carboniferous of Gondwana, and the early evolution of the tetrapod forelimb. *Alcheringa*, **38**, 209–238.

CLACK, J. A. 2002. An early tetrapod from 'Romers Gap'. *Nature*, **418**, 72–76.

CLACK, J. E. and FINNEY, S. M. 2005. *Pederpes finneyae*, an articulated tetrapod from the Tournaisian of western Scotland. *Journal of Systematic Palaeontology*, **2**, 311–346.

CLACK, J. A., BENNETT, C. E., CARPENTER, D. K., DAVIES, S. J., FRASER, N. C., KEARSEY, T. I. MARSHALL, J. E. A., MILLWARD, D., OTOO, B. K. A., REEVES, E. J., ROSS, A. J., RUTA, M., SMITHSON, K. Z., SMITHSON, T. R. and WALSH, S. 2016. Phylogenetic and environmental context of a Tournaisian tetrapod fauna. *Nature Ecology & Evolution*, published online 5 December. doi:<**dx.doi.org/10.1038/s41559-016-0002**>.

DAESCHLER, E. B, CLACK, J. A. and SHUBIN, N. H. 2009. Late Devonian tetrapod remains from Red Hill Pennsylvania, USA: how much diversity? 306–317. *In* AHLBERG, P. E., BLOM, H. and BOISVERT, C. A. (eds). Forty years of early vertebrates: papers from the 11th International Symposium on Early and Lower Vertebrates. *Acta Zoologica Special Issue*, **90** (Suppl.)

COATES, M. I. 1996. The Devonian tetrapod *Acanthostega gunnari* Jarvik: postcranial anatomy, basal tetrapod relationships and patterns of skeletal evolution. *Transactions of the Royal Society of Edinburgh, Earth Sciences*, **87**, 363–421.

LOMBARD, R. E. and BOLT, J. R. 2006. The mandible of *Whatcheeria deltae*, an early tetrapod from the Late Mississippian of Iowa. 21–52. *In* CARRANO, M. T., GAUDIN, T. J., BLOB, R. W. and WIBLE, J. R. (eds). *Amniote paleobiology: perspectives on the evolution of mammals, birds, and reptiles*. Chicago University Press.

OLIVE, S., AHLBERG, P. E., PERNÈGRE, V. N., POTY, É. STEURBAUT, É. and CLÉMENT, G. 2016. New discoveries of tetrapods (ichthyostegid-like and whatcheeriid-like) in the Famennian (Late Devonian) localities of Strud and Becco (Belgium). *Palaeontology*, **59**, 818–826.

PANCHEN, A. L. 1985. On the amphibian *Crassigyrinus scoticus* Watson from the Carboniferous of Scotland. *Philosophical Transactions of the Royal Society of London, Series B*, **309**, 461–568.

SHUBIN, N. H., DAESCHLER, E. B. and COATES, M. I. 2004. The early evolution of the tetrapod humerus. *Science*, **304**, 90–93.

SMITHSON, T. R., RICHARDS, K. R. and CLACK, J. A. 2015. Lungfish diversity in Romer's Gap: reaction to the end-Devonian extinction. *Palaeontology*, **59**, 29–44.

THULBORN, T., WARREN, A., TURNER, S. and HAMLEY, T. 1996. Early Carboniferous tetrapods in Australia. *Nature*, **381**, 777–780.

Overseas Representatives

Argentina: Dr M. O. Manceñido, Division Paleozoologia invertebrados, Facultad de Ciencias Naturales y Museo, Paseo del Bosque, 1900 La Plata, Argentina.

Australia: Dr Rudy Lerosey-Aubril, School of Environmental & Rural Science, University of New England, Armidale NSW 2351, Australia.

Canada: Professor R. K. Pickerill, Dept of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada E3B 5A3.

China: Dr Z. Zhonge, Institute of Vertebrate Palaeontology and Palaeoanthropology, Academia Sinica, P.O. Box 643, Beijing 100044.

France: Dr J. Vannier, Centre des Sciences de la Terre, Université Claude Bernard Lyon 1, 43 Blvd du 11 Novembre 1918, 69622 Villeurbanne, France.

Germany: Professor F. T. Fürsich, GeoZentrum Nordbayern, Fachgruppe Paläoumwelt, Universität Erlangen-Nürnberg, Loewenichstrasse 28, D-91054 Erlangen, Germany.

New Zealand: Dr R. A. Cooper, GNS Science, P.O. 30368, Lower Hutt, New Zealand.

USA: Professor P. Selden, The Paleontological Institute, University of Kansas, Lawrence, Kansas, 66045, USA.

Professor N. M. Savage, Department of Geology, University of Oregon, Eugene, Oregon 97403, USA.

Professor M. A. Wilson, Department of Geology, College of Wooster, Wooster, Ohio 44961, USA.

TAXONOMIC/NOMENCLATURAL DISCLAIMER

This publication is not deemed to be valid for taxonomic/nomenclatural purposes [see Article 8.2 of the International Code of Zoological Nomenclature (4th Edition, 1999)].

Newsletter copy

Information – whether copy as such or Newsletter messages, review material, news, emergencies and advertising suggestions – can be sent to Maria McNamara, e-mail <**newsletter@palass.org**>). The *Newsletter* is prepared by Nick Stroud, and printed by Y Lolfa, Talybont, Ceredigion.

Deadline for copy for Issue No. 95 is 5th June 2017.

Palaeontological Association on the Internet

The Palaeontological Association has its own pages on the World Wide Web, including information about the Association, and copies of the *Newsletter*. Internet Officer Alan R. T. Spencer can be reached by e-mail at <**webmaster@palass.org**>. The locator is <**http://www.palass.org/**>.

Advertising in the Newsletter

Advertising space in the *Newsletter* will be made available at the rates given below to any organisation or individual provided the content is appropriate to the aims of the Palaeontological Association. Association Members receive a 30% discount on the rates listed. All copy will be subjected to editorial control. Although every effort will be made to ensure the *bona fide* nature of advertisements in the *Newsletter*, the Palaeontological Association cannot accept any responsibility for their content.

£75 for half a page £130 for a full page

These rates are for simple text advertisements printed in the same type face and size as the standard Newsletter text. Other type faces, line drawings *etc*. can be printed.

Rates for distribution of separate fliers with the Newsletter:

1,100 copies for worldwide distribution	£250
850 copies for worldwide distribution exclusive of North America	£200
600 copies for U.K. circulation only	£150

— — — **Newsletter design by Emma Davies, 31 Stafford Street, Edinburgh EH3 7BJ** — — —