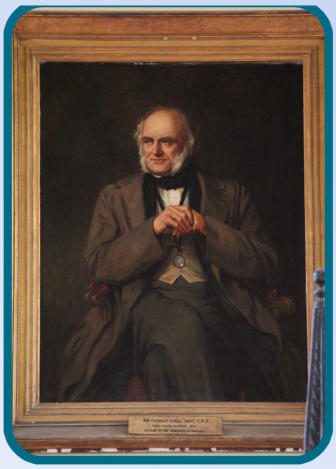
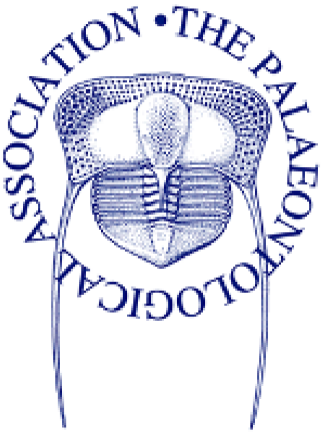


Progressive Palaeontology

Oxford 2016

19th - 22nd May 2016

Abstract Booklet



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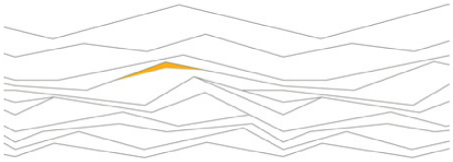


Welcome

Welcome to the University of Oxford, host of Progressive Palaeontology 2016.

The Committee

This year's committee has been a fluid affair, with everyone doing a bit of everything. Loose roles are included below, but everyone has worked hard to make Progressive Palaeontology a success. Please come and find us at the conference if you have any questions, we will be modelling this year's T-shirts!

Gemma Benevento

Chair - Gemma is a second year PhD student interested primarily in quantitative macroevoloutionary palaeobiology. Her current research focuses on exploring how and why mammal disparity has changed trough time, and in particular across the K-Pg boundary.

Harrie Drage

Secretary - Harrie is a second-year PhD, aiming to bring back old-school palaeontology by studying trilobite exoskeleton moulting. She spends a great deal of her time nagging people by email and organising committee meetings. She also makes time to go on "research" jaunts to Australia, and act like a nerd over video games, cinema, and music.

Mimi Beckett

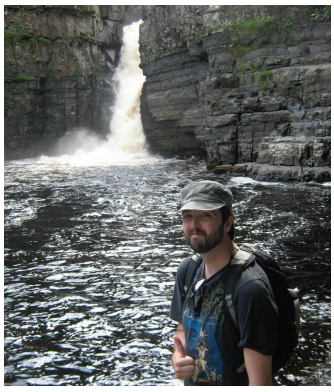
Editor - Mimi is a second-year PhD student working on fishes with Matt Friedman. She studies the 'adaptive radiation' of tunas and mackerels after the K-Pg extinction. She put together this abstract book among other things. Outside of work, cycling to and from work takes up a large portion of time, and she is looking for new hobbies since she has quit rowing and no longer has to organise a wedding!

David Ford

Treasurer - David completed his M.Sci in palaeobiology at UCL in 2014 before joining the DTP in Oxford. Although focusing on sauropodomorph phylogeny for his masters, his D.Phil research is on the evolution of the early diapsid reptiles, from their origins in the late Carboniferous to what appears to be an adaptive radiation in the early Triassic.

Steve Pates

Field Trip - Steve is a first year PhD student studying predator-prey interactions in the Cambrian. He is currently looking at the diversity and ecology of anomalocaridids (Cambrian apex predators) from the Great Basin (USA), as well as weird looking trilobites from all over. Steve enjoys everything football, but truly enjoys nothing more than going for a long walk to a nice beach and hitting things inquisitively with a geological hammer.

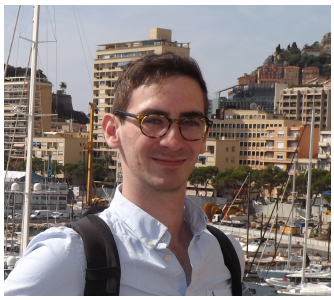


Brooke Johnson

Field Trip - Brooke had already been a keen amateur geologist for several decades before completing his geology BSc at Birkbeck College in 2015. His current work looks at how unstable redox conditions may have affected major biotic events in Earth History. In addition to the development of early life, Brooke's research also looks at how established ecosystems respond to changing redox conditions during the Early Jurassic Toarcian Anoxic Event.

Serjoscha Evers

Awards and Grants - Serjoscha is a 2nd year student supervised by Roger Benson and Paul Barrett investigating secondary marine invasions of turtles. He uses CT data, GMM, and phylogenetic implementation to tackle these questions. Since his B.Sc. and M.Sc. project, he also has a lively interest in theropod dinosaurs.



Dan Delbarre

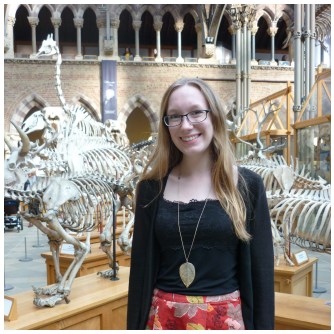
Publications - Dan is a 3rd year DPhil student studying the evolution of the Eurypterygii, a group of teleosts containing over a third of all living vertebrate species. He uses CT scan data and a number of phylogenetic methods to understand the evolution of these fish. When not working on his DPhil he enjoys rowing and going travelling.

Cesar Espinoza-Campuzano

Currently a second year PhD student, he did his undergraduate in Mexico, followed by an MSc in Bristol. His current research interests are applying the concepts of geometric morphometrics and adaptive landscapes to birds, defining a framework that can be applied to fossil birds.

Andrzej Wolniewicz

Andrzej graduated with a degree in Biological Sciences from the University of Oxford in 2013. Currently, he focuses mainly on understanding the anatomy, taxonomy and systematics of ichthyosaurs, which will ultimately lead to better understanding of evolution in this long-lasting, secondarily marine tetrapod clade.



Fiona Jones

Fiona is a penguinologist-in-training, and is currently a 1st year DPhil in the Department of Zoology, University of Oxford. While now researching organisms that are very much extant she retains a keen interest in palaeontology. Past research includes an examination of the morphology and cladistics of the extinct trigonotarbid arachnids, and various dinosaur-related projects at the NHM, London.

Logistics

Venue

This year Progressive Palaeontology visits the University of Oxford for the first time. Oxford has a growing palaeontological community split across several departments; the Department of Earth Sciences, the Oxford Museum of Natural History, and the Department of Zoology. A large number of PhD students are based in these departments, many of whom have been involved in this year's organising committee. A key aim of the committee this year was to showcase the broad range of research that Oxford is involved in. To that end, the Icebreaker and main conference talks will be held in the Oxford Museum of Natural History, with the Workshops, tea breaks, lunch and Poster Session being held in the Department of Earth Sciences, which is just around the corner from the museum. Both are situated in the University Science Area, South Parks Road, Oxford.

Travel

Road: Oxford is located just off the M40 in Oxfordshire. Parking cannot be provided at the University, and parking in central Oxford is severely limited. We recommend using a Park and Ride if you are planning on driving into Oxford. These are clearly signposted from all main routes into Oxford and cost £2 to park for the day plus your bus ticket. If you have access requirements that mean you need parking at the conference venue please contact us at progpal2016@palass.org to discuss these.

Bus: Buses run to Oxford from various cities around the UK, and the Oxford Tube runs frequently from London. Coaches stop at Gloucester Green Bus station. From here the University Science Area is a 10-15 minute walk through town. If you are getting a local bus from the park and ride, you either want to alight at the High Street (if you are coming from the South) or at Keble Road or Magdalen Street (if you are coming from the North), you will then want to walk to the Science area. Unfortunately no local buses run through the science area.

Train: There are now two railway stations in Oxford; Oxford and Oxford Parkway. The main railway station is served by buses that run into the city centre (alight at High Street or Magdalen Street depending on the bus). To get into central Oxford from Oxford Parkway take either the 500 directly from the station, or walk up onto the main road and take any of the 2s or the S5 and alight at either Keble Road or Magdalen Street.

Air: National Express run coaches run from Stansted and Luton to Oxford, and the Oxford Bus Company run "The Airline" from Heathrow and Gatwick to Oxford; this costs £29 return from Heathrow, and £37 return from Gatwick.

Accommodation

We cannot provide accommodation for the conference, although there are many Bed and Breakfasts, and a Youth Hostel by the station. Some Oxford Colleges may have B&B rooms available. There are also Premier Inn, Travelodge and other such hotels a short bus journey away (and near to Park and Ride sites). There are plenty of options for accommodation in Oxford, most of which are within a short distance of the conference venues due to the small size of the city.

Conference

Registration

Main registration will be at 6.30pm at the same time as the icebreaker in the Oxford Museum of Natural History. Please come in through the main entrance and register. You will be given your registration pack and lanyard. **You will need to wear your lanyard at all times when in the Oxford Museum of Natural History.**

If you are attending a workshop on the Thursday afternoon in the Earth Sciences department, you will receive your packs at the beginning of the workshop. Please come to the reception at the Earth Sciences building and you will be directed to the workshops.

If you are arriving on Friday morning, your registration packs will be available to pick up at 8.45am at the front of the Oxford Museum of Natural History, and then outside the lecture theatre from 9am.

Icebreaker

The icebreaker will be held at 6.30pm in the Oxford Museum of Natural History, with drinks and nibbles provided. It will be an opportunity to network with your peers and meet the committee. You are welcome to join the committee in heading to the King's Arms pub afterwards.

Presentations

Presentations will be taking place in the Oxford Museum of Natural History Lecture Theatre. This is upstairs off the left gallery as you enter the museum. Committee will be on hand at the start of the day to direct you.

There will be four oral sessions and one poster session. The four oral sessions will contain a mixture of full talks and lightning talks. Members of the committee will be chairing the sessions. Standard talks are 12 minutes plus 3 minutes for questions, while lightning talks are 4 minutes and 1 minute for questions. We have a very busy schedule and are trying to give as many delegates as possible the chance to talk, so please keep to time.

Powerpoint 2013 for Windows, Powerpoint 2011 for Mac, and Keynote 2009 for Mac will be available for slide presentations. At the end of the previous session please bring your talk on a memory stick to the committee member chair at the front of the room to load it onto the computer. If you are speaking in the first session, please bring your talk at 8.45am to load it onto the computer.

Posters should be brought with you to the first coffee break on Friday where they should be put up on your allocated numbered board. They will then be available throughout the day on Friday. Please take them down at the end of the Poster Session as the room will be needed later on in the day.

Travel Grants

Thanks to the success of last year's auction and the crowdfunder, we have been able to award 6 travel grants for international travel to Progressive Palaeontology 2016. We hope you will also support this year's auction (to be held immediately following the conference dinner) to help provide international students with the opportunity to attend next year.

Live Streaming

Palaeocast will be doing what they do best, and live streaming the conference at http://palaeocast.com/. If you do not want to have your talk streamed or recorded please inform the committee in advance at abstract acceptance.

Social Networking

Prior to the conference, announcements and updates will be posted to the Progressive Palaeontology 2016 Facebook page. Please be mindful of the possible sensitivity of data when tweeting, particularly in photographs. However we encourage tweeting using #ProgPal16.

T-shirts

We will be selling Progressive Palaeontology t-shirts at the icebreaker and during the conference for £5. The design is a stylised version of this year's logo - we hope you like them!

Lunch

We will be providing lunch for delegates in the RCR in the Department of Earth Sciences at 12.30pm. Feel free to browse the posters during lunch.

Annual Dinner

The conference dinner will be held on the Friday evening in Exeter College. Oxford is one of only a handful of Universities in England to have the collegiate system, and therefore dining in college seemed like a must for our conference dinner. At over 700 years old, Exeter is the 4th oldest college in Oxford. The early 17th century dining hall is not only architecturally stunning, but also steeped in history. For delegates of Progressive Palaeontology, by far the most intriguing and inspiring historical fact about Exeter College is that Charles Lyell himself once studied there, graduating in 1819. His portrait hangs in the dining room, meaning delegates can enjoy

their meal under the watchful gaze of the man who lay the foundations for many of the principles of geology and evolution we still use today!

The entrance to Exeter College is on Turl Street, on the left side of the road when entering from Broad Street. Dinner will be at 7.30pm sharp, so please arrive at least 10 minutes early, at 7.20pm. Porters at the lodge will be able to direct you to the hall. After dinner, we will move on to the 'second' annual auction. Wine will be served with dinner, however if you would like to purchase extra wine to keep you going through the auction you can do so on the night, at a cost of £15 per bottle. There is a cash point just a few yards away from the college entrance, so plenty of opportunity to fill those purses and wallets before the auction. David Button will be back by popular demand to lead the auction, so make sure you don't miss out and sign up for the conference dinner today!

Menu

Fresh garden herb and potato soup

***

Home smoked chicken breast, roasted salsify, grilled baby gem, thyme butter sauce and olive oil mash

or

Pan fried gnocchi glazed with a rich cream sauce, served with wilted spinach and salsa rosa (v)

***

Warm chocolate fondant, white chocolate and raspberry sherbet sorbet

***

Wine included

Workshops

Both workshops will run at the same time on Thursday 19th May so you will only be able to attend one workshop. Both will include a short tea break and be followed by a question and answer session about publication of research from Wiley. The workshops will run from 2.30-5.30pm in Seminar Rooms 1 and 2 (ground floor) in the Department of Earth Sciences, University of Oxford. There are still a few spaces available on both workshops; please sign up here if you are interested: http://goo.gl/forms/hUdkDUCEAE.

You will need to bring your own laptop for both workshops, with either R (https://www.r-project.org/) or SPIERS (http://spiers-software.org/download.htm) installed respectively. Laptops will need fully-charged batteries as there is limited plug availability. For the workshop in R, a familiarity with coding in R will be assumed.

Processing CT data in SPIERS

This workshop will cover how to visualise and segment CT data to obtain three-dimensional models in the freeware SPIERS. SPIERS is a free software (http://spiers-software.org/download.htm), which is especially helpful for people or institutions without costly licenses for payware alternatives such as VGStudio, Mimics or Avizo. SPIERS also lets you visualise 3D data in form of standard formats such as ply-files that were generated in other programmes, and is therefore very helpful for visualising 3D data that has been shared by colleagues.

Visualising phylogenies in R

This workshop will provide an overview of basic tools for visualising phylogenies in R. Quite often for presentations of course or project work, people need to show consensus or overview

phylogenies of groups, with specific features highlighted such as ecological adaptations, or differential rates of evolution across branches. R is a powerful tool for these types of visualisations. The workshop will not cover phylogenetic inference, but will teach how to read and write Nexus files, scale cladograms to geological time scales, adjust colours for different branches to represent rates of evolution or ecological adaptations, and perform other tweaks that allow you to produce publication-quality representations of phylogenies.

