

# PALAEONTOLOGICAL ASSOCIATION

## 43rd Annual Meeting

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**Notes:** search for keywords using your browser's Find command. An asterisk (\*) denotes that the presenter is eligible for the President's Award or the Council Poster Prize for best oral and poster presentations by palaeontologists under the age of 30.

**Notes for Presenters:** due to the large number of oral presentations this year, all talks will be limited to 15 minutes (including questions). However, there is still plenty of room for poster presentations; if you would like to offer a poster, or change your contribution from an oral to poster presentation, please contact [Paul Selden](#). Please check your contribution is correct, e.g. the type of contribution, and whether you are eligible for one of the President's Awards.

For booking details, see the [Palaeontological Association](#) web site under "meetings"

### ABSTRACTS and PROGRAMME

#### **Rhynchonellid brachiopods from Jurassic (Bathonian-Callovian) rocks of Gebel El-Maghara, northern Sinai, Egypt**

*an oral presentation by*

**Adel Ali Hegab & Edward Tkhorghevsky**

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Well preserved rhynchonellid brachiopods were collected from Jurassic (Bathonian-Callovian) rocks of Gebel El-Maghara, northern Sinai; they were cleaned, sorted, identified and serially sectioned at different intervals. From each specimen, 17-24 serial sections were obtained and drawn with camera lucida attached to a binocular microscope. Measurements of length (L), width (W), thickness (T), L/W and L/T for each fossil were carried out. Nine species, *Maghararhynchiamagharaensis* sp., *M. sadekin* sp., *Pycnoriamagna* Cooper, *Septirhynchellakamyshanin* sp., *Wadirhynchiasinaican* sp., *W. raran* sp., *Gebelirhynchiagebelikan* sp., *Burmihynchiagutta* Buckman and *Torquirhynchiaroueriana* (Orbigny), belong to five new genera of subfamily Tetrarhynchiinae Ager. Also, the new species *Faragirhynchiaarkellin* sp., family Cardinirhynchiidae, is described. The species were recorded from the Safa and Masajid Formations, whilst the two known genera *Burmihynchia* and

*Torquirhynchiawere* found in Wadi Mahl near Bir Maghara. All species are described and compared with other rhynchonellid species from other localities around the world.

## **Microbial communities in Lower Cambrian shallow-water carbonates (Cantabrian Mountains, north-west Spain)**

*an oral presentation by*

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Microbial deposits are particularly abundant in the carbonate-dominated shallow-water sediments deposited on the extensive platforms that bounded the western Gondwana margin during latest Early Cambrian times. In the Esla nappe (Cantabrian Mountains, north-west Spain), the lower member of the Lancara Formation exhibits two distinct stratigraphic units rich in microbialites: white bedded and grey lenticular limestones, the latter one underlying the Lower-Middle Cambrian boundary. The underlying white bedded limestones contain birdseyes, peloids, lumps and aggregates, microbial laminae, and display common subaerial exposures, representing peritidal environments on an homoclinal ramp. *Proaulopora* and *Subtiflora* microbialites occur as complete or broken, micritic tubes. In contrast, the grey lenticular limestones represent oolitic and bioclastic shoals, and protected (back-shoal) archaeocyathan buildups rich in microbial crusts, such as *Renalcis*, *Epiphyton* and *Girvanella*. The contrasting morphologies of the microbial growth structures may be related to environmental parameters and trapping activity. Archaeocyathan and microbial organisms were able to construct self-supported boundstones, resulting in the formation of protected buildups, whereas the binding role of the *Proaulopora* and *Subtiflora* tubes were constrained by high-energy conditions and the lack of supported structures.

## **Rhynie revisited: new discoveries from an early Devonian, terrestrial, hot-spring basin, Aberdeenshire, Scotland**

*an oral presentation by*

**Lyall I. Anderson\***

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The Rhynie cherts situated on the outskirts of the village of Rhynie, Aberdeenshire, Scotland, have been famous for their exceptional preservation of an early Devonian flora and fauna since their

discovery in 1912. Recovery of rock core from a programme of exploration drilling located in the SSSI field and at a number of adjacent sites has revealed valuable new information on the extent and depositional setting of the cherts. In total, there occur in excess of 35 discrete chert horizons interbedded with fluvial and lacustrine sediments over a vertical interval of approximately 50 m. Some of these horizons are laterally persistent and can be correlated between boreholes. A second hot spring site located 700 m north at Windyfield and apparently discrete from the Rhynie vent, yields conclusive evidence for previous geyser activity in the form of distinctive splash textures. This vent with its associated bedded cherts has yielded further additions to the flora and fauna of this early Devonian Konservat-Lagerstätte including a myriapodous detritivore with gut contents, scutigermorph centipeds, a notostracan crustacean and a euthycarcinoid. The arthropods occur within a chert pod with a distinctive micro-texture characterised by the presence of numerous elongate amorphous coprolites amongst scattered plant stems.

## **Meet Medusa: silicification of arthropods in a modern-day, terrestrial, hot-spring system**

*a poster presentation by*

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The Norris Geyser Basin is arguably the most changeable and geothermally active area of Yellowstone National Park, Wyoming, USA. The basin consisting of many fumaroles, ‘frying pans’ (areas of sizzling ground), hot springs, hot pools, mud pots and geysers. Norris is predominantly an acid sulphate area with many of the geothermal features currently precipitating silica from solution. We present here the initial findings of a survey of the Norris Geyser Basin deposits and report a wide and varied fauna of arthropods preserved, and currently preserving, within the siliceous sinters of the area. These include dragonflies, crickets, moths, spiders, beetles and hoverflies. To date, only three of the many hot springs in the area have yielded silicified fauna: Porkchop geyser, Opalescent spring and Medusa geyser. Subtly different preservational mechanisms are in operation at each locality, but the main controlling factors are abnormally high dissolved silica values, frequent vent overspill and the presence of adhesive bacterial mats. The mode of preservation of these arthropods has obvious implications for floral and faunal studies on the fossil sinter deposits of the Early Devonian Rhynie and Windyfield cherts, Scotland, and the Upper Devonian Drummond Basin cherts, Australia and comparisons are drawn with these sites.

## **Rugose coral biostratigraphy in relation to carbonate facies in the**

# Lower Silurian sequence on Gotland, Sweden

*an oral presentation by*

**Lill Ann Andersson**

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The upper Telychian-lower Sheinwoodian sequence on Gotland, Sweden, is represented by the Visby and Högklint Formations which are divided into several members based on more or less pronounced facies variations. These formations are interpreted as a continuously shallowing marine sequence, showing an increasing number of reef structures upwards. Hede (1960, and several earlier papers) thoroughly described this sequence and distinguished most units. Riding & Watts (1991) revised this stratigraphy in part, and formally designated modern lithostratigraphic units, including the Visby Formation, comprising the Ygne Member and the Rövar Lilja Member (formerly called the Lower and Upper Visby Beds) as well as the Högklint Formation (corresponding to the Högklint Group of Hede), to include the following members: Korpklint, Millingsklint, Irevik, Brissund, Hallshuk, Domkyrka, Kappelhamnsvik and Högklint Patch Reef Members. Some of these units are regarded isochronous. The aim of this study is to thoroughly collect rugose corals from the lithostratigraphic type localities for all the members mentioned, and observe the palaeobiological relation between corals and sedimentary framework. Detailed taxonomic identification of the rugose coral taxa and their stratigraphical distribution will reveal much about their facies dependency, palaeoecology and reliability as index fossils.

# The paleoecology of a ‘coral-reef’ at Royseux - an extraordinary facies in Belgian Dinantian

*an oral presentation by*

**Markus Aretz**

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The coral reefs in the Upper Visean of Royseux are currently the only known coral reefs in the Dinantian of Belgium. One reef horizon is found at the base and a second one at the top of one sequence. The sequence reflects a lower deepening-upward and an upper shallowing-upward trend, the other sequences show only the shallowing-upward trend. Three evolutionary stages (stabilisation, colonisation, diversification) can be observed in a biostrome (first horizon). The structure of the second reef horizon is more complex and it must be divided into three sub-horizons with completely different origins. The different types of reef structures are associated with changing marine environments. The coral fauna of each evolutionary stage or sub-horizon is adapted to a special paleoecological situation. Corals of the genus *Siphonodendron* seem to have the highest ecological distribution and variability. Changes in the coral fauna are connected with changes in the paleoenvironment, caused by sea-level fluctuations or a changed geometry of the sea-floor.

# Environmentally entrained growth in the earliest vertebrate teeth

*an oral presentation by*

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Conodonts were the first vertebrates to produce a mineralised skeleton and species of *Protopanderodus* and *Periodon* were some of the first animals to inhabit the deep-sea realm. Crown enamel in *Protopanderodus* and *Periodon* records seasonally entrained growth and cyclical alternation of episodes of growth and function. Growth episodes spanned 7-10 days in *Protopanderodus graei* and only 2-3 days in *Periodon aculeatus*. It is postulated the former had a pelagic/nektonic mode of life whilst the latter was nekto-benthic and specialised to living in deep-water habitats. The growth of *P. graei* is further characterised by two distinct phases, the production of a triangular, symmetrical 'proto-element' followed by addition of increments of different thickness to the inner and outer edges. The curved and twisted geometry of the adult element was not initiated until the second phase of growth. This has implications for the function of the proto-element and the mode of life of juvenile animals.