Travel Grants

This year as part of efforts to widen participation beyond the UK we started a crowdfunder to raise money for students to come to Progressive Palaeontology 2016. This year, in combination with the money raised from the auction last year, we have offered 6 students financial support to attend Progressive Palaeontology 2016. Thank you to everyone who supported our fundraiser!
Valentin Fischer (Silver Sponsor)
Marc Jones (Silver Sponsor)
Colin Palmer (Bronze Sponsor)
David Pyle (Bronze Sponsor)

"Progressive palaeontology is a special meeting for two reasons:

1. It is the conference where many British palaeontologists first present a talk or poster on their research.

2. It is also an invaluable opportunity to build relationships with other graduate students. You will be frequently told about the value of conferences for meeting and impressing senior researchers that might be able to offer you future collaborations or employment. This is true but do not underestimate the importance of building relationships within your peer group: the people who will be facing the same challenges as you. This pool of promising students will often be the ones learning the latest methods and exploring the novel questions with an open mind. Some of them will also become the next generation of movers and shakers and are the people you want in your future support network. You have a lot in common and a lot to offer each other." - Marc Jones

OUMNH Tours

The Oxford University Museum of Natural History behind-the-scenes tours will take place on Saturday 21st May, and will be lead by Dr Hilary Ketchum, the museum's Collections Manager of the Earth Collections. Delegates will be given tours in groups of 10, and there will be four tours in total. The times of these tours will be 10am-10.45am, 11am-11.45am, 12pm-12.45pm, and 1.30pm-2.15pm. If you have signed up for a museum tour the committee will be in touch regarding allocation of tour time slots. Please arrive at least 5 minutes early, and wait to be collected at the museum's reception.

The city of Oxford is steeped in palaeontological and zoological history, and the Oxford Museum of Natural History is home to many historically important fossils, including the first published picture of a dinosaur (*Megalosaurus*) bone, and the 'last Dodo'. As well as housing a historically significant collection, the museum's palaeontology archives are also home to numerous scientifically important specimens, which are available to researchers. These exclusive behind-the-scenes tours can also serve as a 'sneak-peak' into some of the fantastic material that the museum has which researchers can make use of in the future.

About our Sponsors

GLENCORE

Glencore UK Ltd is pleased to sponsor Prog Pal Oxford 2016 which we are sure will be a stimulating and interesting conference. We are headquartered in London's Mayfair and manage Glencore's oil business, trading in various oil products and gas. We also have upstream investments in oil production.

The Glencore Group is based in Baar, Switzerland and is one of the world's leading integrated producers and marketers of commodities. Our global activity includes the production, sourcing, processing, refining, transporting, storage, financing and supply of metals and minerals, energy products and agricultural products. We directly or indirectly employ about 160,000 people worldwide in some 90 offices across more than 50 countries. The commodities we trade often originate from our proprietary mining and refining assets. The Group also provides financing, logistics and other supply chain services to producers and consumers of commodities.

The Oxford DTP in Environmental Research seeks to recruit the most promising research students, from a wide variety of backgrounds, capable of developing their own research projects in line with the interests of our broad selection of supervisors. Each year between 24 and 30 students will be accepted into the DTP Programme through one of the above Research Streams. Candidates are invited to look through the Stream pages to see the broad range of environmental research that can be undertaken with Oxford supervisors.

The British Geological Survey (BGS) is a world-leading geological survey focusing on public-good science for government, and research to understand earth and environmental processes. We have:
1. an annual budget of £50 million; approximately 50% from the Natural Environment Research Council (NERC)
2. approximately150 private-sector customers
3. over 500 scientists working with more than 40 universities and institutes
4. 120 science support staff
5. 20 unique science laboratories 6. NERC and national science facilities including the isotope geosciences, radiocarbon, and geophysics and geodesy facilities.

Utilising new technologies and our existing research capability, we aim to rise to three major challenges across the world:
1. using our natural resources responsibly
2. managing environmental change
3. being resilient to environmental hazards

Timetable

Thursday 19^{th} May		*page*
14.30 - 17.30	Workshops *Department of Earth Sciences Seminar 1 and 2*	
18.30	Registration and Icebreaker *Oxford Museum of Natural History*	

Friday 20^{th} May		*page*
9.00	Announcements and Welcome	
Session 1 - Chair: Steve Pates		
9.10	Thomas Arbez *An exceptionally well-preserved skull of a Stanocephalosaurus amenasensis (Capitosauria: Temnospondyli) leads to a new hypothesis on the temnospondyl ear functioning*	*13*
9.25	Pedro L. Godoy *Tracking changes in the ecological diversity of Crocodylomorpha through deep geological time*	*13*
9.40	Melanie Tietje *From fossil record to amphibian conservation*	*14*
9.55	James Ormiston *Evolutionary Biomechanics of the Dinosaur Jaw Mechanism*	*14*
10.10	Zhang Hanwen ^{LT}*Understanding Elephant Evolution: Still A Formidable Task*	*15*
10.15	Claire Bullar ^{LT}*What were they thinking? Exploring the potential of neurocranial anatomical studies throughout Ceratopsia*	*15*
10.20	Daniel D. Cashmore ^{LT}*The completeness of the tetrapod fossil record*	*16*
10.25	Serjoscha W. Evers ^{LT}*Homology issues with the trigeminal nerve foramina in turtles and saurians*	*16*
10.30	Tea/Coffee Break *RCR - Department of Earth Sciences*	
Session 2 - Chair: Brooke Johnson		
11.00	O. Bath Enright *Turbulent behaviour: Preservation and survivorship potential of soft-bodied organisms in sediment-density flows*	*17*
11.15	Thomas Hearing *Cambrian microfossils to Cambrian climates: can 'small shelly fossils' be used to quantify ancient ocean conditions?*	*17*
11.30	Nidia Álvarez Armada *Experimental degradation of insects*	*18*
11.45	Frances S. Dunn *Ediacaran Developmental Biology*	*18*

12.00	Thomas Clements *Seeing into the Carboniferous: eyes of Tullimonstrum gregarium (Mazon Creek, Carboniferous) reveal a vertebrate affinity*	*19*
12.15	Elspeth Wallace *[LT] Microvertebrates from the Hell Creek Formation of South Dakota, USA*	*19*
12.20	Harriet B. Drage *[LT] Exceptional preservation of trilobite moulting behaviour from the Emu Bay Shale, South Australia*	*20*
12.25	Luke Parry *[LT] Meiofaunal burrowing at the Cambrian-Precambrian boundary*	*20*
12.30	Lunch *RCR - Department of Earth Sciences*	

Session 3 - Chair: Serjoscha Evers

1.30	Armin Elsler *Macroevolution of parareptiles*	*21*
1.45	Suresh Singh *Investigating the decline of the Synapsida across the Permo-Triassic extinction and early Mesozoic using mandibular morphometrics*	*21*
2.00	Edward Strickson *Dynamics of dental evolution in ornithopod dinosaurs*	*22*
2.15	Katherine Williams *Quantitative virtual histology: visualising the microstructure of avian bone using high-resolution and high-throughput synchrotron-based computed tomography*	*22*
2.30	Maurizio Sansonetti *[LT] Multidisciplinary methodological study on the origin of tissue-specific uv luminescence emission on well preserved vertebrate fossils*	*23*
2.35	Ellen MacDonald *[LT] Investigating Siliceous Microfossils using Imaging Flow Cytometry*	*23*
2.40	Jordan Bestwick *[LT] Inferring the diets of pterosaurs and extant analogues using quantitative 3D textural analysis of tooth microwear*	*24*
2.45	Arindam Roy *[LT] Bacteria or Melanosomes?*	*24*
2.50	Alexander J. Askew *[LT] Middle Devonian ecological change and the Kazák event in Northern Spain*	*25*
2.55	Valentin Rineau *[LT] New insights for the rudist phylogeny (Bivalvia, Hippuritida)*	*25*

Session 4 - Poster Session

3.00	Posters with Tea/Coffee *RCR - Department of Earth Sciences*	

Session 5 - Chair: David Ford

4.00	Jonathan P. Tennant *A hidden extinction in tetrapods at the Jurassic/Cretaceous boundary?*	*26*

4.15	Andrew Jones *Exploring the phylogeny and form of Phytosauria*	*26*
4.30	Richard P. Dearden *The articulated visceral skeleton of an acanthodian-grade stem-group chondrichthyan*	*27*
4.45	Marco Castiello *The role of petalichthyid placoderms in early jawed vertebrate evolution: old problems, new insights and future prospects*	*27*
5.00	Sophie Macaulay *Towards Improved Predictions of Centre of Mass Position, and its Pivotal Importance in Modelling Locomotion*	*28*
5.15	Gabriele Mazzuferi *LT The first evidence of eggs in a Eocene stingray from Bolca, Italy*	*28*
5.20	Emma Dunne *LT Quantifying Biodiversity During the Terrestralisation of Life*	*29*
5.25	Imelda M. Hausmann *LT Late Triassic Cassian Formation - Significance for the estimation of fossil and modern biodiversity*	*29*

Saturday 21st May		*page*
9.30	Field trip to Sheppey *leaves Department of Earth Sciences*	*52*
10.00 - 2.00	Tours of Oxford University Museum of Natural History *please sign up to a tour slot and meet at the OUMNH reception*	*8*

Talk Abstracts

Talk abstracts are included here. [LT] indicates a lightning talk. [*] indicates the presenting author, whose email address can be found in the delegate list on Page 54.

Session 1

An exceptionally well-preserved skull of a *Stanocephalosaurus amenasensis* (Capitosauria: Temnospondyli) leads to a new hypothesis on the temnospondyl ear functioning

Thomas Arbez[1*] and J-Sébastien Steyer[1]

[1]Centre de Recherches en Paléobiodiversité et Paléoenvironnements (CR2P), Muséum national d'Histoire naturelle, France

Temnospondyls are a clade of extinct non-amniotic tetrapods, similar to giant salamanders. Like lissamphibians, most of temnospondyls have an amphibious lifestyle, occupying ecosystems such as rivers, lakes and swamps.

The hearing abilities of temnospondyls are an ongoing debate. The temnospondyl stapes is often considered as a middle ear bone, close to the anuran condition and linked with an acoustic function adapted to airborne sound perception. However this bone is sutured with the parasphenoid in several taxa. This peculiar condition questions the traditional acoustic function attributed to the stapes, which could also play a role in the support of a spiracular canal, a conduct allowing to supply in water a hypothetic internal gill cavity. But this hypothesis also has some morphological constraints.

The specimen ZAR05 is an exceptionally well-preserved skull of *Stanocephalosaurus*. A cranial exploration has been investigated thanks to a micro-CT scan by the AST-RX facility of the Muséum national d'Histoire naturelle. The resulting 3D reconstruction reveals a highly detailed anatomy of columellar cavity and stapes leading to a new hypothesis of the stapes function, as part of a hearing system adapted to underwater sounds perception.

This hypothesis is promising as it explains some peculiar morphological features shared by several temnospondyls and provides an evolutionary scenario which is also compared with that of extant anurans.

Tracking changes in the ecological diversity of Crocodylomorpha through deep geological time

Pedro L. Godoy[1*], Richard J. Butler[1], Ivan J. Sansom[1], James Bendle[1] and Roger B. J. Benson[2]

[1]University of Birmingham, Birmingham, UK. [2]University of Oxford, Oxford, UK.

Crocodylomorpha includes the living crocodylians and all their extinct relatives with similar body plans. Unlike the small number of extant species today (23 species), the fossil diversity of Crocodylomorpha is remarkable. Whereas living forms occupy a limited range of ecological niches, fossil crocodylomorphs are represented by fully marine forms, giant terrestrial predators, bizarre filter- feeders, and even plant-eaters. The main goal of this project is to combine morphological information with environmental data in order to quantitatively investigate how crocodylomorph ecological diversity evolved through time, and which factors drove diversity changes. Among the different methods to assess this disparity is the study of body size and mass evolution, since these features are strongly related to many aspects of animal physiology and ecology. A comprehensive taxonomic sampling across all Crocodylomorpha is important

since most evolutionary studies quantifying patterns of morphological radiation are either temporally limited, restricted to the origins of modern groups or based on discrete characters. To do so, using the R package GEIGER we fitted four maximum-likelihood models of trait evolution to body size data mapped onto a time calibrated phylogeny, based on a modified version of a recent crocodylomorph supertree. Comparisons of AICc weights obtained for each model demonstrates that the Ornstein-Uhlenbeck (OU) model provided the best fit. The OU is a process which has a constant pull toward an optimum value (in this case 3.23 m). This indicates a constrained pattern of body size evolution around a trait 'optimum', suggesting constraints within long-term patterns of crocodylomorph body size evolution.

From fossil record to amphibian conservation

Melanie Tietje[1*] and Mark-Oliver Rödel[1]

[1]Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science, Berlin

An increasing number of publications call for a synergy of palaeobiology and conservation biology, i.e. using the fossil record to increase knowledge on extinction risk. Amphibians are particularly threatened, however there is still uncertainty why some species are threatened and others not. In my PhD research I am investigating the usefulness of the fossil record in amphibian conservation, a fossil record that is often neglected despite amphibians being of great interest in conservational tasks today. We use trait data from fossil and extant amphibians to search links between certain traits and extinction risk of amphibian species. The approach is based on fossils of extinct species, correlating traits and stratigraphic range. Our basic model includes traits that are typically part of IUCN Red List assessments to estimate the conservation status of species, like geographic range. The fossil-based models are then applied on extant species to see how fossil data matches with today's extinction risk assessments. The amphibian fossil record proves to be of sufficient quality to allow an assessment of extinction risk among amphibians. First results agree with studies usually conducted on fossil invertebrates, underlining the importance of range size and abundance for a species' survival. Apart from range size and abundance, the type of habitat seems to influence extinction risk in extant amphibians. In this talk, I want to focus on the influence of habitat utilisation on the longevity of species, using the fossil record as a deep time approach.

Evolutionary Biomechanics of the Dinosaur Jaw Mechanism

James Ormiston[1*]

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Mechanical advantage (MA) is a useful metric of jaw performance which is easily measured, well-suited to data processing and represents a potential target for selection. This study presents a clade-wide comparison of MA within Dinosauria to identify major trends in the evolution of the jaw mechanism, with a focus on the relevance of phylogeny and dietary preference to MA variation between adductor muscle groups. MA was calculated at three points along the top tooth row for the MAME, MAMP and MPT adductors in 144 taxa. MA values were then placed onto a phylogeny of Dinosauria and subjected to statistical analyses to identify sources of variation between groups and dietary preferences. Phylogenetic signal for MA was also quantified using Pagel's λ. MA is generally different between ornithischians and saurischians, and between carnivores and herbivores, but herbivores were found to be much more mechanically disparate in PCA plots. This appears to be due to herbivorous saurischians such as diplodocoideans and therizinosaurians diverging from ornithischians in performance space, with the MAME group being responsible for most MA variance. Phylogenetic signal is found to be strong in theropods but less so in ornithopods, with small sample sizes confounding reliable comparisons with other

groups. Mechanical divergence of herbivorous saurischians from ornithischians could potentially be interpreted as evidence of anatomical constraints (such as absence of the coronoid process), shifting selection pressure away from saurischian jaw musculature and towards other herbivorous adaptations. Future work would ideally include more marginocephalian and thyreophoran taxa to better optimise statistical comparisons.