# The origins of herbivory in dinosaurs

*an oral presentation by*

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The first herbivorous dinosaurs arose from their carnivorous dinosaurian ancestors very early, certainly in the Carnian (Late Triassic, 235-220 Ma). New specimens from Brazil, named *Saturnalia*, are probably the oldest sauropodomorphs. These are currently under study in Bristol by Max Langer. Slightly younger is *Thecodontosaurus* from Bristol. This was the fourth dinosaur to be named from anywhere in the world, in 1836, and the first dinosaur to be reported from the Triassic. It was widely rumoured that all the specimens of *Thecodontosaurus* were lost when Bristol City Museum was bombed in 1940. However, some 250 individual bones remain. These show that *Thecodontosaurus* was a 2.5 m long slender biped. It falls in a basal position in the cladogram, according to a new cladistic study. This new work begins to shed some light on the origin of the sauropodomorphs, the group that later included the giant 50-tonne plant-eaters, like *Brachiosaurus* and *Diplodocus*.

# Dinosaur Isle

*a poster presentation by*

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A new museum called 'Dinosaur Isle' will replace the Museum of Isle of Wight Geology in the year 2001. A brief history of the museum and its successful application for Millennium Commission funding is given. Illustrations of the exterior of the new building are included along with a description of its interior. The new museum will consist of three exhibition spaces: the first is given over to a new interpretation of the island's geological history, the main gallery to the dinosaurs, and the third for temporary exhibitions. Interior design will be by Haley Sharpe Associates, who designed of the Evolution of Wales Gallery at the National Museum of Wales. The new exhibitions will have a thematic approach, replacing the formal stratigraphic style of the existing museum, fossils will be put into reconstructed palaeoenvironments, and functional morphology and evolution will be discussed.

## **Silurian birkeniid anaspids from Britain**

*a poster presentation by*

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Most studies of Silurian birkeniid anaspid fish are based on exceptionally well preserved articulated specimens confined to a few stratigraphically restricted horizons in Scotland and Norway. However, disarticulated anaspid scales and plates are fairly common in Silurian marine sediments, show potential for higher resolution biostratigraphy and offer an insight into the phylogeny of this important early vertebrate group. This poster shows articulated specimens of *Birkenia* from the Llandovery-Wenlock of Scotland and *Rhyncholepis*, *Pterygolepis* and *Pharyngolepis* from the lower Ludlow of Norway. Using information on scale and plate morphologies and styles of micro-sculpture from these specimens it is possible to clarify the taxonomy of other disarticulated specimens previously undescribed or left in open nomenclature. A suite of scales from the uppermost Silurian of Man Brook, near Cleobury Mortimer, Shropshire, is shown to be distinct from scales from articulated specimens. Following comparison with disarticulated scales and plates from Estonia, Severnaya Zemlya, the Canadian Arctic and North Greenland, the Welsh Borderland material has been assigned to three new genera: *Manbrookia*, *Trimpleylepis* and *Septentrionia*. A single, partially preserved articulated specimen from the Prídolí of Herefordshire has been re-classified under the genus *Tahulalepis* on the basis of scale sculpture and similarity to scale material from Estonia.

# The ecological effects of volcanic ash-fall in the Middle Ordovician of central Wales

*an oral presentation by*

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Studies of graptolitic and trilobitic shales in the Llandrindod region of central Wales have produced evidence of complex ecological perturbations following ash-fall events. These reactions are shown primarily by the abundance and population characteristics of the partly pseudoplanktic inarticulate brachiopod *Schmidtites?micula*. A two-stage population structure is observed, reflecting planktic and benthic blooms respectively, and involving a range of organisms including inarticulate brachiopods, graptolites, trilobites, ostracodes, bryozoans and sponges. Several sections have been studied, and all show the same basic pattern, although a distinction between those from originally anoxic and dysaerobic benthic facies is discernible. A working hypothesis for the mechanism is outlined, in which localised downwelling through ash entrainment is accompanied by benthic oxygenation and upwelling of nutrient-rich deep water. The tuff compositions vary between andesitic and rhyolitic, with variable levels of alkalis and trace elements. Uranium is absent from all samples analysed, although thorium, lanthanum and niobium are generally enriched.

# Eurypterid palaeobiology: breathing life into fossil sea scorpions

*an oral presentation by*

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Recent research on the palaeophysiology of the eurypterids, extinct aquatic chelicerates, has revised our interpretations of their respiratory and reproductive capabilities. Exceptionally preserved fossils, notably *Onychopterella augusti* from the Soom Shale Lagerstätte, and comparisons with extant taxa have been used to breathe life into these extinct animals, revealing important implications for their palaeoecology and phylogeny. The nature of the eurypterid respiratory system has been unresolved for over a century, but is now interpreted as having involved four pairs of vertically orientated lamellate gills, housed within the branchial chambers (for aquatic respiration) and five pairs of accessory Kiemenplatten, situated on the roof of the branchial chambers (for accessory aerial respiration, by analogy with the pseudotracheae of some extant Crustacea). Eurypterid reproduction is interpreted as having involved indirect spermatophore transfer via the substrate; the female able to store a spermatophore in paired spermathecae until suitable environmental conditions prevailed for spawning. Cladistic analyses generally favour a monophyletic Arachnida, although similarities in their gross morphology and respiratory structures, infers a closer relationship between eurypterids and scorpions. This palaeobiological evidence also supports the view that some eurypterids were

capable of limited amphibious excursions, perhaps associated with their life-cycle (mass-moult-mate events).

## **Plant pyritization: microbial model experiments**

*an oral presentation by*

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Plant tissues may be preserved as fossil charcoal, as macromolecular organic remains, or as a result of the formation of authigenic minerals. Although pyrite is the most commonly involved authigenic mineral, the mechanics and timing of this process are poorly understood. Laboratory microbial decay experiments carried out under a range of conditions (e.g. freshwater/marine, oxic/anoxic) have shown that iron sulphide precursors to pyrite can form within plant material in relatively short periods of time (less than 12 weeks). Such mineral formation, precipitating between cell walls in particular, is associated with cytoplasmic degeneration, deterioration of pit closing membranes and enlargement of pits, flaking and pulling apart of cell walls, and the presence of both bacteria and their by-products. The results of decay and diagenic mineral growth in these experiments are compared with pyritized fossil plants (e.g. from the Eocene London Clay) in order to indicate the conditions under which pyritization occurred and to understand the taphonomic biases involved.

## **Sex, multicellularity and first 'big bang' of eukaryotic evolution**

*an oral presentation by*

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An increasingly well resolved Proterozoic fossil record documents the late Mesoproterozoic to early Neoproterozoic presence of most of the major clades (kingdoms) of eukaryotes, including the rhodophytes, stramenopiles, alveolates and green plants. A coincident rise in acritarch diversity, combined with molecular phylogenetic evidence for rapid cladogenesis, points to a major radiation of eukaryote groups at this time, sometimes referred to as the 'big bang' of eukaryotic evolution. *Bangiormorphapubescens*, from the 1200 Ma Hunting Formation, arctic Canada, is the earliest taxonomically resolved eukaryote on record. More importantly, it is the earliest known example of both sexual reproduction and complex multicellularity. The introduction of differentiated multicellular organisms would have had profound implications for contemporaneous ecology (e.g. with its differentiated basal holdfast *Bangiormorphapubescens* able to anchor itself in the substrate and orient itself vertically-the first instance of eukaryotic tiering-which would in turn have induced new



environments and evolutionary opportunities). Buss (1987) has presented compelling arguments for why sex is a necessary prerequisite to complex multicellularity (by enabling the expulsion of somatic cell parasites), and it is clear that complex multicellularity is the source of almost all organismal morphology. I suggest that the principal significance of the evolution of sex was the 'invention' of organismal morphology, and thereby the directional, escalatory and 'progressive' evolution of a biological environment. The modern eukaryotic kingdoms would appear to be the consequence of that first indulgence.

## **Missing molluscs in a Silurian silicified Lagerstätte - evidence of large scale aragonite dissolution in ancient shallow marine settings?**

*an oral presentation by*

**Lesley Cherns<sup>1</sup> and V. Paul Wright<sup>2</sup>**

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Typical inter-reef faunas from the Silurian carbonate platform of Gotland, Sweden, are dominated by calcitic shells, especially brachiopods. By contrast, shelly assemblages from this same palaeoenvironmental setting that are preserved by very early silicification are dominated by aragonitic molluscs, notably gastropods and infaunal bivalves. Limestone beds formed as a result of shallow burial calcite precipitation, which previous studies have suggested was sourced from aragonite mud. The silicified Lagerstätte represents a taphonomic window, which allows assessment of the importance of aragonitic shells among the original fauna, and points to molluscs as the major source of diagenetic carbonate. Studies of modern carbonate environments indicate that aragonite dissolution is likely to be a significant process in shallow buried sediments as a result of microbially-mediated reactions. Hitherto there has been little evidence to support this from the stratigraphical record. The Silurian case study raises the possibility that paucity of aragonitic molluscs among many fossil faunas is a purely taphonomic effect, and that aragonite dissolution took place on a large scale, even in very shallow tropical 'calcite seas'. This taphonomic bias would have major implications not only for the completeness of the fossil record, but also for estimates of carbonate production rates and sediment budgets.

## **The first articulated Tournaisian tetrapod: an update**

*a poster presentation by*

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A nodule from the the Scottish Calciferous Sandstones, found near Dumbarton, western Scotland, preserves the only known articulated tetrapod material from 'Romer's Gap'. This period between the end Devonian and the mid-Viséan represents the time when tetrapods underwent a major diversification and acquired true terrestriality. However, tetrapod fossils from this period are almost unknown. This specimen is a nearly complete skeleton, lacking only the tail, some digits and the right side of the skull. It derives from the Ballagan Formation, Inverclyde Group, dated as the *claviger-macrapalynozone*, Dinantian, Upper Tournaisian. The animal resembles the Viséan genus *Whatcheeriain* skull morphology, but differs in many postcranial features. Recently uncovered regions include the left stapes, a stout, stubby bone with a large stapedia foramen, resembling that of the Devonian *Acanthostega*. The ribs bear large triangular flanges, the vertebrae are rhachitinous, and the presacral vertebral count is about 27. There is a five-digit pes, but only two manual digits are preserved, one short and stubby and the other slender. The humerus bears a spike-like latissimus dorsi process, resembling that of the baphetid genus *Baphetes*. This specimen should help resolve character polarities, phylogenetic relationships and the acquisition of terrestrial morphologies in early tetrapods.

## **Palaeoecological reconstruction of Lower Cretaceous coral communities of the Neo-Tethys: examples from the Barremian and Aptian of southern France**

*an oral presentation by*

**Nick Clack\***

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A Palaeoecological study of a significant number of Lower Cretaceous (Barremian and Aptian) coral-bearing sequences in southern France has permitted the classification of coral-bearing units according to their litho- and biofacies. Depositional models have been produced, and major controls of coral community development elucidated. Three main types of coral-bearing unit are recognized, based principally upon sedimentological criteria. The nature of the coral fabric and fauna has been used to sub-divide these groups. The classification scheme comprises: (1a) biostromal units developed within pure carbonate facies and typified by tabulo-lenticular coral colony morphotypes; (1b) a biostrome developed within pure carbonate facies, characterized by lamellar to tabulo-lenticular colonies; (2a) biostromal units developed within mixed carbonate/siliciclastic facies, dominated by lamellar and tabulo-lenticular colonies; (2b) biostromal units developed within mixed carbonate/siliciclastic facies, dominated by phaceloid morphotypes; (3) lenticular units developed in relatively pure carbonate facies with evidence for early cementation and dominated by lamellar colonies. Unit types 1, 2 and 3 represent different ranges of environmental conditions, which are discussed. Important abiotic factors controlling development of the coral communities were: light intensity, degree of siliciclastic input and sedimentation rate. In contrast to many shallow marine carbonate systems, hydrodynamic energy was not an important control.

# **Biomolecular Palaeontology - so far, so what?**

*an oral presentation by*

**Matthew Collins**

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‘The topic of Biomolecular Paleontology is rapidly growing in interest but is still largely unknown to most palaeontologists’, wrote Tom Broadhead a decade ago in an introduction to an SEPM short course. Ten years down the line, how has the bandwagon rolled? Undoubtedly a success in terms of acres of newsprint, the field seems to have failed where it matters most, in engaging the scientific community itself. The presentation will consider the potential for the methods to obtain information from degraded proteins in fossils comparing laboratory predictions with experiences in the field. Comparison will be made between survival of proteins in bones and shells; how long do signals last, what types of information can be recovered? Laboratory based estimates of survival generally seem to underestimate the persistence in the fossil record. Conversely there is considerable variation in the signals observed in archaeological and fossil samples, presumably due to accelerated degradation. What controls these patterns and will proteins ever provide useful information for palaeontology?

# **The origins and evolution of the hantkeninid planktonic Foraminifera: an intimate view**

*an oral presentation by*

**Helen Coxall\***

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Morphometric methods are used to explore the origin and evolution of the hantkeninids, a biostratigraphically useful group of planktonic Foraminifera that evolved rapidly during the middle and upper Eocene. Comparative studies of ontogenetic changes in test morphology (using novel X-ray and micro-dissection techniques) combined with the discovery of rare transitional forms, solve the long standing mystery of their origin. During the subsequent evolution of the hantkeninids a number of morphologic characters changed gradually, including (1) orientation of the tubulospines, (2) degree of lateral chamber inflation, (3) pre-adult (internal) chamber geometry and (4) aperture morphology. Isotopic records suggest that the pronounced morphological evolution coincided with a shift from a deep to shallow-water habitat. Further detailed analysis of the biometric data will be aimed at determining the taxonomic status and evolutionary relationships between the 30 described morphospecies of *Hantkenina* and closely related genus *Cribrorhantkenina*, and evaluating their ability to stand as meaningful biostratigraphic markers.

# Changes in molluscan faunas across the K-T boundary in Antarctica

*an oral presentation by*

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Recent field and laboratory investigations have established that the latest Cretaceous (i.e. Campanian-Maastrichtian) sedimentary succession exposed within the James Ross Basin, Antarctica is in excess of 2 km in total thickness. Comprising essentially fine-grained, shallow-water, volcanoclastic rocks that are in places intensely fossiliferous, it represents one of the best opportunities to investigate palaeobiological and palaeoenvironmental changes leading up to the K-T boundary anywhere in the southern hemisphere. The exceptionally early extinction patterns of the inoceramid bivalves and belemnites can be confirmed, but it is apparent that other key groups such as the ammonites and trigoniid bivalves go right up to the boundary itself. Studies throughout the 1000 m thick Maastrichtian sequence indicate that, although molluscan assemblages are abundant, they are never particularly diverse. The benthic element has a distinctly temperate aspect and there is both sedimentological and palaeontological evidence to suggest that it was subjected to periodic intervals of reduced oxygen levels. The comparatively small, but nevertheless still abrupt, extinction event at the end of the Cretaceous in Antarctica may well have been buffered to some extent by both the high-latitude position and unusual sedimentological setting of the basin.

# Latest Cambrian-earliest Ordovician Radiolaria and ribbon cherts from Kazakhstan

*a poster presentation by*

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Our current knowledge of Cambrian-Early Ordovician radiolarian assemblages is very poor, despite their importance for our understanding of the early evolution of the skeletonised planktonic biota and their biogeochemical role in the oceanic silica cycle. Many Radiolaria, some conodont elements and megascleres of hexactinellid sponges were extracted from a ribbon chert, collected from a continuous sequence of radiolarian cherts covering the Cambrian-Ordovician boundary. These cherts form part of the Burubaital Formation, in south-central Kazakhstan, west of the Lake Balkhash. The studied sample comes from the uppermost Cambrian *Cordylodusproavus* conodont biozone (one metre thick

in this section), dated by conodont elements identified in the chert. The radiolarian chert sequence is part of a composite subduction-accretion complex formed along the active margin of the Arenig to Llandeilo volcanic arc, known as Chu-Ili terrane. Amongst the few radiolarian specimens extracted with preserved skeletal elements some seem to be of entactiniid affinity (?*Polyentactinia* sp., e.g. cortical shell made of angular and irregularly shaped pore frames), while others possibly belong to the dominant Ordovician family Inaniguttidae. This poorly preserved radiolarian assemblage is currently the oldest well constrained latest Cambrian fossil evidence linking the single Cambrian species known so far and the diversified Ordovician faunas.

## Unusual soft tissue preservation in Middle Devonian fish-bearing nodule beds

*a poster presentation by*

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The classic Tynet Burn and Gamrie fish localities, in north-east Scotland are of Middle Devonian (Eifelian) age and have, since last century yielded beautifully preserved fossil fish, typical of the Achanarras fauna which occurs in deposits exposed to the south of the Moray Firth and to the far North. The fish are mostly preserved in calcareous concretions and despite the large quantities of specimens that have come from the sites, no special significance has been attributed to the material with respect to unusual preservation. Current detailed work on newly collected material however, has identified new preservational potential for the fish bearing concretions. A number of rare specimens of acanthodians from both sites consistently exhibit dark traces within the body cavity which are analogous with the sites of internal organs in modern groups. Furthermore, dark 'spots' in the heads of acanthodians from Gamrie can be interpreted as the position of the eye. To date, these structures have only been observed in three acanthodian genera, but other groups are present and clearly there is potential for more work. A museum collection survey has been initiated and two more specimens, collected last century, have been located which exhibit internal organ site preservation.