[LT]Understanding Elephant Evolution: Still A Formidable Task

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Since its early days, the science of elephant evolution has undergone considerable confusion, as the majority of evolutionary diversity is exclusively confined to the fossil record. A seminal monograph by Vincent Maglio (1973) formed the blueprint of the current consensus, using traditional morphoclines derived from stratigraphic context of the fossils and *a priori* assumptions about trends of change. On the other hand, cladistic studies have largely focused on broader evolutionary patterns, with emphasis on dental characters obscuring exact species-level interrelationships, due to prevalence of homoplasy. In particular, convergent evolution of hypsodonty (heightened molar tooth crown) and increase in number of enamel ridges. Recent advancements in understanding early evolution of Eurasian mammoths from China have the potential to provide crucial breakthrough, but the generally confused state of fossil elephant taxonomy from Africa and Asia remains a critical caveat. Therefore, key systematic and palaeobiological questions of early elephant evolution in Africa and their subsequent dispersal to Eurasia must be addressed holistically. A thorough reappraisal of elephant evolution requires a strongly phylogenetic approach based on an updated cladistic analysis. 164 characters compiled from literature are first examined on modern elephant specimens for logistic repeatability of scoring and intraspecific variations. Key fossil collections in the museums of Europe, Africa, Asia and North America will be visited to provide a renewed global picture of elephant phylogeny. Preliminary observations of extant and fossil elephants will be presented here.

[LT]What were they thinking? Exploring the potential of neurocranial anatomical studies throughout Ceratopsia.

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The neurocranial anatomy of extinct organisms has intrigued the palaeontological community for years. Since the 19th Century palaeontologists have been examining whether endocasts can provide a good estimate of brain size and morphology and, if so, what this can tell us about the sensory capacity of these long dead organisms. Ceratopsians were one of the most diverse dinosaur clades of the Late Cretaceous and have an outstanding fossil record of basal forms in Asia. Ceratopsian palaeontology currently lacks comprehensive neuroanatomical studies which can illuminate how neurology might predict behaviours that have been suggested by previous research. In this project, we have imaged ceratopsian skulls using high resolution micro-CT scanning to capture small scale internal structures such as cranial nerves and semi-circular canals. These scan stacks are then digitally segmented into brain endocasts and braincase elements using 3D analysis software (Avizo). The first project, described here, investigates changes in neurocranial architecture through ontogeny of one species (*Psittacosaurus*). This has been a rare chance to acquire detailed 3D information on numerous ontogenetic stages of a single dinosaur species, from hatchling through juvenile to adult, and to link the various allometric

and morphometric deviations from isometry to wider function. In further work, the study of this basal form will provide an excellent comparison with more derived neoceratopsians from North America.

[LT]The completeness of the tetrapod fossil record

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Changes in the quality of the fossil record through time and space can bias our interpretations of tetrapod diversity, ecology, biogeographical patterns and macroevolutionary processes. This project, like recent studies, aims to assess this potential bias by quantifying the completeness of fossil specimens using two main metrics - the Character Completeness Metric (CCM) and the Skeletal Completeness Metric (SCM). CCM quantifies the phylogenetic information contained within a specimen (i.e. the proportion of phylogenetic characters it can be scored for), and SCM quantifies the proportion of a complete skeleton that a specimen preserves. SCM data has been initially compiled for non-avian theropod dinosaurs, and compared to previously generated CCM scores for the same taxa. Each bone of the theropod skeleton was assigned a relative percentage on the basis of 2D modelling of skeletal reconstructions. This allowed the preserved skeletal elements of each specimen to be given a percentage score dependent on the number and completeness of those elements. Data collection for theropods is not yet complete but the average skeletal completeness is around 20-30%. In the future, this project aims to address a number of key questions. Is the marine tetrapod fossil record more complete than the terrestrial? Do species with similar body sizes / ecological preferences share similar levels of fossil completeness? Do changes in fossil completeness through time correlate with major changes in global tetrapod diversity, evolutionary radiations and mass extinctions? Do changes in fossil completeness correlate with estimates of differing fossil record sampling and/or geological bias?

[LT]Homology issues with the trigeminal nerve foramina in turtles and saurians

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The trigeminal (cranial V) nerve of reptiles exits the endocranial cavity through an opening on the lateral wall of the braincase - the trigeminal foramen. This foramen is on the laterosphenoid-prootic contact in most archosaurs and lepidosaurs, and is modified to a broad fossa with separate foramina for the trigeminal rami in taxa with an extracranial trigeminal ganglion. Extant turtles, and most fossil forms, lack an ossified laterosphenoid. Instead, the parietal extends far ventrally, contacting the bony palate and forming the lateral wall of the braincase. The trigeminal foramen of turtles is located at the parietal- pterygoid contact. Topologically, this is at odds with the situation in other reptiles. These differences raise questions about the morphological transformations involved in the origins of the turtle trigeminal foramen, and warrant an assessment of the homology, which might inform the phylogenetic position of turtles among Sauria. New observations on fossil turtles, including the stem-turtle *Proganochelys* reveal a possible hypothesis for the evolution of the trigeminal nerve foramina in turtles. The trigeminal foramen in turtles transmits the maxillomandibular ramus of the CN V, but not the ophthalmic ramus. In *Proganochelys*, a medial foramen involving the laterosphenoid, and a laterally placed, dorsally open aperture indicates that an internal trigeminal foramen as present in most other reptiles was secondarily reduced in turtles, and that the trigeminal foramen of turtles is possibly homologous to the maxillomandibular foramen of reptiles with extracranial trigeminal ganglia, such as crocodiles. These observations form the basis for a revision of phylogenetic characters concerning the trigeminal foramen in analyses including turtles and other saurians.

Session 2

Turbulent behaviour: Preservation and survivorship potential of soft-bodied organisms in sediment-density flows

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A fundamental question in palaeoecology is whether different types of organisms can remain intact during transport and, if alive at the time, could they actually survive such transport? Here I present the results of two annular flume tank experiments designed to determine the effects of turbulent flows on the durability, preservation potential, and survivorship of the polychaete *Alitta virens*.

The first set of experiments tested the effects of transport duration, grain angularity, and sediment concentration on the damage state caused to freshly euthanized subject. Results show that flow duration and grain angularity are both important factors that had statistically significant effects on the state of damage. However, concentration by itself had no significant effect.

The second set of experiments was conducted to explore the "doomed pioneer" hypothesis. This states that organisms living in an oxygenated environment could be caught up in a turbulent flow and transported to an oxygen deficient environment where they are then able to colonize and create trace fossils in anoxic sediment, at least briefly, before eventually expiring. This has significant impacts for interpreting trace-fossils in deep-marine settings. Results demonstrated that all polychaetes were capable of surviving turbulent transport over a period of 180 minutes and were also capable of burrowing; however, the time taken to burrow was statistically significantly greater, and the burrowing style differed, compared to those that had not undergone transport.

Care must therefore be taken in interpreting both body- and trace- fossil assemblages preserved in sediment-density flows.

Cambrian microfossils to Cambrian climates: can 'small shelly fossils' be used to quantify ancient ocean conditions?

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The "Cambrian explosion" of animal body and trace fossils across the Neoproterozoic-Phanerozoic transition puzzled Charles Darwin and remains an area of vigorous research. Konservat-Lagerstätten have helped illuminate the biological changes of this ecological revolution, but its environments remain quantitatively poorly constrained. Such quantitative palaeoenvironmental constraints are commonly derived from geochemical proxy data, such as the stable oxygen isotope ratio (δ^{18}O), found in fossil biominerals. Commonly collected from calcareous brachiopod shells and phosphatic conodont elements, δ^{18}O data are used to estimate both water temperatures and the δ18O composition of seawater (often translated into global land ice volume). Unfortunately, euconodonts are not known below uppermost Cambrian strata, and Cambrian carbonate biominerals have often undergone severe diagenetic alteration. Cambrian 'small shelly fossils' (SSFs) - the remains of some of the earliest biomineralizing animals - may be an alternative source of this proxy data, but first they must be shown to be robust to diagenetic alteration. We examined the

external morphology and internal microstructures of SSFs from the Comley Limestone (Cambrian Stage 4/5), Shropshire, UK, using optical and scanning electron microscopy. Additionally, we used energy- dispersive X-ray spectroscopy to map the chemistry of selected SSFs. Biological microstructures were dominant, though localised diagenetic microstructures were also observed. Original chemistry is also well preserved in most specimens, with alteration either localised to fractures or discernible by optical microscopy where whole fossils are affected. Carefully selected SSFs could therefore be investigated with a view to placing quantitative constraints on the marine environment of the 'Cambrian explosion'.

Experimental degradation of insects

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Coloration plays important ecological and physiological roles in modern insects. Evidence of colour in fossil insects can therefore inform on the original colours of their cuticle and their functions in fossils. Studies on fossil insect colour to date have focussed on structural colours; the fossil record of insect pigments has not been investigated. An understanding of the taphonomy of colour is essential to accurate interpretations of evidence of colour. Here we use an experimental approach to understand the taphonomy of pigmentary colours in insects. Untreated and experimentally degraded specimens of extant insects were analysed using light microscopy, microspectrophotometry, scanning electron microscopy (SEM), electron microprobe microanalysis (EPMA) and synchrotron-X-ray fluorescence (XRF), in order to quantify the colour of cuticles during decay and to characterise the trace element signatures. The optical properties of dark coloured regions of the cuticle show minimal alteration during decay; light coloured regions, however, show substantial alteration in both hue and intensity. SEM, EPMA and synchrotron-XRF elemental maps show that sodium, magnesium and calcium are concentrated in dark regions of the cuticle in untreated specimens of all taxa; this elemental zonation is enhanced after decay. Zonation patterns for other elements are more complex, whereby zonation is inverted during decay, or is apparent in only some taxa. These preliminary analyses indicate that spatial distributions of certain trace elements are a widespread marker for melanin in insect cuticles, even after decay, and thus may be a good proxy for melanin-based colour in fossil insects.

Ediacaran Developmental Biology

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The Ediacaran Period, 635-541 million years ago, possesses some of the earliest fossils of complex macroscopic organisms. Some of these fossils have been rationalised as members of early animal groups and, thus, may potentially inform the evolution of metazoan axis specification, symmetry making and breaking, and the appearance of a segmented body plan. However, since many Ediacaran organisms cannot be easily reconciled morphologically with modern metazoan clades, multiple alternative interpretations have been proposed, including as algae, fungi, and Xenophyophores. In an attempt to reconcile among competing phylogenetic interpretations of the Ediacaran biota, we have adopted a developmental approach. The few existing developmental analyses of Ediacaran macro-organisms invariably conflate developmental pattern with developmental process. We compare growth patterns across populations of three iconic Ediacaran groups - the rangeomorphs, erniettomorphs and dickinsoniomorphs - revealing hitherto unrecognised ontogenetic characters, such as a basal pre-terminal pole of growth in Charnia masoni. By then considering morphogenetic process in these taxa, we tentatively reassess the

phylogenetic position of the Ediacaran macro-organisms. Our findings ally certain members the Ediacaran macro-organisms to the Metazoa, revealing the potential of developmental techniques for study of enigmatic fossil groups.

Seeing into the Carboniferous: eyes of *Tullimonstrum gregarium* (Mazon Creek, Carboniferous) reveal a vertebrate affinity

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Tullimonstrum gregarium is an iconic soft-bodied fossil from the Carboniferous Mazon Creek Lagerstätte (Illinois). Despite a large number of specimens and distinct anatomy, various analyses over the last five decades have failed to determine the phylogenetic affinities of the "Tully Monster", and although it has been allied to such disparate phyla as the Mollusca, Annelida or Chordata, it remains enigmatic. The phylogenetic affinities of *Tullimonstrum* have defied confident systematic placement because none of its preserved anatomy provides unequivocal evidence of homology, without which comparative analysis fails. Here we show that the eyes of *Tullimonstrum* possess ultrastructural details indicating homology with vertebrate eyes. Anatomical analysis using scanning electron microscopy reveals that the eyes of *Tullimonstrum* preserve a retina defined by a thick sheet comprising distinct layers of spheroidal and cylindrical melanosomes. Time of Flight Secondary Ion Mass Spectrometry (TOF-SIMS) and multivariate statistics provide further evidence that these microbodies are melanosomes, confirming the discovery of the oldest pigment in the fossil record. A range of animals have melanin in their eyes, but the possession of melanosomes of two distinct morphologies arranged in layers, forming retinal pigmented epithelium (RPE), is a vertebrate synapomorphy. Our analysis indicates that in addition to evidence of colour patterning, ecology and thermoregulation, fossil melanosomes can also carry a phylogenetic signal. Identification in *Tullimonstrum* of spheroidal and cylindrical melanosomes, forming the remains of RPE, indicates that it is a vertebrate; considering its body parts in this new light suggests it was an anatomically unusual member of total group Vertebrata.

[LT]Microvertebrates from the Hell Creek Formation of South Dakota, USA

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Microvertebrate fossil assemblages are present within the Hell Creek Formation (South Dakota, USA) preserving a wealth of different fauna including mammals, amphibians and birds. Such fossils provide key insights into the palaeoecology of the latest extent of the Mesozoic. Microvertebrate fossil assemblages have been identified from new sites within the Hell Creek Formation, forming the basis for this study. The aims of this investigation are to understand the processes of preservation relating to these assemblages and to describe the recovered microvertebrates for the first time. With this new information, the palaeoecology of the South Dakotan part of the Formation will be reconstructed. Meticulous stratigraphic logging was undertaken during fieldwork to investigate the preservation of the accumulations. This shed light on the palaeoenvironment present at the time of deposition and elucidated the taphonomic bias associated with the accumulations. It was shown that microvertebrate accumulations are the result of deposition as a precursor and/or conclusion to flooding events. Palaeoecological research was undertaken at the AMNH (New York) where fossils were identified to the lowest taxonomic

level possible and an understanding of the organism?s lifestyle gained before an ecological pyramid was recreated. Future research will include comparison of these results to those of other researchers to develop a better understanding of the processes and palaeoecology of the Hell Creek Formation as a whole. This study will provide an insight into the enigmatic environment present during the last days of the dinosaurs and illuminate a complex, dynamic ecosystem lost in time.

[LT]Exceptional preservation of trilobite moulting behaviour from the Emu Bay Shale, South Australia

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Exoskeleton moulting behaviour is uniquely variable in trilobites with respect to other Arthropoda. *In-situ* preserved assemblages of shed trilobite exoskeleton sclerites from the Cambrian Stage 2 Emu Bay Shale (EBS), South Australia, record unparalleled detailed behavioural information for moulting events. This exceptional preservation results from a lack of disruptive abiotic and biotic processes (currents, bioturbation), and rapid burial.

The extensive collections of *Estaingia bilobata* and *Redlichia takooensis* moult assemblages housed in the South Australian Museum were surveyed, and a number of specimens displaying the full observable range of variation in moulting chosen for closer examination. Moulting behaviour was interpreted for each of these specimens. Results were contrasted to moulting behaviours described for the extremely common two other extremely common trilobite species from other localities also with exceptional fossil preservation (*Ogygopsis klotzi* from Burgess Shale in British Columbia, and *Elrathia kingii* from Wheeler Shale in Utah).

Observations and inferences made on moulting behaviour were much more detailed from the EBS in comparison to species from the other localities. At the EBS, very rare moulting events (such as disarticulation of the entire cephalon) requiring unusual patterns of movement are discernable. These are not preserved in other localities with greater transportation of disarticulated sclerites. These observations suggest that trilobite moulting is more variable than expected, and flexible within a single species even during their early evolution. Further work will involve quantifying the proportion of each of the moult assemblages for the extensive populations of EBS trilobites.

[LT]Meiofaunal burrowing at the Cambrian-Precambrian boundary

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Macroscopic animals are first represented as both body and trace fossils in the latest Ediacaran Period, with diversification of the metazoan crown group phyla occurring across the Ediacaran-Cambrian boundary. Despite the emerging consensus on the origin of macroscopic animals, the origin of the meiofauna - a polyphyletic assemblage of animals that includes both phyla known from the macrofauna and clades that are wholly restricted to the interstitial realm - remains poorly constrained, due to the low preservation potential of both their body and ichnofossils. We describe a new exceptionally preserved ichnofauna from the Neoproterozoic-Cambrian Corumbá Group of central western Brazil. The burrows are preserved in three dimensions by

infills iron oxide (originally pyrite) framboids, making them amenable to 3D reconstruction using CT scanning. The ichnofossils consist of meandering trails with sub-horizontal to shallow-vertical trajectories, exhibiting rare dichotomous branching and sinusoidal movement. The traces reach an observed minimum diameter of 50μm and are sub-circular in cross section, indicating a likely small-bodied, vermiform trace maker. The moderately dense ichnofabric is largely confined to discrete sedimentary horizons, and reveals micro-bioturbation by meiofaunal organisms not normally visible in the conventional trace fossil record. U-Pb TIMS dating of associated tuff horizons constrain the age of these ichnofossils to slightly younger than 541Ma, approximately coeval with the Ediacaran-Cambrian boundary. Sediment reworking by meiofaunal organisms is otherwise only known back to the Triassic, confirming a hidden history of meiofaunal animals from the Fortunian onwards.

Session 3

Macroevolution of parareptiles

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Parareptilia is an enigmatic clade of early tetrapods that was previously regarded as being related to modern turtles. Molecular and relatively recent morphological analyses reject such a relationship, making parareptiles an extinct group known from the latest Carboniferous to the latest Triassic. Despite being diverse in terms of ecology, morphology and body size, Parareptilia have been largely neglected in recent macroevolutionary analyses.

Here we present new data on the diversity and body size evolution of parareptiles. A database containing information on different proxies for body size, diet and stratigraphic range (at substage level) of clade members was assembled. A biodiversity estimate based on raw taxic richness shows several alternating drops and peaks during the Palaeozoic. A phylogenetic diversity estimate, based on an informal supertree of all known species of Parareptilia, depicts a slightly different picture with a more gradual increase in biodiversity over time. Both diversity curves show that the overall number of species wasn't much affected by the end-Permian mass extinction. Biodiversity reached a peak in the Induan and plummeted rapidly afterwards, staying relatively low throughout the Triassic.

Femur length was chosen as a proxy for body size and various likelihood models of continuous character evolution were fitted to the dataset. Preliminary analyses indicate that an OU model fits the data best, followed by a trend model.

This study is part of a larger project trying to shed light on the evolution of body size of all early tetrapods.

Investigating the decline of the Synapsida across the Permo-Triassic extinction and early Mesozoic using mandibular morphometrics

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The decline of non-mammalian synapsids in the early Mesozoic was a key moment in evolutionary history that fostered the rise of the dinosaurs. Synapsids experienced great taxonomic and ecological success through the early Permian to the middle Triassic, and were the predominant terrestrial vertebrates. Despite being severely impacted by the Permo-Triassic extinction event, surviving clades (Anomodontia and Eutheriodontia) were quick to recover. Nonetheless, synapsid diversity fell through the late Triassic. The circumstances surrounding the turnover

from synapsid to diapsid prevalence within the Triassic remain uncertain, though it is traditionally attributed to competitive exclusion by the emerging archosaurs. Conversely recent studies suggest the turnover resulted from independent intrinsic factors, and was ultimately a passive process. Here we use mandibular landmark data collected from 152 genera and geometric morphometric methods to chart synapsid mandibular disparity and morphospace evolution through the late Permian to the early Jurassic. By studying functional anatomy linked closely to feeding, we discern possible patterns of trophic ecology, which is a key influence on evolution and a significant area of contemporary interspecific competition. Our results provide an eco-morphological perspective to non-mammalian synapsid macroevolution from their peak in the late Permian to their decline in the late Triassic, and provide some support to aspects of the competitive exclusion narrative. This study illustrates how investigations of macroevolution benefit from consideration of morphological, as well as traditional taxonomic approaches.

Dynamics of dental evolution in ornithopod dinosaurs

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Ornithopods were key herbivorous dinosaurs in Mesozoic terrestrial ecosystems, with a variety of tooth morphologies. Several clades, especially the 'duck-billed' hadrosaurids, became hugely diverse and abundant almost worldwide. Yet their evolutionary dynamics have been disputed, particularly whether they diversified in response to events in plant evolution. Here we focus on their remarkable dietary adaptations, using tooth and jaw characters to examine changes in dental disparity and evolutionary rate. Ornithopods explored different areas of dental morphospace throughout their evolution, showing a long-term expansion. There were four major evolutionary rate increases, the first among basal iguanodontians in the Middle-Late Jurassic, and the three others among the Hadrosauridae, above and below the split of their two major clades, in the middle of the Late Cretaceous. These evolutionary bursts do not correspond to times of plant diversification, including the radiation of the flowering plants, and suggest that dental innovation was a major driver in ornithopod evolution.

Quantitative virtual histology: visualising the microstructure of avian bone using high-resolution and high-throughput synchrotron-based computed tomography

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Accurate estimation of ontogenetic age in fossils is crucial for understanding taxonomy and evolutionary patterns in extinct animals but, in birds, robust ageing remains to be established. Histological study provides a promising approach, since bone microstructure is known to vary with both age and tissue deposition rate. However, to date, most histological studies have been qualitative, 2D, and tested in only a limited range of extant species. Our aim is to use minimally destructive 3D imaging to quantify the relationship between ontogenetic age and microstructural bone features in living birds, to accurately estimate age in avian fossils.

Our approach centres on using synchrotron-based computed tomography (SR CT) to image cortical bone in growth series of two extant bird species (duck and quail). From these 3D data sets, we describe cortical bone microstructure through quantitative morphometry down to cellular scales, including measures such as canal volume density or mean osteocyte lacuna volume.

Preliminary results show that SR CT imaging of modern avian bone allows for high spatial resolution and provides sufficient contrast required to accurately assess cortical bone microstruc-

ture in 3D for quantitative virtual histology. In contrast, lab-based micro-CT measurements of the same bones, did not provide a high-throughput approach at sufficient contrast-to-noise and signal-to-noise ratio for reliable virtual histology.

As next steps, we are including a phylogenetically and functionally broader sample base for our virtual histology approach, which will be applied to fossil material to estimate ontogenetic age and growth rate in fossil birds.

[LT]Multidisciplinary methodological study on the origin of tissue-specific uv luminescence emission on well preserved vertebrate fossils

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UV photoluminescence is an extended tool in paleontology, used to highlight morphologies, to recognized artifacts and to discriminate tissues. During restoring phase at the *Museo Geologico Giovanni Capellini (MGGC)*, Bologna, UV light was used to find fragments of harmed by falling's fossils during the earthquake of 2012. Right that time it has been noticed that Bolca's specimens show an unexpected photoluminescence emission for each well preserved soft-tissues. As well known from museographic study, MGGC fishes of Bolca's collection are historical specimens, they had been prepared attractively to be sold easily by the owners of the pit to collectors and scientists since the XVII century. As historical goods, the sampling on MGGC Bolca's specimens is usually not allowed, and in light of that value it has been decided to study the origin of this Tissue-specific UV photoluminescence Emission proceeding by a multidisciplinary approach. Several approaches has already been used to deeply understand the triggers of this phenomenon: UV photoluminescence in historical fossil specimens could have origins in various causes identified in (1)artifacts, (2)preserved autofluorescent compounds from (2a)original organs or from (2b)other biological activities, (3)different mineral compositions, and/or (4)fluorophores in part per billion into the crystal lattice. Palaeontological interpretation for each deduced from bibliography potential triggers, or overlay of more than one of them, will help to recognize the evidence of a exact common event that had could happened between life of the specimens and exposition of its fossil, stepping through decomposition processes, digging, preparation... Not only paleontology disciplines are involved, but also biology, microbiology, thanatology, taphonomy, museography, history, chemistry of cultural heritage.

Multidisciplinary investigation is then the most suitable approach to deeply understand the phenomenon of Tissue-specific UV Luminescence in vertebrate fossil from historical collection.

[LT]Investigating Siliceous Microfossils using Imaging Flow Cytometry

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Diatoms are used extensively in investigations of past climate reconstruction pollution, productivity and silicon cycling. Traditional methods of diatom identification involve time consuming slide production and counting. This study is the first to test the capabilities of Imaging Flow Cytometry to capture the diversity of microfossils in a sediment sample. Imaging Flow Cytometry is commonly used in cell biology as a means to quantify fluorescence and automatically image cell types. An ImageStream X Mk II flow cytometer was used to process a cultured sample of the diatom *Phaeodactylum tricornutum* and Holocene sediment samples from Edward VIII Gulf, East Antarctica. An automatic identification method was developed using IDEAS software to automatically group images into 7 final classifications. In a test population of 163 focused diatom images the accuracy of identification was 86%. In batches of 100, 000 images

this accuracy dropped to an average of 52.5% over 11 core depths. Automatic identification of diatoms is much more successful in cultured samples. Colonial and solitary morphotypes of *P. tricornutum* were identified to an accuracy of over 90% in sample sizes of 100, 000 images. Sediment sample images were dominated by fragments, unidentifiable particulate matter and diatom girdle bands. The lack of usable images in each data set limited the identification abilities of the IDEAS software. Future work would investigate improved methods of cleaning and isolating diatoms in the core sediments.

[LT]Inferring the diets of pterosaurs and extant analogues using quantitative 3D textural analysis of tooth microwear

Jordan Bestwick[1*], David Unwin[1] and Mark Purnell[1]

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Pterosaurs (Pterosauria) were a successful group of Mesozoic flying reptiles that successfully persisted for 150 million years. The diets of pterosaurs have been debated and a range of hypotheses have been proposed, including insectivory, piscivory and carnivory. Most of these hypotheses are founded on similarities between the tooth morphologies of pterosaurs and extant organisms. This approach assumes that tooth form and function are correlated with diet, which is not always the case. An alternative method involves quantitative analysis of the 3D sub-micron scale textures of worn tooth surfaces - dental microwear texture analysis. Microwear is produced during feeding as abrading food items alter tooth surface textures. Material properties of food create different microwear characteristics; in general harder items create rougher surfaces. 3D textural analysis of microwear has never been applied to pterosaurs. This study will determine whether microwear patterns can be detected in pterosaur teeth, and the extent to which microwear textures differ between pterosaur taxa with putatively different diets. An important component in this process is to validate pterosaur microwear by examining microwear textures of extant analogues with known diets to provide comparative data sets. Prospective analogues include bats (Chiroptera) and crocodilians (Crocodylia), as species within each clade have insectivorous, piscivorous and/or carnivorous diets. This study will test the hypothesis that microwear textures in extant analogues vary according to diet, and that textures reflect dietary similarities more than evolutionary relatedness. These results will provide a context for robust quantitative tests of dietary ecology in pterosaurs.

[LT]Bacteria or Melanosomes?

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The study of fossilized melanosomes has allowed for the colour of ancient organisms to be reconstructed. The shape of melanosomes is strongly diagnostic of their colour; they occur as either sausage shaped 'eumelanosomes' or meatball shaped 'phaeomelanosomes' imparting colours that range from black to dark brown and buff to red respectively. These structures range in diameter from 0.4-2 μm. However, the view that these microstructures are misidentified preserved bacteria still persists. But this hypothesis does not explain why rod and sphere shaped microstructures are the most prevalent morphologies in the fossil record. We had set up timed decay experiments using chicken feathers (both melanized and un-melanized) in isolated jars (using bacterial inoculum in mud samples from intertidal mudflats) as well as in artificial saline tanks with a mixed assemblage of microflora and fauna. These experiments were designed to simulate decay in ancient Lagerstätten settings. The decayed feathers are visualized using scanning electron microscopy (SEM). Our results show bacteria did not selectively colonize melanized or non-melanized feathers. The morphological diversity of bacteria was recorded in

terms of length, width and aspect ratio. The aspect ratio was then compared to the morphology of melanosomes from various fossil avian taxa using one way- ANOVA (Welch's unequal variance F-statistic), followed by post-hoc Kruskal-Wallis test and both indicated statistically significant differences in variance and median respectively. Also bacterial growth occurred preferentially along the rachis (which frequently does not preserve in fossils) rather than the barbs or barbules where melanosomes are normally located, contradicting the interpretation of microstructures as bacteria.

[LT]Middle Devonian ecological change and the Kazák event in Northern Spain

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The Middle Devonian was an important time of change in the history of life on Earth, particularly on land which saw the development of the earliest forests. The Devonian was also punctuated by various extinction events, including the relatively poorly understood Ka?ák Event around the Eifelian-Givetian boundary. The Ka?ák Event is known to have caused marine extinctions in Middle Devonian Laurentia, but relatively little is known about its effects in Gondwana, or in a terrestrial setting in general. To address these issues we are conducting a palynological analysis of the Eifelian and Givetian age Huergas, Naranco and Gustalapiedra formations of Asturias, Castilla y León and Palencia provinces in Northern Spain. These laterally equivalent formations represent a transect from shallow nearshore marine through to deep offshore shelf deposits on Peri-Gondwana. They are comprised of large sandstone bodies, interspersed with black shales, sandwiched between the thick limestone sequences constituting the rest of the Devonian succession. Samples have been collected from 30 exposures including four logged sections and have yielded rich assemblages of land-derived spores and marine palynomorphs (acritarchs, chitinozoans and occasional scolecodonts). Analysis of these palynological assemblages is shedding light on ecological and evolutionary changes taking place across both time and space, and is enabling identification and characterization of the Ka?ák event in Northern Spain, including its effect on the primary producers in both the ocean (marine phytoplankton) and on the land (terrestrial flora).

[LT]New insights for the rudist phylogeny (Bivalvia, Hippuritida)

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Rudists (order Hippuritida) are Heterodonts Bivalves. They appear in upper Jurassic and spread all around the Thetys in warm shallow seas, to become completely eradicated at the Cretaceous/Paleogene boundary. This group develop completely original morphologies - probably due to a shell uncoiling - which make them recognizable at first glance. A strong development of the myocardinal apparatus constituted of the hinge and myophores, the loss of a ligament and the presence of canals in the shell that can adopt a very large diversity of morphs are some examples of astonishing morphological events occuring in rudists. Here I present a new phylogeny based on representatives of each family - from Diceratidae to Hippuritidae -to resolve the early nodes of the Rudist phylogeny. I point out the weaknesses of the unique previous phylogeny from Skelton and Smith in 2000 on the formalization of homology hypotheses. I propose also a completely new set of morphological descriptors, and therefore characters, based on comparative anatomy with a decomposition of traditional "morphological wholes" (as hinge) into independent characters (i.e. anterior tooth, central tooth socket). Accessory cavities are also an example of "trash character" that is redefined. I show that the previous unique character "pallial canals" can be decomposed to point four different origins. The results are presented in

three- taxon analysis, a cladistic method that uses a new formalization of homologies directly in trees and without matrix representation of characters. The cladistic analysis leads to a single most parsimonious tree (RI=0,87) computed with LisBeth 1.3.

Session 4

For poster abstracts please see Page 33.

Session 5

A hidden extinction in tetrapods at the Jurassic/Cretaceous boundary?