## Upper Ordovician crinoids that rose from the grave

*an oral presentation by*

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Extant stalked crinoids may survive after detachment of the crown, presumably feeding by the

absorption of nutrients through the ectoderm. Oji and Amemiya (1998, *Paleontological Research* 2) have shown that isolated fragments of isocrinid stem can survive for over a year under laboratory conditions, while Donovan and Pawson (1998, *Bulletin of Marine Science* 61) provided compelling evidence for survival for bourgueticrinid stems following predatory decapitation. Hitherto, only one analogous pattern of crownless survival has been reported from the fossil record. D.S. has collected Cincinnati crinoid pluricolumnals from Kentucky, Ohio and Indiana that have rounded ends reminiscent of some modern bourgueticrinid overgrowths following predation. These pluricolumnals are derived from the disparids *Cincinnatiocrinus* and/or *Ectenocrinus*. Such specimens have hitherto been interpreted as distal terminations of mature individuals that have become detached from their holdfasts through autotomy. However, it is considered more probable that they represent overgrowths of the column following predatory decapitation. If this new interpretation is correct, then post-decapitation survival of crinoid stems is now recognized for most of the history of this group, predation on crinoid crowns occurred at least as far back as the Upper Ordovician. Ancient crinoid populations can no longer be determined merely by counting crowns.

## **Acritarch evidence of Silurian cyclicity and climate change**

*a poster presentation by*

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Silurian marine sediments often show a prominent 2nd order cyclicity, recognised in eastern Avalonia and Baltica as alternations in carbonate content and recorded as Primo and Secundo episodes. In the type Wenlock area the large acritarchs *Hogkintia* and *Estiastra* are associated with Secundo episodes, while the climatically wetter, Primo episodes have diverse acritarch assemblages often with a high relative abundance of *Diexallophasis*. Given a duration of 6.4 Ma for the Wenlock, the second-order cyclicity is estimated to have a duration of 5.3 to 5.8 Ma based on 246 to 271 m of sediment thickness in the type area. Third order cycles of increased carbonate or mudstone average 20 m thickness and span 0.43 Ma. Variation in nodular limestone thickness illustrates fourth order cycles averaging 1.25-1.33 m and of 27,000 to 29,000 years duration. These cycles show apparent shifts in the relative abundance of some key acritarchs, and may well reflect climate change. Small-scale limestone-mudstone couplets typical of the Farley Member average 114 mm in thickness, deposited over 2,600 years. These have remarkably uniform acritarch assemblage compositions, although differences in acritarch abundance may suggest they are dilution cycles.

## **Sphenopsids from the late early Carboniferous of Paracas (Peru): implications for sphenopsid evolution in Gondwana**

*an oral presentation by*

## **Beatrice Lucy Dower**

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Carboniferous deposits from the Paracas Peninsula, Peru, have yielded numerous vegetative and reproductive remains of sphenopsids. These represent a warm temperate climatic region different from the tropical deposits of Euramerica and Angara, and the cool temperate deposits of other parts of Gondwana. There are six organ taxa, three of which are new: *Pothocites benavidesi* sp. nov., *Nazcaphyllum ricardi* gen. et sp. nov. and *Piscostachys rotatus* gen. et sp. nov. *P. benavidesi* is an adpressed archaeocalamite strobilus differing from *P. grantonii* Paterson, also present in the flora, in non-operculate sporangiophores and overall dimensions. It is equivalent to the anatomically preserved *Protocalamostachys farringtonii* Bateman from Scotland, and is organically attached to *Archaeocalamites radiatus* Brongniart. *N. ricardi* is a new foliage taxon with large, broad, flexible leaves in whorls on juvenile shoots of Sphenophyllum-like axes. *Piscostachys rotatus* strobili are very complex, with globular-ended sporangiophores and pedunculate sporangia, possibly held on *Nazcaphyllum* stems; the ordinal affinity remains enigmatic. Paracas also yields Sphenophyllum cf. *myriophyllum* Crépin. These new organ species illustrate the potential wealth of new taxa in this relatively unknown floral realm, and have revealed several potential homologies in vegetative and reproductive morphology.

## **Footprints on the shore: twitching in the Miocene**

*an oral presentation by*

**Peter Doyle, Jason L. Wood & Gareth G.T. George**

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The Late Miocene Sorbas Member of the Sorbas Basin, Almería Province, southern Spain contains an extensive avian ichnofauna preserved in lagoonal marls. From five excavated surfaces, the largest being up to 3 square metres in areas, at least three distinct avian track morphologies may be recognised, with rarer mammalian tracks. The avian tracks can be related to shorebird trace makers, including plovers, storks and ducks, and are consistent with other recorded examples of the shorebird ichnofacies in the latest Cretaceous to Recent fossil record. The Almerían tracks are abundant and show a range of behavioural aspects consistent with Recent shorebird behaviour. Duck and stork tracks have mostly single and multiple unidirectional movement, and are associated with mostly desiccated surfaces. Plover and wading-bird traces are most commonly multidirectional, with a larger number of individuals, and are associated with moister sediments. This is indicative of finer-scale environmental aspects of individual trace makers, with waders operating at the shoreline itself, close to water's edge, while ducks traversed outer desiccating surface. This example demonstrates the value of the shorebird ichnofacies as an environmental tool in Cenozoic shoreline environments.

# The Carboniferous arachnid *Plesiosiro*

*a poster presentation by*

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*Plesiosiro madeleyi* Pocock, 1911, is the monotypic representative of the fossil order Haptopoda Pocock, 1911, from the British Middle Coal Measures (Upper Carboniferous, Westphalian B) of Coseley, Staffordshire. *Plesiosiro* was probably a predator, having tooth-like projections on the femora for prey capture and shows adaptations of the limbs for crawling in narrow spaces.

*Plesiosiro* resembles troglid opilionids, but the redescription presented here identifies a large genital operculum in *Plesiosiro*, a synapomorphy for Tetrapulmonata (i.e. spiders and their closest relatives), and it is tentatively referred to this clade. Based on the synapomorphies of a divided sternum and subdivided tarsi a relationship of the form: (*Plesiosiro*(Amblypygi (Thelyphonida + Schizomida))) is proposed.

# *Glaucanome*: a probable primitive charophyte from the Silurian of Clare Island, County Mayo, Ireland

*an oral presentation by*

**David H. Evans<sup>1</sup> & John R. Graham<sup>2</sup>**

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Small frond-shaped organisms from the Silurian Inliers of the Midland Valley of Scotland were termed *Glaucanome* by Peach & Horne (1899) who attributed them to the Bryozoa. A similar organism was reported from the Bunnamohaun Siltstone Formation of Clare Island by Philips (1974) who attributed it to a 'a problematic sea pen-like structure'. Re-examination of Phillips's material by Muggier & Palmer, and study of material from the Midland Valley, confirmed that the specimens were identical, and the term *Glaucanome* is used for the material described and discussed here. Large collections of *Glaucanome* made by Maguire, Graham & Palmer in 1987 from Clare Island have made a detailed study of this organism possible. The units from which *Glaucanome* has been recovered on Clare Island consist of red siltstones associated with coarser beds, which with the presence of climbing ripple drift cross lamination, together with water escape structures and polygonal dessication cracks are interpreted to represent the deposits from floods onto extensive mudflats where temporary bodies of standing water persisted after the floods, but eventually dried out. Study of the Clare Island *Glaucanome* specimens has involved a detailed analysis of their taphonomy, yielding much information with regard to the nature of the skeleton and morphology of the organism. It is argued the taphonomic data combined with the overall morphology indicates that they are most likely to represent structures forming part of an early charophyte. A Wenlock age has been attributed to the Bunnamohaun Siltstone Formation. But there is no independent evidence to



constrain this date. Nevertheless, if correctly assigned, *Glauconomea* may represent one of the earliest charophytes known at present. Although some Devonian and early Carboniferous charophytes have been regarded as marine in habitat, the group has otherwise been regarded as inhabiting freshwater or brackish environments; their presence in the Bunnamohaun Siltstone Formation seems to support the interpretation of the depositional environment made on sedimentological grounds.

## **The relationship between leaf longevity and growth-ring markedness in conifers: palaeoclimatological and palaeoecological implications**

*an oral presentation by*

**Howard J. Falcon-Lang\***

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Growth rings in modern conifer woods were numerically analysed to investigate the relationship between leaf longevity and the markedness of the growth-ring boundary. Five conifer taxa grown in southern England and exhibiting a wide range of Leaf Retention Times (LRTs) were examined in transverse section. These were: *Larix decidua* (deciduous), *Pinus sylvestris* (LRT = 1-3 yrs), *Picea abies* (LRT = 3-5 yrs), *Cedrus libani* (LRT = 3-6 yrs), and *Araucaria araucana* (LRT = 3-15 yrs). Two aspects of ring markedness were quantified: (1) the percentage of latewood in each growth-ring increment and (2) the difference between the maximum and minimum radial cell diameters in the growth-ring increment expressed as a percentage of the maximum cell diameter (percentage diminution). The product of these two parameters were calculated to give a Ring Markedness Index (RMI) for each taxon. Statistical analysis of these data show that there is a significant inverse linear relationship between median LRT and RMI ( $R^2 = 0.91$ ), percentage latewood ( $R^2 = 0.86$ ), percentage diminution ( $R^2 = 0.77$ ) at  $p < 0.001$ . These data clearly indicate that leaf longevity not growing environment exerts the largest control on growth ring markedness. These results have two important palaeontological implications: (1) percentage latewood cannot be used as simple tool for interpreting palaeoclimate and (2) fossil woods produced by evergreen and deciduous conifer taxa may be distinguished from one another by means of a detailed numerical analysis of growth rings.