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Reconstructing deep time trends in diversity remains a central goal for palaeobiologists, but understanding the magnitude and tempo of extinctions and radiations is confounded by uneven sampling of the fossil record. In particular, the Jurassic/Cretaceous (J/K) transition, around 145 million years ago, remains poorly understood, despite a minor apparent extinction and radiation of numerous important clades. Here, a rigorous subsampling approach (SQS) is applied to a comprehensive tetrapod fossil occurrence dataset to assess their macroevolutionary dynamics across the J/K transition. Almost every higher tetrapod group was affected by a significant decline across the boundary, culminating in the extinction of many basal taxa. This is coupled with ecological release and radiation of numerous modern lineages, including eusuchians, sharks and marine turtles. The timing of this extinction varies, with some groups (e.g., sauropods) in decline prior to the boundary, and others (e.g., turtles) suffering their greatest diversity drop in the earliest Cretaceous. This is coupled with extremely high and widespread extinction rates at the J/K boundary, and suppressed origination rates in all groups throughout the earliest part of the Cretaceous, culminating in an overall wave of diversity decline and gradual ecological turnover. Maximum-likelihood modelling shows that eustatic sea level was the primary mechanism regulating diversity changes for most tetrapod clades through the availability of near-shore environments and shallow marine basins. Much of this pattern derives from the European fossil record, where eurybathic changes around the J/K boundary were driven by a major regression and the closure of shallow marine basins.

Exploring the phylogeny and form of Phytosauria

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The crocodile-like phytosaurs were a widespread group of carnivorous Archosauriformes in Late Triassic ecosystems (220-200 Ma), with their abundant remains demonstrating a cosmopolitan global range, suggesting their success and ecological importance. Functional similarities between phytosaurs and crocodilians have been proposed qualitatively on the basis of gross morphological similarities between the two clades. These hypotheses of evolutionary convergence require explicit testing considering the many varied phytosaur skull morphologies known, but such analysis is hampered by the lack of a complete global phylogeny to provide evolutionary context. To address this I here present the initial findings of a new taxonomically comprehensive cladistic analysis, based on extensive first-hand study of both European and American specimens, aimed at clarifying the in-group relationships of Phytosauria. These phylogenetic results are then mapped onto a 2D geometric morphometric analysis of skull shape to produce preliminary estimates of cranial shape evolution throughout the group. Phylogenetic

results support the monophyletic status of the genus *Parasuchus* as found in previous studies. By contrast, *Nicrosaurus* is recovered as a paraphyletic series of outgroups to *Mystriosuchus*. Morphometric results indicate that phytosaurs explored cranial morphospace widely even in the most basal clades, with certain derived taxa showing a homoplastic reversion toward more basal morphologies.

The articulated visceral skeleton of an acanthodian-grade stem-group chondrichthyan

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Jawed vertebrates (gnathostomes) exhibit a vast variety of species and morphologies, a diversity based upon a unique suite of adaptations which evolved during one of the most important, yet poorly understood, transitions in vertebrate evolutionary history. The "acanthodian" fishes - a grade of prodigiously fin-spined stem-chondrichthyans from the Mid-Late Palaeozoic - are amongst the very earliest known members of the gnathostome crown-group, making them crucial for understanding this transition. However our knowledge of their anatomy is lacking, in particular that of their endoskeleton - a rich source of phylogenetically informative characters. Here we present the articulated endoskeleton of the "acanthodian" *Diplacanthus crassissimus* from the Middle Devonian (393-383 Mya) of Scotland. X-ray synchrotron tomography uncovers details of the visceral skeleton hitherto unknown in a Devonian stem-chondrichthyan, as well as novel information about the jaw, braincase, and shoulder girdle. A branchial skeleton with similarities to both the bony and the cartilaginous fishes is revealed, as well as the first evidence for endochondral mineralisation outside osteichthyans. This provides a sorely needed point of comparison for the branchial skeleton in early gnathostomes, helping inform current debates about the gnathostome branchial skeleton's primitive state and the polarity of phylogenetically important characters. It also gives us a more general insight into the anatomy of a member of Chondrichthyes' poorly understood stem-group, helping identify characters that unite some chondrichthyans to the exclusion of other gnathostomes. These data help us better understand phylogenetic relationships, and correspondingly evolution, in the very earliest parts of the gnathostome crown.

The role of petalichthyid placoderms in early jawed vertebrate evolution: old problems, new insights and future prospects

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Placoderms are the only known stem-group jawed vertebrates with jaws and their phylogenetic relationships have become central to the question of how gnathostomes evolved. Among placoderms, the petalichthyids are a focal point of research as they possess an unusual combination of jawed and jawless vertebrate features. Recent discoveries and investigations have raised questions about the phylogenetic relationships of placoderms as a whole, and consequently their impact on understanding of early gnathostome anatomical conditions. Here we explore the phylogenetic importance of petalichthyids within these competing hypotheses. We summarise extant knowledge about their anatomy and add new observations thanks to new computed tomographic datasets. In particular, we examine the significance of petalichthyid cranial morphology, comparing the strengths and weaknesses of competing scenarios of placoderm relationships. Within

the Petalichthyida, some members exhibit features that recall the ostreostracans-the jawless sister group of gnathostomes. This fact has been central to arguments in favour of placoderm paraphyly. By contrast, some petalichthyids present features which could nest them with the arthrodires-the group most commonly considered a close sister group to the jawed vertebrate crown group. Previously, the monophyly of Petalichthyida has been based on probably plesiomorphic dermal bone characters and never tested in a global analysis of placoderm taxa. This discrepancy prevents us from having a clear understanding of petalichthyids. The question of their monophyly and relationships to other placoderms is pivotal in understand the role of placoderm characters in our hypotheses on gnathostomes bodyplan evolution.

Towards Improved Predictions of Centre of Mass Position, and its Pivotal Importance in Modelling Locomotion

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An organism's centre of mass (CoM) position is a primary determinant of its stability at rest and in motion. CoM is therefore critical in determining posture and locomotor capabilities. As a result, CoM has been used extensively as an indirect predictor of locomotion in extinct taxa, where motion cannot be observed directly. It is recognised that, in order to maximise the accuracy of any estimates made, predictions should be grounded in a thorough knowledge of the same traits in closely related extant taxa. Previous analyses however, have included only limited data from extant taxa and basic validation steps. Here, I examine CoM in a range of extant archosaurs, with unprecedented model detail and validation. The digital models produced consist of flesh (i.e. muscle, bone, viscera etc.) and air cavities, in addition to integumental structures, which have never previously been included in models of avian CoM. Improved density data for the 'flesh' component is also incorporated. This culminates in the most comprehensive digital models of archosaurian mass properties to date. Results are validated in two extant avian species, comparing physically and digitally derived CoM estimates in order to assess the accuracy of the approach. Post-validation, this methodology will be applied to a range of avian species, in order to assess patterns in CoM position according to other biological factors such as locomotor type. Additionally, application of the improved methodology to members of Dinosauria has the potential to provide new insights into the biology of these enigmatic taxa.

[LT]The first evidence of eggs in a Eocene stingray from Bolca, Italy

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Known for its exceptionally preserved fossils since the 16th century, Pesciara di Bolca *Konservat-Lagerstätte* represents one of the most intensively sampled Eocene marine localities. This late Ypresian Lagerstätte chronologically coincides with or immediately postdates the Early Eocene Climatic Optimum (EECO), thus documenting the earliest occurrences of numerous shallow marine fish families. The Bolca fauna provides an unparalleled data set to tract a key question: how the Cenozoic climatic patterns correlated with early evolution of modern fish lineages and shaped the rise of modern shallow marine communities. The long-term collecting efforts have accumulated more than 250 species representative of 82 families of vertebrates. Among them, chondrichthyans taxa have received surprisingly little attention beyond alpha taxonomy, despite a sample of fully articulated individuals with exquisite soft tissue preservation. A full restoration of a nicely preserved ray from the Pesciara di Bolca housed at the Museo Geologico

Giovanni Capellini (Bologna, Italy) allowed for a complete analyses of the specimen and a revision of its taxonomic status. Historically referred to as *Platyrhina bolcensis* (Myliobatiformes: Platyrhinidae), the specimen is assigned to the genus *Dasyatis* (Myliobatiformes: Dasyatidae), represented in the Bolca localities by the species *muricata* and *dezignoi*. A comparison with specimens housed in the collections of Padova and Verona indicate that such species may be synonymous. Exquisite preservation of soft tissues in the Bologna specimen (MGGC 7456) allowed to observe overall disc morphology, shape and size of pelvic fins, the finely serrated tail spine, as well as cartilages and gills. Most importantly, it was possibly to identify the individual as sexually mature female based on the presence of the left oviduct bearing four eggs. This is the first report of preserved fossilized eggs for stingrays. Shape, microscopic structure and relative size compared to the overall body size of specimen indicate an early stage of development of the eggs but also provide an incredible opportunity to compare fossil and extant representative of this genus. Being a sexually mature female, this specimen also support the postulated Eocene 'nursery' habitat for the Bolca locality. Finally, this research aims to underline the incredible potential of neglected specimens included in '*historical collections*' and their potential in the field of vertebrate paleobiology.

[LT]Quantifying Biodiversity During the Terrestralisation of Life

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Tetrapods (four-limbed vertebrates) first invaded the land during the late Devonian, 370 million years ago. Over the next 200 million years they diversified into a spectacular range of morphologies and body sizes, surviving two mass extinctions at the Permian/Triassic and Triassic/Jurassic boundaries. Recent attempts to track Carboniferous-Jurassic tetrapod biodiversity have shown there is widespread disagreement on the major patterns of diversity change, stemming from the ongoing debate on the importance of spatial and temporal sampling biases in distorting observed diversity signals.

The end of the Carboniferous saw a major environmental transition when the tropical rainforests collapsed. Previous studies noted a rise in tetrapod diversity immediately following this time, resulting from increased endemism on the newly created fragmented landscape. These studies, however, did not account for spatial and temporal biases in sampling amongst the data used.

A comprehensive occurrence-based dataset of global tetrapod species diversity and distribution is currently being developed within the framework of the Paleobiology Database. Once fully assembled, this dataset will be amenable to rigorous sampling standardisation, allowing genuine diversity patterns through the Palaeozoic and into the Mesozoic to be estimated. These analyses will also investigate how sampling of the early tetrapod record varies in space and time, and to what extent these biases limit our ability to identify genuine diversity patterns during periods of environmental change, such as that at the end of the Carboniferous.

[LT]Late Triassic Cassian Formation - Significance for the estimation of fossil and modern biodiversity

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Taphonomic loss prevents in many cases a reliable evaluation of biodiversity in fossil assemblages and therefore impedes a meaningful comparison with extant faunas. The Late Triassic

Cassian Formation offers a solution for this major problem, because of its exceptionally good preservation of marine fossils. The Cassian Formation is situated in the Dolomites (north Italy) and yields a highly diverse tropical marine invertebrate-dominated fauna. Surface and bulk samples were collected from different sampling spots within the Cassian Formation and sieved with 0.5 mm mesh size as lower limit. After sorting and species identification, all species and specimens were quantified to conduct statistical analyses, including rarefaction, rank-abundance, and calculation of diversity indices. One dataset from a locality named Stuores Wiesen showed a remarkably high diversity and was dominated by molluscs, expecially by gastropods. Preliminary comparisons to other Cassian localities, which comprise different palaeoevironments, indicated that Cassian localities can vary greatly in diversity and taxonomic composition. A first comparison between the Late Triassic tropical assemblage from the Stuores Wiesen to comparable recent assemblages from the Gulf of Aqaba (Jordan) indicated that Late Triassic tropical molluscan assemblages were already in a similar diversity range as recent ones. The following questions will be adressed in the near future: (1) Is the time-saving analysis of the three most abundant species, instead of considering all species in fossil and recent assemblages, an appropriate approach for diversity assessments? (2) Can fossil surface samples be used for rapid and meaningful palaeodiversity estimations?

Notes

Notes

Poster Abstracts

P1 Taphonomy of the Cambrian eocrinoid *Lichenoides* from the Barrandian area (Czech Republic)

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Fossil echinoderms, including Cambrian eocrinoids, have a great potential to be a useful palaeoenvironmental indicator. However, eocrinoid taphonomy is only rarely studied. Numerous disarticulated echinoderm ossicles as well as abundant articulated specimens of the stem-less eocrinoid *Lichenoides* Barrande 1846 are preserved in shales, greywackes and even in fine sandstones in the Barrandian area. This fossil material provides an exceptional opportunity for taphonomic analyses. In the Barrandian area the genus *Lichenoides* comprises the abundant type species *L. priscus* Barrande, 1846 known in the Jince Formation of the Príbram-Jince Basin and the slightly smaller *L. vadosus* Parsley and Prokop, 2004 restricted to the Buchava Formation of the Skryje-Týrovice Basin. Both species occur in the Cambrian Series 3. Detailed evaluation of several tens of specimens of this eocrinoid echinoderm show diverse levels of skeleton disarticulation and makes possible to distinguish different semi-quantitative degrees. The main differences between these degrees are in the extent of disarticulation of brachioles and thecal plates. The *in situ* preserved and fully articulated specimens of *Lichenoides* represent a unique taphonomic window into the West Gondwana marine ecosystem. This research is supported by the GA UK (Grant Agency of Charles University) No. 898416 "Revision of eocrinoids echinoderms from Cambrian of the Barrandian area".

P2 One, no one and one hundred thousand: A phylogenetic experimental approach to test the systematic position of the Kem Kem Abelisauridae (Dinosauria: Theropoda)

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The Kem Kem Compound Assemblage (KKCA) of North Africa has yielded isolated skeletal elements (two maxillae and a femur) unambiguously referred to Abelisauridae, a Middle Jurassic to Late Cretaceous ceratosaurian clade with a predominantly Gondwanan distribution. Although two clearly distinct abelisaurid taxa have been recognized in sub-penecontemporary deposits in Northern Africa (*Rugops primus, Kryptops palaios*), no definitive autapomophy can distinguish the KKCA specimens. The taxonomy of the theropod clades from the "middle" Cretaceous of North Africa is still controversial due to the fragmentary nature of the material found and lack of stratigraphic resolution. Referring all isolated elements of one lineage to a single taxon is a phylogenetic hypothesis itself that needs to be explicitly tested by quantitative analyses. The systematic position of the two abelisaurid maxillae and femur has been investigated by means of Total Evidence Phylogenetic Approach (maximum parsimony and Bayesian phylogenetic analysis with tip dating), coding these specimens as distinct operational taxonomic units in several updated morphological matrixes from previous ceratosaurian analyses. The results support the distinct position of the two maxillae, respectively as sister taxon of *Rugops* and as more closely related to *Majungasaurus*. The relationship of the large Kem Kem abelisaurid femur is unstable, showing either a basal position (closer to *Rugops*) or a more derived position, nested in Majungasaurinae. The co-occurrence of two distinct abelisaurid taxa in the KKCA may reflect the lack of stratigraphic resolution in a heterogeneous sample recovered from multiple

units, rather than a genuine evidence of sympatry between these theropod taxa.

P3 The canals of *Welwitschiophyllum* leaves

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This study provides an analysis of some unusual morphological features of *Welwitschiophyllum* leaves, from the Aptian-Albian Crato Formation of north-east Brazil. These features are canals filled with a solid material, similar in appearance to resin. Intriguingly, Welwitschia (the extant relative of *Welwitschiophyllum*) has a polysaccharide based gum present in the canals within the leaf. There may therefore be an opportunity to discover if this fossil material has similar components. Resins have been shown to have a greater fossilisation potential than gums as they are water insoluble, whereas gums, are water-soluble complex sugars.