## **Forests, fire and frost: Jurassic forests and volcanic environments in Antarctica**

*an oral presentation by*

**Jane Francis**

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From the Permian until the early Tertiary, Antarctica was covered by lush forest vegetation, despite its high latitude position. During the Jurassic, however, the break-up of Gondwana led to the rifting

and extrusion of a great volume of volcanic magma across the Antarctica landscape. Forests were engulfed in volcanic lava flows and lahars, and their scorched remains subsequently petrified. A few plants survived alongside small ponds amid vast lava fields, along with a rich fauna of fish, insects, ostracods and gastropods that lived in the freshwater lakes. The threat of glaciation, as indicated by Jurassic diamictites, may also have made this dynamic environment an even more dangerous place for trees.

## **A major fire event and its effects on the peat forming vegetation of the Permian, Lower Whybrow Seam, New South Wales**

*an oral presentation by*

**Ian Glasspool**

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Petrographic and mesofossil analyses of the Upper Permian, Lower Whybrow Coal, New South Wales, Australia, have revealed a significant fire event in both the swamp setting and the hinterland. This fire event is marked by a change in the proportion of inertinite (charcoal) and mineral matter in the seam. The latter resulting from increased run-off and erosion in the hinterland following vegetation death. This major fire event is also recognised by a change in the vegetation, as represented by the mesofossil content (pollen sacs, seeds and megaspores) of the seam. Destruction of the glossopterids, and a subsequent re-colonisation event by rhizomorphs (a fern spike) is recorded. This evidence for a major fire, and its implications for the origin of inertinites, leads to the conclusion that in this, and other Permian Gondwana coals, fire was an integral part of a dynamic temperate swamp ecosystem.

## **Functional morphology of the coracoid bar of the Spiny Dogfish (*Squalus acanthias*): implications for the evolutionary history of the shoulder girdle of vertebrates**

*an oral presentation by*

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The head skeleton of sharks (Selachii) consists of the chondrocranium and the mandibular, hyoid and branchial arches. The coracoid bar, which serves as base for the pectoral fins, is generally homologized with the pectoral girdle of the appendicular skeleton of tetrapods. However, new

functional-morphological observations and theoretical considerations, warrant a reanalysis of these assumptions. The coracoid bar of the Spiny Dogfish (*Squalus acanthias*) plays two major roles: (1) as separator between the lateral undulations of the trunk and the vertical movements of the visceral arches; and (2) as place of origin for specific muscles (*M. coracomandibularis*, *M. rectus cervicis*, and certain *Mm. coracobranchiales*), which not only open the jaw and expand the branchial basket, but also support the contractions of the heart and influence the timing of the blood circulation through the gills. As a consequence, the coracoid bar is an integral part of the head, which is a mechanical unit formed by the skeletomuscular and circulatory systems. This particular conceptualization of the selachian head raises questions concerning the evolutionary transformations of the various components of the head, cervical region, and pectoral appendages during the transition from aquatic pisciform to terrestrial tetrapod vertebrates.

## **Cladistic analysis of rugose corals-some methodological aspects**

*an oral presentation by*

**Bjarte Hannisdal**

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The construction of a character-taxon matrix is fundamental to cladistic analysis, and some of the methodological issues involved in the making of the data matrix are discussed. Three vital stages are emphasized: 1) character construction, 2) coding procedure, and 3) polarity and rooting. Characters used in cladistic analyses are constructed, on the basis of observed variation, in a manner fitted to a specific taxonomic problem. In the case of rugose coral species, this necessitates the recognition of continuous, quantitative variables. There is a subtle interaction between the observation of variables and the semantics of character naming, with non-trivial implications for parsimony analysis. Character coding can be approached in several ways, and alternative coding schemes are considered. Incorporating stratigraphical information in the data matrix may represent a way of adding a temporal dimension to the analysis, in a 'total evidence' approach. Examples are drawn from a preliminary study, in which cladistics is applied to entelophyllid rugose coral species from the Silurian of Northern Europe, to illustrate some effects of different approaches. Specific choices of procedure affects character distribution, tree topology and homology assessment. It is argued that if the data matrix is to be accessible to other workers, and open to testing, the construction of the data matrix must as far as possible be made explicit.

## **Patterns of boring predation on brachiopod prey: ancient and modern**

*an oral presentation by*

**Liz Harper**

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There is a strange contradiction in the perceived importance of predation pressure on the evolution of brachiopods. On the one hand, there is a popular notion that brachiopods, articulates in particular, are unattractive to predators and have been so in the geological past, in which case predation cannot have been an important evolutionary selection pressure. On the other hand, direct predation pressure on vulnerable brachiopod taxa has been used to explain why brachiopods failed to significantly re-radiate after the Permian-Triassic mass extinction. Feeding experiments on *Trophon* sp., a large boring muricid gastropod from Antarctic waters, show that they are capable of preying on terebratulid brachiopods in a stereotyped manner. Observations from these experiments will be used in the interpretation of Mesozoic and Palaeozoic brachiopods which appear to have been punctured by boring predators.

## **Middle and Upper Devonian palynology of the Sierra de Perijá, western Venezuela**

**Craig Harvey\***

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Middle and Upper Devonian deposits crop out in a small inlier in the Sierra de Perijá, western Venezuela. These deposits belong to the Campo Chico Formation which is subdivided into lower and upper members. Palynological investigation has revealed that each member is characterized by a distinct palynomorph assemblage. The assemblage from the Lower Member is dominated by terrestrial palynomorphs that are poorly preserved. Age diagnostic taxa include the spores *Samarisporitestriangulatus*, *Aneurosporagreggsii* and *Geminosporalemurata*, and the assemblage suggests a mid to late Givetian age. The assemblage from the Upper Member contains well preserved terrestrial (spores) and marine (acritarchs and chitinozoans) palynomorphs. Important spores include *Verrucosisoritesbulliferus*, *Geminosporaboleta*, *Cymbosporiteshormiscoides*, members of the *Spealeotriletes* complex and *Ancyrosporasp.*; noteworthy acritarchs include *Chomotriletesvedugensis* and *Daillydiumpentaster*. The assemblage is assigned an early Frasnian age. The Campo Chico Formation is interpreted as accumulating within a delta environment controlled by a complex fluvial system. Acritarch/chitinozoan abundances suggest that marine influence increased into the early Frasnian. The new biostratigraphical data provide age constraints for important plant megafossil assemblages preserved in these deposits. It is anticipated that palynological comparisons with material from adjacent palaeocontinents will determine the palaeophytogeographic affiliations of the Venezuelan material (Gondwana or Euramerica?).

## **Ghosts of ammonites past**

*a poster presentation by*

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A single specimen of the Jurassic ammonite *Sigaloceras calloviense* collected from a calcareous sandy concretion within the Kellaways Beds (Lower Callovian) from Fairford, Gloucestershire appears to preserve ghosts of soft parts preserved within the body chamber. The outer shell of this adult ammonite (microconch) has been dissolved away, revealing the sutures and body chamber. The aperture is plugged with sediment, but the anterior portion of the body chamber is occluded by amber-coloured ferroan calcite which contains a dark area whose outline compares with morphology of soft tissues seen in *Nautilus pompilius*, the ammonites' closest living relative. Fabric-destructive geochemical analysis is precluded as no other specimens from the same locality have been found with calcite-filled body chambers, although the search continues!

## **A new Tertiary flora from West Antarctica: implications for palaeoclimate and geochronology**

*an oral presentation by*

**Richard J. Hunt<sup>1</sup> & John L. Smellie<sup>2</sup>**

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A leaf flora of ?Miocene age has been described from a sedimentary sequence close to Vaureal Peak, King George Island, West Antarctica. The sedimentary succession is dominated by debris flows with minor fluvial deposits indicating a humid environment, with unstable topography which was prone to inundation by lahars and avalanching. The macrofossils are preserved as impressions in a fine- to coarse-grained, volcanically derived sandstones, retaining no original organic matter. Six angiosperm leaf forms have been identified and a single fern form. Leaves of the genus *Nothofagus* account for c. 75% of the total leaf specimens. Three of the angiosperm leaves are referable to *Nothofagus*, whilst two of the remaining specimens may be referable to the Lauraceae and/or Myrtaceae families. No evidence was found of gymnosperm remains. Vaureal Peak itself is a stacked lava sequence whose source vent is unknown but was probably situated close by (within a few kilometres), possibly within the margins of the present day Bransfield Strait. Birkenmajer (1987) interpreted the Vaureal Peak outcrop (including the beds now known to contain plant fossils) as a post glacial sequence, which was lifeless following the presumed glacially induced extinction of the terrestrial biota. The presence of the Vaureal Peak flora indicates either that land plants survived at least one phase of West Antarctic glaciation or that the current geochronology for the area is inaccurate and that the flora is actually much older, possibly contemporaneous with other macrofossil assemblages on the island. New <sup>40</sup>Ar-<sup>39</sup>Ar dates of the basaltic-andesitic volcanics and a reinterpretation of the local geology will determine which of these two hypotheses is correct.

# **Benthic foraminiferal assemblages and geochemical variations: proxies for sea-level change in the Lower Jurassic of Yorkshire?**

*a poster presentation by*

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The Pliensbachian-Toarcian (Lower Jurassic) sediments of the north Yorkshire coast contain highly organic-rich shales where the sequence stratigraphic significance is somewhat obscure. Benthic foraminiferal species distribution (as a function of organic flux and oxygenation) allows palaeobathymetry to be determined on quantitative assemblage characteristics. In parallel with this methodology, a suite of trace elements (including Mn, Ca, Fe, and Al) have been analysed following nitric and hydrofluoric acid digestion. Mn, in particular, has been considered to be a robust indicator of sea level change. Maxima of Ca and Mn occur at the base of the *Falciferum* Subzone (*Falciferum* Zone); Al values show minimum values at this horizon. It is suggested that these maxima are an artefact of condensation of carbonate fossiliferous material due to sediment starvation and correspond to published estimates of a maximum flooding surface. Interpretations of the benthic foraminiferal assemblages surrounding this event provide further support for a transgressive event associated with the development of low oxygen conditions and the deposition of organic-rich shales. Where single proxies may lack an independently confirmed basis, this study demonstrates that simple multi-disciplinary approaches can effectively be combined to reconstruct sea level histories and palaeoenvironmental change in mudrock dominated successions.

# **Ontogenetic records in the shell of the Queen Scallop as evidence of late Cenozoic marine palaeotemperatures**

*an oral presentation by*

**A. L. A. Johnson<sup>1</sup>, J. A. Hickson<sup>1</sup>, J. Swan<sup>1</sup>, M. R. Brown<sup>2</sup>, T. H. E. Heaton<sup>3</sup>, S. Chenery<sup>3</sup> & P. S. Balson<sup>3</sup>**

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Investigations of modern and subfossil examples of the Queen Scallop (*Aequipecten opercularis*) have shown that shell is deposited throughout the first year of growth and in oxygen-isotopic equilibrium with seawater; a full and accurate record of seasonal temperature variation is thus registered. The shell concentration of the trace elements strontium and magnesium does not vary seasonally but the width of microgrowth increments shows a marked temperature-related seasonality

which affords a means of checking isotopically based temperature estimates. Application of this joint approach to Pliocene shells from East Anglia shows that preliminary isotope results (which yield temperature estimates strongly at variance with indications from assemblage composition) may reflect anomalously cool years. Increment-width data can be recovered easily (and cheaply!) through use of image-analysis software and can thus provide a substantial supplement to isotope data. In view of the short-term variability of marine shelf temperatures a large dataset is essential for correct determination of mean conditions.

## **Definition and correlation of the Turonian sub-stage boundaries in the Egyptian Cretaceous based on ammonites and echinoids**

*an oral presentation by*

Ahmed S. Kassab

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The present study utilizes more than one fossil group to trace the sequence of events around the Turonian sub-stage boundaries in several sections in the Egyptian Cretaceous. Integration of ammonite and echinoid zones has been used for a precise definition of these boundaries. The established macrozones are calibrated with foraminiferal ones for the purpose of regional stratigraphy and inter-regional correlation. Evolutionary trends, morphological changes and faunal diversity have been followed throughout the sections studied. The basal Turonian is marked by occurrence of the ammonites *Vascocerasporium* and/or *Pseudaspidoceras flexuosum* as well as the echinoid *Micrasterleskei*. The Lower/Middle Turonian boundary is defined by the appearance of ammonites of the *Choffaticeras segne* group and the echinoid *Petalobrissus balli*. The Middle/Upper Turonian boundary is drawn at the first appearance of *Coilopoceras requienianum* ammonites as well as occurrence of the echinoids *Micraster corbovis* and *Petalobrissus ammonis*. The Upper Turonian boundary is marked by the disappearance of *Coilopoceras* and *Micraster corbovis* as well as the appearance of ammonites and echinoids of Coniacian age. Palaeobiogeographic relations and inter-regional correlation of the studied sequence are also discussed.

## **Giant bivalves from a Barremian (Early Cretaceous) seep system in Wollaston Forland, Northeast Greenland**

*an oral presentation by*

**Simon R. A. Kelly, Eric Blanc, Simon P. Price & Andrew G. Whitham**

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Anomalous mound-forming limestones occur within normally poorly fossiliferous Barremian

mudstones on Wollaston Forland, NE Greenland. They contain a locally abundant and unusual faunal assemblage, dominated by the large lucinid bivalve *Cryptolucina*, and occasionally with *Solemya*; both are known seep-associated genera. Locally, a giant anomalodesmatid, gen. et sp. nov., is common; it reaches 400 mm in length and has a shell thickness reaching 20 mm. Common driftwood and the abundant associated wood-boring bivalve *Turnus* may be fortuitously preserved because of the mineralisation associated with the seep. A number of ammonites, belemnites, nautiloids, and a remarkable, large, orthoconic phragmocone indicate the presence of active predators. The form of the mounds, with calcite-cemented tube systems, associated laminated calcite crusts and void fills probably indicates a methane-based cold-seep complex. However, the shell preservation is now mainly siliceous, which precludes conclusive geochemical studies concerning their origin. It is believed that the mounds formed on a mid- to outer-shelf situation during the period of quiescence following earlier Cretaceous extensional rifting on the eastern Greenland passive Atlantic margin. The underlying faults may have provided routes for methane migration which was probably generated by biogenic action.

## How did Palaeozoic stromatoporoids relate to their substrates ?

*an oral presentation by*

**Stephen Kershaw<sup>1</sup>, Rachel Wood<sup>2</sup> and Li Guo<sup>3</sup>**

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The traditional view of growth of stromatoporoid sponges is that individuals began by settling on a hard object (e.g. shell fragment), and grew across neighbouring substrate, which was often soft argillaceous calcareous muds. In some cases they may have settled directly on soft muds, and until recently little evidence of original growth cavities has been recognised. In most cases, the base was assumed to have been in complete contact with substrate throughout life, with lateral growth more important than vertical growth. Common cryptic faunas on stromatoporoid bases were assumed to be facilitated by scouring of sediment, or storm-induced movement across uneven substrates, creating secondary cavities. Ragged margins of stromatoporoids were assumed to have formed by episodic sedimentation killing topographically lower flanking portions of the skeleton, with recovery over the new sediment surface. Reassessment of these assumptions is stimulated by discoveries of numerous examples of original growth cavities, proved by downward growing cryptic organisms and geopetal cements beneath stromatoporoid bases. Cavities were formed by the stromatoporoid skeleton arching over sections of substrate, touching the sediment in only a few places; in stabilised stromatoporoids, thin laminar outgrowths can extend laterally for up to 1 m, without touching substrate. Original growth cavities seem to be common in Devonian stromatoporoids, their preservation assisted by the large amounts of early marine cement known in Devonian rocks. Original cavities are also recognised in some Silurian examples, and suspected to be more common, but there is less early cement to prevent compactional closing of cavities. The likely reason why stromatoporoids grew above their



substrates is a response to sedimentation, so that while the formation of ragged margins cannot be always assumed to be due to direct deposition, they retain their value as sedimentation indicators. Accompanying reef metazoans (corals) produce lateral outgrowths, so their occurrence in stromatoporoids is consistent with reef metazoan growth habits.

## **Measuring growth rates in fossil bryozoans: inferences for carbonate production**

*an oral presentation by*

**Marcus M. Key, Jr<sup>1</sup>, Patrick N. Wyse Jackson<sup>2</sup>, Abigail M. Smith<sup>3</sup> & Catherine M. Jamet<sup>1</sup>**

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This is a preliminary report on a methodology to quantify growth rates in fossil bryozoans. It uses seasonal water temperature fluctuations as recorded in skeletal oxygen isotopic ratios to determine annual growth rates, rather like counting geochemical tree rings. A correlative study was performed on living cyclostome and cheilostome bryozoans from the Otago Shelf, New Zealand, including *Adeonellopsis* sp., *Celleporaria agglutinans*, *Celleporina grandis*, *Cinctiporaelegans*, and *Hippomenella vellicata*. Growth rates were determined from mark and recapture, <sup>14</sup>C dating, and oxygen isotopes. Carbonate volume was determined morphometrically. The methodology is now being applied to fossil bryozoans from the Ordovician Tramore Limestone Formation which crops out in Co. Waterford in southeastern Ireland. This formation was chosen as it had a high paleolatitude (60°N), and thus GCMs predict a 5°C seasonal water temperature variation. Several species of trepostome bryozoans, with either hemispherical or ramose growth forms, have been collected, and their mineralogy is being tested for diagenetic alteration before isotopic analysis. It is hoped that this methodology will permit the quantification of carbonate production rates in fossils that lived in environments with strong seasonal water temperature fluctuations and whose original oxygen isotopic signatures are preserved.

## **The walking techniques of Burgess Shale arthropods: a quantitative assessment**

*a poster presentation by*

**Abigail Lane**

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Although the arthropods of the Burgess Shale fossil assemblage have been described in detail and in

many cases their functional morphology has been assessed, few studies have interpreted their walking techniques; those which have were based on qualitative rather than quantitative analyses. Computer modelling was used to quantify the range of walking techniques available to the arthropods *Burgessiabella*, *Canadaspisperfecta*, *Habeliaoptata*, *Olenoidesserratus* and *Sidneyiaexpectans*, from the Burgess Shale. The range of both possible and optimal gait patterns were identified, in terms of body stability and power efficiency. The optimum gait patterns were used to produce hypothetical trackways for these arthropods, under conditions where all footfalls produce a track. Comparison of these hypothetical trackways with fossil trackways from Cambrian deposits (e.g. the Tapeats Sandstone and Bright Angel Shale Formations of the Grand Canyon) can allow the attribution of producers to trace fossils, and infer the presence of some of these arthropods in sediments where their body fossils are not preserved.