Previous publications have used micro-Fourier Transform Infrared Spectroscopy (micro-FTIRS) to analyse various gymnosperm exudates, including those from *Welwitschia*, and demonstrated that *Welwitschia* has a gum exudate rather than a resin or gum-resin. Preliminary spectra produced by my micro-FTIRS analysis of the Crato *Welwitschiophyllum* material, together with a selection of extant and fossil resins for comparison has shown that polysaccharide peaks are present.

Future work will include coupling the micro-FTIRS data with pyrolytic gas chromatography mass spectrometry, to show the abundance and specific composition of the macromolecular components. The morphology of the leaf will be compared to its living counterpart using the scanning electron microscope and thin sections.

P4 Evidence for an unknown high diversity of agglutinated foraminifera in Upper Cretaceous marl-/ and limestones (NW-Germany)

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With a derived method from research on conodonts in Paleozoic ages with formic acid, there are new possibilities for the biostratigraphical and paleoecological use of agglutinated foraminifera. It was possible to prove five of seven stage and lower-stage boundaries from Albian to Coniacian in Wunstorf in NW-Germany. Within this stratigraphical level different faunal developments, LADs (Last Appearance Date) and FADs (First Appearance Date) show a so far unknown diversity of agglutinated foraminifera and significant changes in foraminiferal record. In total 46 genera and groups provide a good tool for stratigraphical and paleoecological approaches.

P5 Morphological variability of *Sao hirsuta* (Trilobita, Cambrian) and the case for neutral evolution

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The solenopleurid trilobite *Sao hirsuta* is known form the Cambrian Series 3 of the Skryje-Týrovice Basin (Czech Republic), the Ossa-Morena Zone (Spain) and the Franconian Forest (Germany). Late meraspid and holaspid morphology of *S. hirsuta* is characterised by hollow

spines, densely covering most parts of the dorsal exoskeleton. A detailed morphological study comparing the specimens from the Skryje-Týrovice Basin and the Ossa-Morena Zone revealed significant differences in spine density and spine sizes between these two populations. While the population from Bohemia shows comparatively dense and thin spines on their cranidia, the population from Spain displays rather sparse and thicker spines. Both populations are of a slightly different age but other factors suggest that the environment in these areas was comparable. We therefore propose the observed variability to be a result of environmentally unconstrained neutral evolution. The previous study on the ontogeny of *S. hirsuta* indicated that its early postembryonic stages were benthic and that *Sao* was a poor disperser. This is in agreement with the isolated distribution of *S. hirsuta* along the West Gondwanan margin. The poor dispersion of *Sao* could have led to a genetic separation of individual populations and a subsequent morphological differentiation, regardless to environment. This work was financially supported by Ministry of Culture of the Czech Republic (DKRVO 2016/06, National Museum, 00023272).

P6 A new earliest Eocene perissodactyl from Le Quesnoy (France): study of the intraspecific variation in a basal perissodactyl

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Perissodactyls appear during the Paleocene-Eocene transition and quickly spread in the Northern hemisphere. Their origin area is still uncertain but the Asian hypothesis is favoured. The Le Quesnoy locality (Oise, France) sheds a new light on the early perissodactyls in Europe. It has yielded the oldest and most complete fauna from earliest Eocene of Europe (MP7). The material is very rich and well- preserved compared with other MP7 localities. A new species of *Cymbalophus* has been identified by dental and post cranial elements. It is of a major interest for both evolutive and paleogeographic stories of perissodactyls. The abundant remains allow to study the intraspecific variation in early perissodactyls. This variation can be strong on molars, which are often used to describe new species. This new *Cymbalophus* seems more closely related to the English species from the London Clay than to the Southern France species. Phylogenetic position of *Cymbalophus* with respect to Hippomorpha and Tapiromorpha is matter of debate. Our data, including the tarsal elements from Le Quesnoy plead for the reattachment of *Cymbalophus* to Hippomorpha.

P7 A reassessment of the phylogeny of Basal Sauropodomorphs

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Sauropodomorpha is the group of dinosaurs that includes the sauropods, the largest land animals that have ever lived, and the group with basal members often referred as "prosauropods". Although the monophyly of the clade Sauropoda has long been established, the relationships within the "prosauropods" are still unclear. Previous analyses have recovered that most of the prosauropods are clustered within a paraphyletic group named Plateosauria, with few basal taxa at the base of this and Sauropoda nested within it. However, the position of certain taxa, such as *Ruehleia bedhemensis*, has changed from the sister-taxon of Plateosauria in earlier works, to the base of this clade in more recent ones. Also, although the existence of the clade Massospondylidae is sustained in previous analyses, the most recent phylogenetic analysis broke it into two groups, with *Lufengosaurus* and *Glacilisaurus* forming its own unnamed clade as the sister-taxon of the clade that contains the sauropods. I reassessed the phylogeny of the group with a more inclusive

matrix obtained from the collection of 820 characters from the previous literature, and the inclusion of almost all the known "prosauropods" to produce a near-comprehensive phylogeny. After using the scores given in previous analyses most of the clade Plateosauria shown to be unstable with Massospondylidae as the sister-taxon of Sauropoda. Here, I discuss a revised preliminary phylogeny with first-hand assessment of specimens from Germany and China.

P8 Faunal Differentiation in the Cenomanian of North Africa

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Since 2014, North Africa has experienced a paleontological renaissance. This work has led to the proposal of the "continual ecological province" hypothesis: North Africa formed one continuous ecosystem, from Morocco to Egypt. Others maintain, however, that the absence of certain species indicates the presence of fundamentally different ecosystems. Using the biotope concept of ecosystem formation, the rarity of ornithopods and rebbachisaurid sauropods can now be seen as a result of aridity and the simplified nature of the proto-mangrove forest structure, while other missing faunal elements can be dismissed as a case of simple non-recovery. Although it's currently difficult to differentiate local population patterns from the general population trends within this ecosystem as a whole, the biotope concept proposes further avenues of research that can prove or disprove the continual ecological province in the future.

P9 Geomometric morphometric analysis of skull shape changes in stereospondyls amphibians

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Stereospondyls were a very successful radiation of early tetrapods. The key to their success is not resolved but could lie in diverse skull morphologies. The shape of the skull can directly influence patterns of feeding, respiration and vision. The aim here was to determine variation in morphospace occupation of skull shapes according to epoch, continent and superfamily affiliations. We used 250 equally spaced semilandmarks on 114 taxa to determine changes in the overall skull outline. PCA showed overall lengthening and narrowing was the biggest source of variation (PC1 - 70%) in the outline and feature of skull roofs. PC2 (10% of variation) had a posterior expansion of the skull and a shortening of the snout. There was a wider distribution of taxa along PC1 than PC2, NPMANOVA of PC1 & PC2 scores showed a significant difference ($P < 0.001$) in the morphospace occupation of stereospondyls of different superfamilies and of different geographical locations. NPMANOVA pairwise comparisons revealed that stereospondyls found in Europe were different from those in Africa, India and Australia. Those from Africa and North America were also different from those in Australia. There were no specific superfamily and continent combinations that could explain all of the variation seen here. Most of the continents that have differences had overlapping superfamilies. There was no effect of geological time with taxa from all epochs overlapping considerably in morphospace. The differences in skull shape and features over different locations may be indicative of different niche availability in different lands masses.

P10 Neogene mammals from the Neotropics (Venezuela and Colombia): implications for the Great American Biotic Interchange

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The Neotropical fossil record can provide insights for the understanding of diversity patterns. However, little is known from the tropics of South America (SA) in comparison to temperate sites. This challenges the study of important events such as the Great American Biotic Interchange (GABI), which refers to the faunal exchange between North and South America around the time of closure of the Central American Seaway, and modified the faunal composition of both continents. We investigate biogeographic patterns in SA and review the temporal and geographical distribution of fossil mammals during the GABI. We support a differentiation between tropical and temperate mammal faunas in SA at least since the middle Miocene. In addition, we present new findings from the Urumaco sequence (late Miocene-late Pliocene) of Venezuela and from Castilletes (middle Miocene and early Pliocene) of Colombia. These localities serve to characterize changes of Neotropical mammal communities during the GABI. Middle Miocene remains from Castilletes include several groups of "native ungulates" (uruguaytheriine astrapotheres, leontinid notoungulates, proteroterid litopterns), representing the earliest records in the tropics for these clades. Material from the late Miocene deposits of Urumaco documents higher diversity of giant neoepiblemid rodents. Pliocene remains from Colombia (Ware Formation) and Venezuela (San Gregorio Formation) provide the oldest records of North American mammals in the tropics (procyonids and camelids), and includes a diverse assemblage of sloths and hydrochoerid rodents. Toxodonts from San Gregorio represent the earliest divergent Toxodontinae. These findings are consistent with the role of the tropics as a cradle and museum of diversity.

[P11] Revision of the Villafranchian *Canis* species of Europe and their implication for wolves evolution

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Canids are a well-diversified family with a forty-million years paleontological record. However, the first *Canis* species appears in Late Miocene North American deposits and it is only around Late Pliocene that they reach western Europe. The present study is based on the anatomical and morphometrical analysis of cranial and dental features of the fossil members of the genus *Canis*, in comparison to extant species. The considered fossil sample comes from selected localities of Spain, Italy and Georgia. This allowed the taxonomical and morphological revision of canid, with new insight on Canidae phylogeny and paleoecology. Five species have been recognized, two of which described hereby for the first time. In fact, our revision casts some doubts on the specific attribution to C. etruscus of the fossil specimens from Dmanisi (Georgia) and those from Venta Micena (Spain) to *C. mosbachensis*. The Early Pleistocene Dmanisi *Canis* sp. presents a closer cranial morphological affinity to *C. mosbachensis* rather than to the coeval *C. etruscus*. This fact makes of this species an important piece of Canini evolution during Pleistocene, as possible first fossil taxon on the evolutive lineage of modern wolves. The scanty fossil sample coming from Venta Micena is almost entirely composed of teeth. Its revision points out a substantial resemblance to *C. mosbachensis*. Nevertheless, unique morphology and proportion of the upper molars are somewhat diverging from the type-form of the other Late Villafranchian canid. These combined features are more similar to modern jackals.

P12 An exceptionally preserved Eocene shark and the origins of modern reef communities

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An exceptionally preserved *Galeorhinus cuvieri* (Carcharhiniformes: Triakidae) from the late-Early Eocene Pesciara di Bolca fossil - *lagerstätte* reveals surprisingly modern morphological and ecological features. A restoration project allowed close examination using natural colour and ultraviolet photography, stereomicroscopy, X-ray computed tomography, and SEM of extracted samples. The specimen (MGGC 1976) preserved in slab and counter-slab lies on the right side of the body with the head twisted clockwise, revealing the upper left side of the face and the branchial region. The pelvic girdle has a long metapterygium that extends beyond the pelvic fin posteriorly into a clasper, which indicates that the individual is a male. As the overall morphology of G. cuvieri closely follows that of the living triakid, modern congeneric genera can be used as a proxy for age and size estimates of the fossil counterpart. The von Bertalanffy growth equation was used to estimate age and weight of the specimen integrating data sets for different extant populations: results suggest an age of 3.9 to 5.8 years and maximum weight of 8.7 kg. Therefore, MGGC 1976 represent a sexually immature male individual. All specimens of *G. cuvieri* with whole body preservation from Bolca (five) represent sexually and somatically immature juveniles, thus the Pesciara di Bolca locality may have been the nursery habitat for school sharks. In addition, MGGC 1976 is preserved with the brain, muscles, cartilages, visceral tissues, and stomach content, the latter identified as an early representative of the barracuda (*Sphyraena bolcensis*). This association provides evidence that a predator - prey relationship between *Galeorhinus* and *Sphyraena* in the modern coral reefs has an Eocene root. SEM analyses on exquisitely preserved dermal denticles sampled from the head, abdominal and pectoral fin regions allowed for a comparison with the living species *G. galeus*, revealing negligible morphological differences. Similarly, a comparison based on dental morphology and dental series of present day carcharhiniformes revealed that for such features *G. cuvieri* and *G. galeus* are almost indistinguishable. The optimum climatic of the early Eocene preluded the evolution of modern vertebrate faunas as well as trophic networks in modern coral reef systems. Therefore, the spectacular preservation of MGGC 1976 provides the unique opportunity to evaluate ecological and evolutional pattern among primary consumers such as Carcharhiniformes. *G. cuvieri* MGGC 1976 from Bolca: 1. is chronologically placed at the time of early divergence of Charcharinidae and Triakiadae; 2. provide direct evidences of trophic levels within primary consumers (i.e., Carcharhiniformes and acanthomorph teleosts); and 3. exhibits behavior and ecological distribution of juveniles Carcharhiniformes. In addition, the lack of detailed anatomical and comparative analyses on the vast majority of Bolca's sharks combined with descriptions dated back to the 1800's, urge a complete taxonomic revision of the sharks diversity from the Eocene of Italy.

P13 Out of ice: Extant global turtle biodiversity is a consequence of the Eocene-Oligocene global cooling event

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A large molecular dataset comprising 12 mitochondrial genes and 5 nuclear genes across 299 species was used to reconstruct a dated phylogeny for extant turtles (Testudines). Maximum likelihood and Bayesian models were used. Multiple fossil data sets were used to provide temporal calibrations. The monophyly of the two extant testudine lineages, Cryptodira and Pleurodira,

and that of all extant testudine families was supported. Relationships between these families was resolved with the exception of the marine turtles (Cheloniidae) whose placement within Testudines is still unclear. Speciation rates were calculated from the late Triassic to the present using the dated phylogeny and using fossil data. The majority of divergence events occurred after the Cretaceous-Palaeogene mass extinction event with rates increasing sharply after the rapid global cooling event at the Eocene-Oligocene boundary. Ancestral preferences for temperature and precipitation were reconstructed for Trionychidae, a Cryptodira family, as it is known that these are limiting factors in the dispersal of extant testudines. Minimum tolerance levels for both variables have fluctuated throughout the evolutionary history of this family. It is likely that this cooling event impacted extant biodiversity within Testudines. This is significant with regards to conservation efforts in the current period of anthropogenic mass extinction.

P14 Anatomy and function of the rhizodont skull

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Rhizodonts have a long history in palaeontology and an important phylogenetic position as the most basal clade in Tetrapodomorpha. However they are poorly understood- their cranial anatomy in particular- due to fragmentary material. This has hampered studies of character change and trait acquisition across the broader fish-tetrapod transition. Additionally, proposed hypotheses about functional anatomy and biomechanics have been proposed but not tested. A well-preserved skull of *Screbinodus ornatus* from the Visean (Early Carboniferous/Mississippian) Gilmerton Ironstone Formation and increased access to CT scanning provide an opportunity to further our knowledge of rhizodont anatomy and to test biomechanical hypotheses, particularly in the context of recent functional studies of extant (*Polypterus*) and extinct (*Eusthenopteron, Acanthostega*) taxa. The specimen was scanned at the University of Bristol and bones are being sectioned (digitally extracted) in Avizo. During this process, suture patterns are being noted in order to assess strain regimes in preparation for the biomechanical tests and erect hypotheses. Preliminary sectioning has clarified the nature of the attachments between the submandibular and gular series, which have been ignored by previous investigations. The submandibulars are strongly attached to each other anteroposteriorly with interdigitating sutures, as are the gular bones. The different series of bones are more loosely attached to each other with overlapping sutures. This suggests that the different units were subject to variable tension and compression, perhaps during feeding (including the head-thrashing and 'death roll' behaviors hypothesized for rhizodonts.) This hypothesis will be tested in the upcoming biomechanical analysis.