## **Solute morphology in the light of a new system of skeletal homologies for echinoderms**

*an oral presentation by*

**Bertrand Lefebvre**

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Solutes are asymmetrical, calcite-plated, marine Palaeozoic fossils (Middle Cambrian-Lower Devonian) whose systematic position is still warmly disputed. In spite of obvious echinoderm characters (stereom), the lack of five-fold symmetry causes them to be interpreted either as very primitive echinoderms or as 'calcichordates' (primitive chordates). Recently, a new model of skeletal homologies for echinoderms has been proposed by Mooi *et al.* (1994): the Extraxial Axial Theory (EAT). This system does not only rely on similarity of position but is also based on major aspects of ontogeny. The EAT allows us to identify two major components in the body wall of all echinoderms: 1) the axial region is associated to the mouth and to the water vascular system; 2) the extraxial region forms the rest of the body wall and contains several openings (anus, hydropore). All aspects of solute morphology can be interpreted in the light of this new model. The short appendage of solutes corresponds to a single brachiole and to the axial component of the body wall. The theca and the long appendage (stem) of solutes consist of extraxial elements. Consequently, the echinoderm affinities of solutes can be definitely established.

## **Synchronous collapse, and recovery, of the terrestrial and marine ecosystems during the Permian-Triassic interval**

*an oral presentation by*

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The marine sediments of Jameson Land, East Greenland, preserve a unique record of the Permian-Triassic extinction event. High rates of sedimentation, controlled by active faulting, have produced a greatly expanded succession compared to other sections worldwide. In addition, the sediments have suffered remarkably little burial and thermal alteration and contain well preserved marine organisms and terrestrially derived plant remains. For the first time, it is possible to compare the terrestrial and marine fossil records of this extinction event using the same samples from the same sections. These studies have importance for palaeoecology as well as for correlation between marine and terrestrial sections worldwide. Marine ecosystem collapse is signalled by a sharp reduction in bioturbation, a disappearance of Permian taxa, a sharp decrease in the  $\delta^{13}\text{C}$  curve (interpreted as an indication of productivity collapse) and the appearance of widespread oxygen restriction. This all occurs within approx. 50 cm at the top of the Schuchert Dal Formation. During the same interval, there is also a turnover in the terrestrial ecosystem from gymnosperm to pteridosperm dominated floras. Studies of sections in northern Italy also suggest that a similar synchronicity exists in the timing of ecosystem recovery in both marine and terrestrial realms during the late Lower Triassic.

## **Palynology, stratigraphy and palaeoecology of the Middle Cretaceous (Aptian to Cenomanian) sequence of the Sanhur-IX borehole, northern Western Desert, Egypt**

*an oral presentation by*

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Characteristic Middle Cretaceous (Aptian to Cenomanian) miospores and dinoflagellate cysts were recovered from the subsurface section of the Sanhur-IX borehole, northern Western Desert. In addition to world-wide correlations, age assessments were partly based on calibrations with the available independently controlled palynomorph data in the region. Other local palynomorph ranges which came from the conventional cores beside the highest appearance data from cuttings were also applied. In this talk we discuss the published material dealing with Middle Cretaceous palynomorphs of the northern Western Desert basins. The study was extended to correlate with other Aptian-Cenomanian miospores known from other closely related palaeogeographic areas in the African and South American continents (i.e. the known Middle Cretaceous African-South American Province of Herengreen 1974). It is suggested that some ranges of stratigraphically significant miospores such as the Aptian-Cenomanian *Afropollisjardinus* (Brenner) Doyle *etal.* 1982 appeared later (Albian) in the Western Desert area. The palaeoecology is interpreted on the basis of the identified palynomorphs in the light of their palaeoenvironmental preferences. The occurrence of marine elements (dinocysts, microforaminiferal linings, marine acritarchs) together with the land-derived pollen, spores and

freshwater algae, is generally indicative of deposition in the shallower parts of the shelf.

## **Palaeoecology of eurypterids from the Upper Silurian of the Welsh Borderland**

*an oral presentation by*

**Phillip L. Manning**

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Eurypterids, an extinct group of aquatic chelicerates, were undoubtedly affected by environmental constraints imposed by their physiology and gross morphology, as are modern aquatic organisms. Kjellesvig-Waering (1961) proposed a series of distinct ecological phases for eurypterids, defined by the environment in which they lived, and based on the Upper Silurian Welsh Borderland fauna. However, evidence from the eurypterid fauna of the Upper Silurian Bertie Waterlime Formation, New York, suggests that two distinct transitional assemblages existed, perhaps caused by a difference in the environmental preferences of juvenile and adult eurypterids ('ontogenetic segregation') (Manning 1993). The eurypterids from the Upper Silurian of the Welsh Borderland may represent a previously undescribed, ontogenetically mixed, eurypterid assemblage, influenced by a series of facies changes; this is supported by sedimentological evidence (Manning, 1993). The distinct ecological phase model (Kjellesvig-Waering 1961) is rejected in favour of ecological gradients overlapping non-distinct eurypterid phases (inter-phase mixing). Inter-phase mixing might have been complicated further by the influence of ontogenetic migration of species across both physiological and environmental gradients. Combining this with new fossil evidence on the dual respiratory and osmoregulatory systems of eurypterids (Manning 1993; Manning & Dunlop 1995) leads to a better understanding of the palaeoecology of this enigmatic group.

Kjellesvig-Waering, E. N. 1961. The Silurian Eurypterida of the Welsh Borderland. *Journal of Paleontology*, **35**, 784-835.

Manning, P. L. 1993. *Palaeoecology of the eurypterids of the Upper Silurian of the Welsh Borderland*. Unpublished M.Sc. thesis, University of Manchester.

Manning, P. L. & Dunlop, J. 1995. The respiratory organs of eurypterids. *Palaeontology*, **38**, 287-297.

## **The earliest known Devonian seed-megaspore**

*an oral presentation by*

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During Devonian times plants showed a rapid evolution in the sophistication of their reproductive structures from simple homospority to heterospority and ultimately the earliest seeds. This evolution is not a regular progression but rather a series of grades of reproductive sophistication which occurred within many different Devonian plant groups. Hence there are a number of reproductive structures with a seed-like organization. An example of this are the seed-megaspores which characteristically consist of tetrads in which only one member becomes large and fully functional. The earliest known seed-megaspores of this type are those from the late Middle Devonian of East Greenland. Additional specimens have been collected from the Ella Island locality which enables a more comprehensive description and interpretation to be made including its palaeobotanical affinities. Detailed documentation of the megaspore samples shows that these seed-megaspores, although apparently common within a few samples, are in fact exceedingly rare and only present at low percentages within the most megaspore rich horizons. These megaspores are generally large and ovoid often with the three smaller abortive spores attached in a tetrad. Seed megaspores without the abortive spores are larger in size whilst those which show the most inflation are those with gaping suturae. These are presumed to be megaspores within which the gametophyte germinated. The seed-megaspore shows, under the optical microscope, three distinctive wall layers. An inner optically homogenous layer, the main megaspore wall and a rarely preserved outer striated layer. This layering is confirmed by transmission electron microscopy which also shows these layers to be homogeneous in composition. These seed-megaspores have a variably developed distal stalk. None have been found attached to a parent plant. This material is significant in that it demonstrates that reproductive structures very close to seeds were present for quite a considerable interval of the Devonian before what are strictly defined as true seeds evolved.

## **Dishing the dirt on our ancestors: fossilisation in archaeological cess pits and its implications for the fossil record**

*an oral presentation by*

**Lucy M. E. McCobb\***

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Archaeological fossils are a valuable source of information about fossilisation processes in terrestrial environments, revealing the early effects of the diagenetic processes which ultimately shape the ancient fossil record. Biological remains and sediments from ancient cess pits in York have been investigated. The fossils recovered include bones, and mineralised and organic arthropod remains and seeds. Mineralised fossils are replaced by calcium phosphate and are often preserved within faecal concretions. Generally only soft tissues, such as fly pupae and seed embryos, are preserved in this way. The fossils show a high level of structural preservation under SEM, retaining cell walls in seed endosperm and cotyledon tissues and muscle tissue, possible blood vessels and setae in maggots. The closed conditions required for phosphatisation may have developed through daily addition of organic matter to the pits or, on a localised scale, within seed coats. Ion concentrations in the phosphatised fossils suggest that iron-reduction and manganese-reduction were important microbial metabolic pathways involved in their decay. Non-mineralised organic remains are represented principally by

seed coats and arthropod cuticles, which show a high level of morphological preservation under SEM. Seed coats and beetle elytra show only minor degradation of cellulose and protein (as revealed by Py-GC/MS).