P15 Evolutionary Changes in the Synarcual of Rhinobatidae over Geological Time

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Batoidea are dorsoventrally flattened cartilaginous fishes that form approximately half of all living Elasmobranchii (Chondrichthyes). The sister clade to Selachii (sharks) within the elasmobranchs, batoids possess a characteristic synarcual (fused anterior vertebrae), and based on the current fossil record, batoids first evolved in the Lower Jurassic (~182 Mya). Most descriptions of the synarcual have either focused on a growth series of a single extant family or broadly on contrasting morphology between several different extant and extinct families. There is limited information available on the evolutionary changes of synarcual morphology over geological time.

To determine whether there is an evolutionary pattern between the morphology and functional aspects of the synarcual, comparisons were made between species from a single group that spans from the Mid Jurassic to the present, Rhinobatoidea. Three extinct fossil species (*Spathobatis bugesiacus, Rhinobatos beurlemi*, and *R.whitfieldi*) and one extant species (*R.formosensis*) are described using macrophotography and computed tomography (CT) respectively. Noticeable differences between extant and fossil taxa include the decreasing number of centra fully enclosed within the length of the synarcual and the posterior position of the pectoral arch and lateral stays (as the length of the synarcual increases in more recent species). These results show the synarcual is progressively becoming a more integral part of the Batoidea axial skeleton, determining its mode of locomotion and feeding mechanism.

P16 Concerning the East Carpathian Foreland Mammal Biostratigraphy (Eastern Romania, Moldova and Western Ukraine)

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The East Carpathian Foreland is a high potential area for the construction of a consistent local mammal biostratigraphy due to its rich and high quality records, internally consistent marine biostratigraphy, and the advances in Parartethys magnetostratigraphy and isotopic dating of the past 10 years. However, information on the existing fossil localities is distributed over a plethora of publications in at least four different languages. Various biozonations for both marine and terrestrial domains have furthermore been devised over time. The terrestrial biozonations are not yet in agreement with one another, due to the lack of unanimous substage boundary definitions and differing correlations to the MN (Mammals Neogene) system. In order to overcome these problems and access the full potential of the fossil record, an overview is made of the state of the art of mammal biostratigraphy for the Middle Miocene to Early Pleistocene of the East Carpathian Foreland. A detailed inventory is made of the existing fossil localities and their faunas, the spatio-temporal distribution is assessed and the resulting implications for Paratethys timescales are discussed. The inventory will form the starting point for an improved local mammal biostratigraphy and plans for publication of the results are underway.

P17 New record of organic-walled microfossils of algal and some uncertain affinities from the Tonian Visingsö Group in southern Sweden

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The diversification of unicellular, auto- and heterotrophic protists and the appearance of multicellular microorganisms, is recorded in numerous Tonian age successions worldwide, including the Visingsö Group in southern Sweden. The Tonian Period (1000-720 Ma) was a time of stability in the marine environments with increasing oxygenation and a high input of mineral nutrients from the weathering continental margins to shallow shelves, where marine life thrived. This is well documented by the elevated level of biodiversity seen in global microfossil record. The Visingsö Group contains a taxonomically rich assemblage of cyanobacteria, stromatolites, algal phytoplankton, and vase-shaped microfossils. A new study of organic-walled, phytoplanktic microfossils, which are extracted by palynological method from the Visingsö 1 drillcore, reveals the presence of morphologically disparate taxa. They are in gross cysts of microalgae (*Pterospermopsimorpha, Pterospermella, Tasmanites, Chuaria, Kildinella, Valeria, Cerebrosphaera,* and certain *Leiosphaeridia* with pylome), and some are of uncertain affinities. Representative taxa of two lineages, prasinophyte and chlorophyte green algae, are recognized. Cyanobacterial clusters

and filaments are abundant and specimens of multicellular, yet un-recognized systematically taxa are recorded. Taxonomically, the assemblage is similar to this of the Chuar Group in Arizona, USA, and some other successions distributed along the margins of Baltica, Laurentia and Siberia in the Tonian Period. Using the biochronologic correlation and isotopic datings on the successions, including new study on the depositional age of the Visingsö Group, its age is >838-740 Ma.

P18 Variation in tooth morphology and niche partitioning in the Lower Jurassic ichthyosaur taxa from Southern England

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Great abundance and diversity of marine reptiles are known from the Mesozoic, especially from Lower Jurassic localities in Southern England. However, little work has been done on the division of niches and trophic levels between these diverse groups. We aim to investigate and quantify the niche differentiation between ichthyosaur taxa from localities in Southern England, particularly Lyme Regis and Street.

Measurements of tooth and jaw characters have been recorded from photographs as well as from museum specimens. In addition, stomach contents were recorded if preserved. Specimens were classified according to two previously proposed guild systems by Massare (1987) and Buchy (2010). PAST software was used to run a PCoA analysis to highlight differences between feeding ecologies and to determine if the proposed guilds are statistically valid. Preliminary results show the presence of two or possibly three different tooth morphologies in Ichthyosaurus and two different tooth morphotypes in *Temnodontosaurus platyodon*. Our findings may indicate an ontogenetic niche shift in these species, particularly if *Temnodontosaurus risor* (*nomen dubium*) does indeed represent a juvenile form of *Temnodontosaurus platyodon*. The tooth morphology observed in ichthyosaurs of the family Leptonectidae differs from the others in the lack of striations, and the functional significance of the overbite teeth in *Excalibosaurus* is considered. Further work will compare the niche partitioning between the Dorset and Somerset faunas, and there is the potential to expand this out in the future to include other localities such as the Yorkshire Lias and to other taxa e.g. plesiosaurs and pliosaurs.

P19 The biostratigraphic importance of conchostracans (Branchiopoda, Crustacea) from the Late Triassic Bristol fissure deposits

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The Bristol fissure deposits offer a key window into Late Triassic island ecosystems, although their biostratigraphic position remains poorly resolved. Previous workers have focussed extensively on the palynological assemblages of these deposits in their attempts to place them within an established biostratigraphy, although the conchostracan faunas of these fissures remain widely undescribed and unused to this end. This study re-analyses conchostracan specimens from a number of key fissure localities across the southwest of England using PCA (Principal Component Analysis) methods, and determines numerically the coeval occurrence of these deposits with the well-dated strata of the Rhaetian Westbury Formation. This supports the findings of previous studies, which have used both microfloral assemblages and geological evidence to date these problematic units to the latest stage of the Triassic. We also offer for the first time tentative evidence of sexual dimorphism within the spinicaudatan taxon *Euestheria brodieana*, using similar morphometric methods to those that have previously been utilised on the Cretaceous conchostracans of the Yixian Formation, China.

P20 Post-mortem activity of terrestrial invertebrates on Cretaceous dinosaur bones from the Wessex Formation, Isle of Wight and the Kem Kem Beds, South-East Morocco

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Numerous factors, biological and physico-chemical, are responsible for the destruction (recycling) of vertebrate mineralised tissues, thus excluding them from becoming fossils. However, fossilisation may occur before these destructive processes are complete. We examined bones from the Early-Late Cretaceous (Barremian ∼128 mya) Wessex Formation of the Isle of Wight and Kem Kem beds (?Albian/Cenomanian ∼95 mya) of southeastern Morocco for traces of osteophagy and other biologically induced damage. Both deposits are well-known for an abundance of diverse terrestrial tetrapods and fishes, including osteichthyans, elasmobranchs, amphibians, squamates, turtles, crocodiles, pterosaurs and dinosaurs. This study concentrates on macrovertebrate remains mainly from dinosaurs and larger crocodiles, although bones of pterosaurs and turtles were also examined. Traces were categorised as fodichnia, praedichnia and domichnia on the basis of comparisons with extant burrowing organisms with a preference for hard (ossiferous) substrates. Bite marks from macropredators (?crocodilians and theropods) occurred on bones from both localities. At least 2 distinct macro boring traces were observed on Kem Kem bones while only micro traces (anastomosing, meanderine and straight) were found on Wessex Formation bones. Although this study is in its infancy it is clear a wide variety of organisms in both palaeoecosystems were responsible for bone destruction. Macroborings are probably attributable to the larvae of dermestid beetles comparable with *Dermestes maculatus* of recent ecosystems. Microborings in the size range ∼7 to ∼500μ are probably attributable to fungi and bacteria. Bite marks from macropredators are probably important for exposing internal structures and making the interior of bones available to osteophages.

P21 The affects of porosity on character decay rate and sequence in the polychaete *Allita virens*

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Decay is an almost ubiquitous process and leads to loss and bias in preservation of soft bodied fossils. Decay experiments have been used to successfully model some of the variables that affect the sequence and the rate of decay of soft tissues. However, little attention has focussed on substrate properties. This is important because most exceptionally preserved fossils occur within sediments and it is within this packing medium that both decomposition and preservation occur. Recent experiments have demonstrated that kaolinite appears to retard the decay process, but it is not understood whether its physical and/or chemical properties are important. Here, we have used chemically inert glass beads, to model whether porosity has an affect on decay in the polychaete worm *Allita virens*. We decayed worms in different porosities and collected data on the decay state of characters over a period of 81 days. Our results indicate that the sequence in which character decay is unaffected by porosity. However, rather counter intuitively, the addition of the inert packing medium significantly increased rate of decay relative to the control with no glass beads. However, decay rate between conditions of low and high porosity was not statistically different. Although more experiments are required our results suggest that the chemical properties of the substrate may well be dominant in controlling decay, or decay retardation, rather than simple porosity.

P22 The shark-beds of the Eyam Limestone Formation (Lower Carboniferous, Dinantian) of Steeplehouse Quarry, Wirksworth, Derbyshire

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The Eyam Limestone Formation of Steeplehouse Quarry, Wirksworth, Derbyshire has yielded, through acid digestion a diverse assemblage of Lower Carboniferous vertebrate remains. The assemblage is dominated by dermal denticles of the enigmatic selachian *Petrodus patelliformis* M'Coy, 1848. Teeth of petalodont, hybodont and neoselachians, and actinopterygian remains also occur. The assemblage has yielded the earliest neoselachian *Cooleyella fordi*, and the earliest species of *Lissodus, L. wirksworthensis*. Associated invertebrate remains and sedimentological data indicates a thriving fore-reef environment as the origin of the material, deposited in a low energy off-reef setting. The vertebrate remains are well preserved with little abrasion, indicating short transport distances. Conodont elements with unusual and extensive euhedral apatite overgrowths and a low CAI indicate a late Brigantian age (Lower Carboniferous, Visean). The first occurrence of the genus *Acanthorhachis* (Listracanthidae) is reported, extending the clades range back some 10 million years.

P23 Increasing the spatial accuracy of planktonic palaeoindicators

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Planktonic Foraminifera are key indicators of palaeoclimates. These single-celled marine organisms build a test (shell) from calcium- and magnesium-carbonate. The Mg:Ca ratio in the test reflects the temperature of the ocean during the organism's lifetime. After the organisms die, their tests sink to the ocean floor. During sinking, the test components dissolve at different rates, such that estimates of palaeotemperatures are heavily affected by the final composition of the test, as this is in turn linked to the duration of sinking. To correct for dissolution rates in palaeotemperature estimates, the sinking speed of foraminiferal tests must be quantified. Current estimates of sinking speed are based on five species (out of >600 fossil and 30 extant species). As the morphology of the test (which theory suggests could affect sinking speeds) varies considerably in planktonic foraminifera, data based on these five species might not give an accurate perspective on the dynamics of sinking across the group. Furthermore, previous sinking speed estimates may not reflect true sinking rates due to the non-intuitive nature of low Reynolds number hydrodynamics. Here we propose the use of correction factors to account for some of the errors, using a baseline of a sinking sphere to gauge the magnitude of shape-derived effects. Our study highlights the need for a reexamination of the sinking rates of other shelled planktonic paleoindicators (such as planktonic foraminfiera and coccolithophores).

P24 Climate and Carbon Cycle Dynamics in the late Eocene "doubthouse" from the Mossy Grove core, Mississippi, Gulf Coast Plain

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The Eocene-Oligocene transition (E/OT: ∼34Ma) is the largest climate transition of the past 65 million years. In less than 0.5 Ma, deep-ocean benthic foraminiferal oxygen isotope ratios (δ18O) record a large (>1‰) positive step-change, corresponding to a deep-water cooling and massive increase in the terrestrial cryosphere, as Antarctic ice sheets grew to a continental extent.

This coincided with a long-term transition from high to low-pCO_2 levels, and from a greenhouse to icehouse climate state. Recent coccolith-dominated high-resolution bulk carbonate isotopic records from the eastern Equatorial Pacific show a pronounced negative shift in both $\delta^{18}O$ and $\delta^{13}C$ between ∼35.5 and 34.5Ma, prior to the E/OT. Here we aim to generate new data from this pre-cursor interval, through into the E/OT, from continuously cored continental shelf section on the US Gulf Coast. Composed of ∼137m (15-152m deep) Yazoo Formation clays, the Mossy Grove core yield high quality microfossil, and palynomorph preservation. More than one hundred palynological slides will provide a ∼28kyr resolution biostratigraphy, including a number of potentially useful palynomorph bioevents and palaeoenvironmental reconstruction and the generation of a high-resolution (∼8kyr) fine-fraction (<20μm) bulk isotope carbonate stable isotope records through the core will be critical for further biotic and palaeoclimate studies. With a detailed isotope stratigraphy, suitable for correlation with sites from the Equatorial Pacific, the project will provide a further stratigraphic and palaeoclimatic framework for the interpretation of the palynological data. This work is supported by CNPq, National Council for Scientific and Technological Development (Brazil).

P25 Problematic paraconodonts - resolving the growth style of Westergaardodina

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Based on samples from the Furongian Deadwood Formation of subsurface Saskatchewan, Canada, the internal structure of elements of morphologically distinct paraconodont genus *Westergaardodina* have been investigated. Thanks to a currently-unique taphonomic occurrence of demineralized elements with a near-purely carbonaceous mode of preservation, a window has been opened on the growth history of these paraconodont elements, with growth lines visible using transmitted light microscopy. With a far larger sample size than has previously been achieved with sectioning-and-etching or hard x-ray microscopy, this poster demonstrates element growth through punctuated, incremental basal accretion, a style consistent with coniform paraconodonts, and discuss the possible functional applications of their unusual morphology, the implications for phylogeny and ontogeny among other tricuspid paraconodont genera, and the utility of experimental demineralization of hard phosphate microfossils.

P26 The Impact of Unstable Redox on Early Life

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Major eukaryotic innovations are widely spaced in Earth History. Even after the appearance of metazoans it is not until during the Cambrian Explosion that large complex animals appear and not until 460ma that modern ecological niches begin to be exploited during the GOBE. This apparent lag has often been attributed to environmental restrictions in either oxygen or food resources. It is also suggested the lag is a result of the slow development of the genetic 'machinery' which allowed the evolution necessary to exploit new resources. This project investigates the hypothesis that unstable redox environments suppressed diversification in the Early Mesoproterozoic and Cambro- Ordovician transition. The authigenic mineral glauconite may act as a mineralogical marker for unstable redox which can be tracked with other sedimentological/geochemical indicators, to uncover the relationship between redox and early life. By providing more stringent constraints on marine environmental conditions we can properly assess the impacts of proposed causal mechanisms, and potentially separate abiotic from biotic drivers during two key intervals in Earth history.

[P27] Lepidosaurian diversity through time: an exploratory look at the data

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[1]Natural History Museum, London

Lepidosauria is comprised of Rhynchocephalia (tuatara plus extinct relatives) and Squamata (lizards, snakes and amphisbaenia). In the past both were geographically widespread, with a complicated history of radiation and extinction. While their diversity in certain periods has been examined, long-term patterns have not. Here I study the diversity of terrestrial lepidosaurs from the Triassic-Paleogene (252-23 Mya) on genus-level occurrence data (1418 specimens representing 332 genera) from the Paleobiology Database (PBDB). Shareholder quorum subsampling is used to alleviate biases associated with 'raw'(face-value) diversity counts.

At substantial quorum levels (>0.5), low diversity in the Late Triassic further declines across the Jurassic boundary. High diversity in the Late Cretaceous plummets between the Campanian and Maastrichtian, prior to the K-Pg extinction. A rise post-Cretaceous represents radiation following the extinction of non-avian dinosaurs and other large-bodied taxa. Diversity falls again in the Late Eocene, recovering somewhat in the Oligocene; this may represent the "Grande Coupure" turnover event.

Current data is highly American-centric, however: 41% of specimens are from the USA and this skews what we observe in the record. Occurrences are also concentrated in the Late Cretaceous and Eocene, likely representing oversampling; further data will be gathered to reduce these biases and improve the PBDB. More complete information will be used to examine potential drivers of diversity, and comprehensively assess bias in the lepidosaur record.

[P28] Myology of the pterosaurian lower hindlimb

Danny Austick[1*]

[1]University of Portsmouth

Previous studies on pterosaur myology have rarely focused on reconstructing the lower hindlimb. Using the Extant Phylogenetic Bracket (EPB) method, the lower hindlimb myology has been reconstructed based upon the myological structures of crocodilians, pseudosuchians, theropod dinosaurs, and aves. Results show that pterosaurian muscle characters are similar to that of theropod dinosaurs yet they still retain some basal archosaur states. This will allow for future analysis of pterosaur terrestrial locomotion and the implications of this to the fossil track record and the ichnogenus *Pteraichnus*.

[P29] Limb and Feather Proportions in Paravian Theropods: Implications for the Importance of Feathers on the Hindlimb for Flight, the Evolution of Flight Surfaces and Body Mass

Carolina Karoullas[1*] and Gareth J. Dyke[1]

[1]University of Southampton, Southampton

Some basal Mesozoic birds, such as *Microraptor*, have integumentary features on the hindlimb similar to the flight feathers on the wings of modern birds. This implies that Mesozoic birds have four planar surfaces that can generate lift (excluding the tail, which counts as a fifth aerodynamic surface in some taxa) rather than the two seen in modern birds. However, the aerodynamic function and significance of these extra aerofoils is highly debated and not many hypotheses have been proposed to address their evolutionary significance. Here, the overall temporal trends in hindlimb bone and feather length were investigated to see if the function of hindlimb feathers could be found. In addition, it was seen if these trends could be linked to

mass as a cause. It was found that hindlimb feathers decreased in length through the phylogeny with a possible link between hindlimb feather length and mass. Through this, a hypothesis explaining why birds went through a "tetrapteryx" stage in their evolution could be theorised: in order to compensate for the excess mass gained from inheriting large, muscular legs from their theropod ancestors, basal birds had flight feathers on their hindlimbs to reduce the resultant excess drag and remain airborne. This would revolutionise our understanding of flight evolution and how the transition from dinosaurs to birds happened. However, this theory needs extensive practical experimentation to determine its validity and thus is the starting point for further research involving aerodynamic modelling of the forelimbs and hindlimbs of the basal birds in the study.

P30 Anomalocaridids from the Great Basin, USA

Stephen Pates[1*] and Allison C. Daley[1]

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Anomalocaridids, large presumed pelagic predators, have been described from numerous Lagerstätten in the Cambrian Great Basin (Utah, Nevada and California). A redescription of accessioned material combined with new finds since the original descriptions has shown that material identified as *Anomalocaris pennsylvanica* actually represents three different morphotypes. This study also identified anomalocaridid taxa not before recognised from the Great Basin, increasing the known geographic and stratigraphic ranges of *Hurdia* and *Caryosyntrips*. Some of these taxa are known from the Burgess Shale (Canada), and some are unique to the Great Basin, but no anomalocaridid taxa from other Cambrian Lagersttätten (e.g. China, Australia) are represented.

The presence of numerous different anomalocaridids, with very different feeding appendage morphologies, at individual localities in the Great Basin suggests that there was some specialisation in prey targeting by these animals. This would have allowed higher predation success rates, by specialisation of the appendage to attack specific prey, and also avoided competition for the same prey items by different anomalocaridids.

The identification of numerous pelagic predators with different feeding strategies, sizes and geographic ranges shows that the Great Basin (Lower Cambrian to basal Middle Cambrian) was home to a number of complex ecosystems, and that complex food webs and specialised predation had originated at this early point in animal life history.

P31 A new basal rhynchocephalian from a Late Triassic fissure fill locality in South Wales, UK

Juan Benito[1*] and Susan E. Evans[2]

[1]University of Birmingham, [2] University College London

Fissure fill localities found all across the Bristol Channel area, UK, have allowed the reconstruction of an ancient archipelago and its diverse faunal assemblages during the Late Triassic and the Early Jurassic. The southern part of the Vale of Glamorgan, Wales, is an exception, and no fissure localities are known in this area. The topography of this region remains uncertain, being blank in most palaeobiogeographic maps.

Survey work was carried out in this region by the British Geological Survey in 1955 and one of the boreholes, in the vicinity of Aberthaw, passed through a fossiliferous fissure infill. The relevant section of the core, containing a large number of isolated bone remains, was given to University College London. Study of this material has revealed at least five different taxa: two rhynchocephalians, including Planocephalosaurus, two unidentified procolophonids, and an

enigmatic taxon. These taxa link this locality with other known Late Triassic fissures in the area.

One of the rhynchocephalians, identified from a disarticulated dentary, represents a new taxon. This specimen has a combination of basal and derived characters, including marked heterodonty, a well-developed coronoid process and an extremely slender dentary ramus. Examination reveals it does not represent a juvenile form of a previously known taxon. Phylogenetic analysis of the specimen reveals it to be an intermediate form between basal and derived rhynchocephalians. The high diversity of rhynchocephalians during the Late Triassic in the region together with the characteristic morphology of the specimen points to a specialized ecological niche for the new taxon.

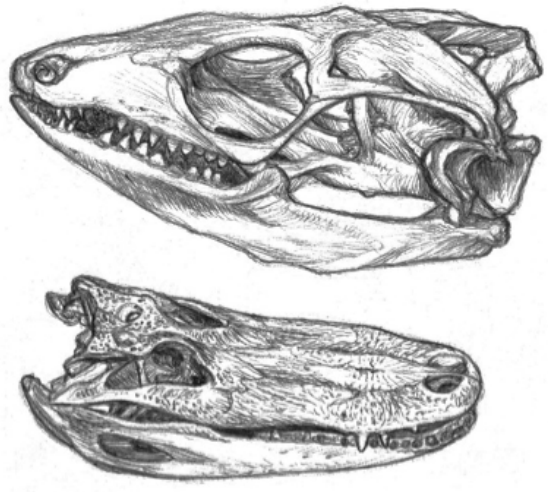
Notes

Notes

James Mckay

Palaeoart - www.jamesmckay.info

James is an illustrator specialising in Palaeoart, including art for journal publications, popular science books, children's books, computer games and comics.
All forms of prehistoric life considered for commissions - plants, invertebrates, vertebrates, environments...
Line reconstructions e.g. skeletals, greyscale drawings, colour paintings, concept sketches, models.
James enjoys working with early career researchers in particular and is interested to help with research projects needing creative input.
Contact jamesmckay76@hotmail.com for details.



Field excursion to Warden Point, Isle of Sheppey

Field trip leaders: Professor Matt Friedman and Dr Roger Close
First aiders: Harrie Drage and Brooke Johnson
Equipment required: warm, waterproof clothing; sun weather protection (sun cream etc.); sturdy boots, preferably Wellington boots; hard hat; lunch for Saturday; water; towel (for accommodation); bags for fossils; change of clothes (in case of mud); means to pay for dinner on Saturday
Dangers: rising tide; rocky terrain; deep mud

Timetable

Saturday 21st May	
9.30am	Leave on coach from outside Department of Earth Sciences (OX1 3AN)
12.00/13.00 (on arrival)	Lunch on the Isle of Sheppey
Afternoon	Fossil hunting at locality (Warden Point)
17.00/17.30	Leave Warden Point, drive to accommodation (Palace Farm, ME9 0AU). Stop at supermarket to buy lunch for Sunday en-route
19.30	Pub dinner

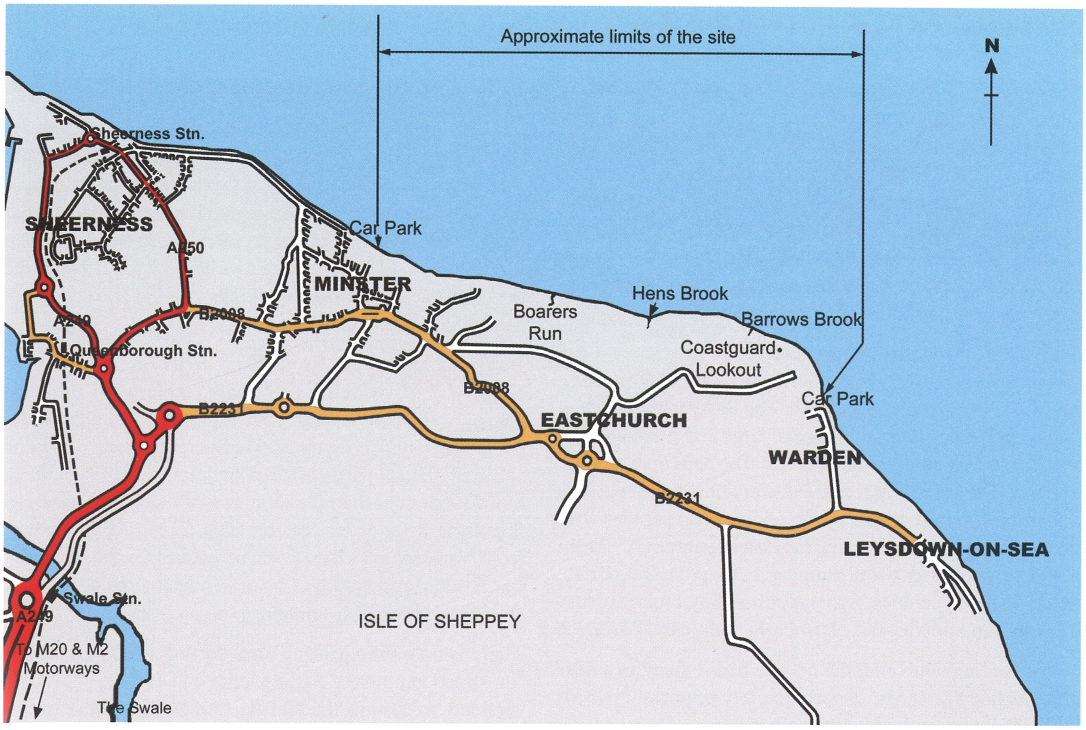
Sunday 22nd May	
8.00	Leave accommodation, drive to Warden Point
Morning	Fossil hunting at locality
12.00/13.00 (tide dependent)	Lunch
Post-lunch	Drive on coach back to Oxford
16.00/17.00	Drop-off outside Oxford Department of Earth Sciences

Warden Point, Isle of Sheppey, Kent

The locality is a beach and foreshore exposure, and the most well-known of the London Clay sites from Kent. It has produced extremely important British Tertiary fossils, including crustaceans, fish, and reptiles. The Warden Point area dates to the Eocene (Ypresian, 51-52Ma). The site runs from the end of the Minster sea wall in the West, and runs eastwards for around 6.1km to the Warden Point car park. We will park at the Warden Point end of the site, from which collecting can progress almost immediately. Staging the visit to the locality over two days should allow a more thorough search for specimens than usually possible due to the length of exposure.

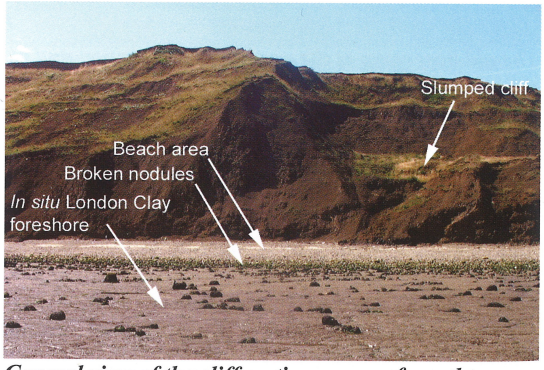
Typical sand and shingle beach between a series of wooden groynes runs from Leysdown (see map) to Warden Point, and at the Minster (East) end of the site. The collecting area of the beach between these two points does not follow this description. The beach of the site slopes gently from the cliff base for 10-15 metres to the exposed *in situ* London Clay foreshore. The top two-thirds of the beach mostly consists of a mixture of sand, shingle, pebbles, iron pyrite areas, disaggregated lumps of London Clay, mud runs, some phosphatic nodules, and septarian nodules. Wave action sorts the material by size and density, meaning large pieces of septaria collect at the bottom, and sand, shingle, and pyrite towards the top.

The foreshore consists of London Clay interspersed with nodule bands, and covered in areas with mud and silt. The nodule bands of the foreshore are mostly made of septarian and phosphatic nodules, flints and pebbles, and larger pyrite pieces. Some of the bands run parallel with the cliff, but some form a half-moon shape formed by past rotational cliff movements.



Map showing the Isle of Sheppey site.

View of Warden Point from the foreshore.



General view of the cliff section as seen from the foreshore.

Collecting can be undertaken either at the beach level, or foreshore. Particularly following high tide, the beach contains smaller fossils such as fish teeth, smaller crustaceans, seeds and fruits, gastropod and bivalve casts, otoliths, vertebrae, small bones, etc. Occasionally, larger specimens weather out of the cliffs, and can be found on the beach. This has included finds of larger crustaceans, fish, turtle, and nautili. A detailed search of the shingle and pyrite patches of the beach can often reveal seeds and fruits, molluscs, and teeth, the latter particularly at the strand line and where the pyrite grades into shingle. Processing and sieving some of this pyrite-shingle material at a later date may also reveal small fossils. Fossils are rarely found in and on the large septarian nodules.

Collecting from the foreshore is best accomplished by inspecting the nodule bands and looking for nodules containing specimens. Fossils are generally found in phosphatic nodules, and are usually recognised by their black and shiny appearance showing on part of the nodule. The exposed areas of London Clay can contain *in situ* phosphatic nodules that should be examined for specimens.

This field guide was put together by Harrie Drage, with reference to London Clay Fossils of Kent and Essex, by Rayner, Mitchell, Rayner and Clouter, and pictures taken from this book.

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