## **A bryozoan boundstone from the Upper Carboniferous of the Cantabrian Mountains, northern Spain**

*a poster presentation by*

**Elke Minwegen**

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A rare and unusual type of red-coloured limestone was found in the Picos de Europa Mountains near the small village La Hermida, approximately 15 km to the south of Panes, Spain. The unit is more than one metre thick and represents a unique facies which is generally uncommon in this area. Bryozoans are the dominant biota found in the carbonates. The colonies are closely packed, frequently preserved in growth position, and consist of branching stems of mostly unbroken bryozoans. Characteristic features, such as fibrous calcitic wall structures and tubular or rounded chambers (zooecia), mainly with radial distribution, are also preserved. The colonies occur in a matrix of dense lime mud, sometimes with pelmicritic texture. It is assumed that the bryozoans influenced the sedimentation locally by mud trapping and binding. Together with crinoids and brachiopods, they built small bioconstructions attaining minor palaeorelief. Other skeletal elements are only accessory contributors. The occurrence of low diversity communities probably reflects the unstable, extreme conditions in this depositional environment. The limestone was deposited in the deep supratidal zone in Moscovian times in a low-energy environment on a carbonate platform, before the Variscan orogeny encroached on this area.

## **Where do mackerel come from?**

*an oral presentation by*

**Kenneth A. Monsch**

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The mackerel-like fishes (suborder Scombroidei) can nowadays be found all over the world. These fishes are the object of my research. The objective is to solve problems regarding their evolutionary relationships. As this is a project that is still very much in progress, I will present the preliminary results of the research into the stratigraphy and palaeobiogeography of these fishes. Using their excellent fossil record, I can compare the stratigraphic record of the scombroids with the different evolutionary hypotheses. Although the cladogram that has the best fit to the stratigraphic record might not represent the real phylogeny, it will weaken or strengthen ideas on evolution of the group in question. Using the same fossil record, I can also track down palaeobiogeographical patterns of

scombroids. Will we be able to find out where the first mackerel came from? How did scombroids spread over the world ever since? Tackling the issues described above, I seek to contribute to the solution of the evolutionary puzzles of mackerel-like fishes.

## Problems pigeon-holing Palaeozoic ‘Paper Pectens’

*an oral presentation by*

**Chris Peel**

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Some lineages of the thin-shelled, flat-valved ‘Paper Pectens’, which are often encountered in the oxygen-restricted facies of the Palaeozoic and Mesozoic, appear to exhibit rapid evolutionary rates. Bivalves, in general, have species durations measured in tens of millions of years. The genus *Dunbarella* has ten species which occur through 30 million years of the Carboniferous of the UK, with some species durations of less than one million years. However, time-series studies of single characters and principal component analyses of *Dunbarella* are interpreted as representing a single, constantly evolving, anagenetic lineage. This is predicted by the *Plusçachange* Model (Sheldon 1996) and casts doubt on the current classification within the genus. Assigning species names within an anagenetic lineage is problematic. It is obvious that single characters cannot be considered diagnostic in a lineage where reversals are common. A multivariate approach is needed. This study uses principal components to re-examine the *Dunbarella* species of the UK Carboniferous. It is proposed that the UK record of *Dunbarella* has six species over around 33 million years, with the shortest-lived species lasting around three million years.

## Chips on fish teeth: wear patterns and feeding in extinct aquatic vertebrates

*an oral presentation by*

**Mark A. Purnell**

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Recurrent patterns of wear and surface damage on vertebrate mouthparts reflect the mechanics of food breakdown, the relative motion of feeding structures, and the nature of food consumed. This empirical relationship means that wear on fossil feeding structures can provide direct evidence of food types and feeding in extinct taxa, and recent work on conodonts has demonstrated the potential power of the technique in investigating feeding in jawless vertebrates. Almost all analyses of tooth wear have focussed on terrestrial mammals, and wear on fossil feeding structures can be interpreted only by reference to these data. However, wear patterns on the occlusal teeth of derived tetrapods may be inappropriate for interpreting feeding in other groups of vertebrates. In order to address this problem the relationship between feeding mechanisms, food type and tooth wear has been

investigated in extant cichlid fish. The results of this analysis strongly support the hypothesis that fish tooth wear preserves direct evidence of tooth movements during food acquisition, of the hardness/abrasiveness of food, and of the relative abrasiveness of the substrate from which food is obtained. Wear patterns thus have the potential to reveal hitherto unknown details of feeding in both extinct and extant aquatic vertebrates.

## **Evolutionary response to fluctuating climate in the Quaternary**

*an oral presentation by*

**J. H. Roberts**

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Sheldon's (1990, 1996) 'plusçachange' hypothesis predicts that organisms existing in stable environments have a tendency towards net directional evolutionary change. Conversely, the hypothesis proposes that organisms in unstable, fluctuating environments will remain in stasis until thresholds are exceeded. Published climate proxy data is used here to subdivide previously published and newly collected evolutionary data into stable and unstable categories. Tests on these data are conducted by application of the Gingerich (1993) method for determining evolutionary rates and modes. To overcome problems of different time-scales the Gingerich test involves pair-wise comparison of the log transformed sample means, standardised by the use of pooled standard deviations. Tests on published evolutionary series indicate little change in evolutionary modes between stable and fluctuating climatic conditions. In particular, cold water planktonic organisms demonstrate an apparent increase in their rate of evolution at the onset of major, Northern Hemisphere glaciations. A morphometric analysis of *Glycimerisglycimeris* (Bivalvia) from the Coralline Crag to Present is also being undertaken to assess predicted modes of stasis (Sheldon 1990) in shallow marine, temperate molluscs during the Quaternary.

Gingerich, P. D. 1993. Quantification and comparison of evolutionary rates.

*AmericanJournalofScience*, **293A**, 453-478.

Sheldon, P. R. 1990. Shaking up evolutionary patterns. *Nature*, 345, 772.

Sheldon, P. R. 1996. *Plusçachange*-a model for stasis and evolution in different environments.

*Palaeogeography, Palaeoclimatology, Palaeoecology*, **127**, 209-227.

## **Do communities evolve? Two hundred million years of taxonomic change and morphotypic stasis in platy coral assemblages**

*an oral presentation by*

**Brian Rosen**

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Close to the limits of euphotic conditions, ecological assemblages ('communities') of modern zooxanthellate scleractinians are invariably characterised by their flattened laminar morphologies. Subject to constraints of substrate steepness and sedimentation, the orientation of calical surfaces is optimised for light capture. Constituent taxa include both those which are exclusively platy, and others which are apparently intra-specific platy ecophenotypes of very variable taxa. Coral cover in these assemblages is often almost continuous, but plates are partially cantilevered above the substrate, their undersides providing surfaces for encrusters. The platy morphology therefore strongly influences the nature of the accompanying biota. In contrast to widely held notions of community characteristics, these assemblages therefore appear to represent communities defined by a distinctive dominant morphotype, rather than by taxonomic composition. In the context of topical concerns about community evolution and global change, platy coral assemblages have been remarkably persistent geologically, ranging back to the Triassic, independently of faunal turnover, and notwithstanding supposed catastrophic ecological collapses during mass extinctions. Ancient examples however are commonly biostromal, whereas modern examples invariably occur on steeply inclined, deep, fore-reef slopes, a contrast probably arising from the 'Pleistocene inheritance' of modern reef-foundations. The growth, form and palaeoecology of platy coral assemblages will be presented in the talk and implications for the community concept, community stability, and for the history of algal symbiosis in corals will be discussed.

## **Thylacocephala (Arthropoda: ?Crustacea) from the Cretaceous of Lebanon**

*an oral presentation by*

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An intensive study of a collection of arthropods from the Cretaceous of Lebanon, formerly referred to as stomatopod larvae or branchiopods, revealed that these forms belong to the problematical arthropod class Thylacocephala. The species *Protozoeahilgendorfi*, *Protozoeadamesi*, and *Pseuderichthuscretaceus* clearly display defining thylacocephalan characters such as a carapace enclosing the entire body bearing a large anterior optic notch; three pairs of large, raptorial appendages; and a posterior battery of small swimming limbs associated with muscle segments. The species also show several anatomical curiosities that provide some insight into the anatomy, ecology, and phylogenetic relationships of these and other thylacocephalan species. Structures found on the carapace surface of these animals may represent sensory organs comparable to the receptors seen on thecostracan crustaceans. To define the systematic affinities of the three Lebanese species a preliminary phylogenetic analysis was performed using all the better known thylacocephalan taxa. Despite our limited data set the analysis shows some clear monophyletic groups.

# Serpulid reefs or mineralised corals? Enigmatic colonial organisms in the Lower Jurassic marginal facies of South Wales

*an oral presentation by*

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Enigmatic fossils with a colonial tubular structure have been found near the base of the Lower Jurassic marginal facies, of Hettangian age, at Southerndown, South Wales. Previously they have been regarded as serpulid colonies yet bear little resemblance either to serpulids known from elsewhere in the Lias or to the few known extant colonial serpulids. However, local preservation of fine detail reveals evidence, in the form of corallites and tabulae, that they are scleractinian corals of the suborder Faviina. Comparison with well-preserved material from other nearby sites on the outcrop of the Lias marginal facies suggests that they are referable to the styllophylid *Phacelepismiliasuttonensis* (Duncan). The examples in question occur in close association with barite-galena veins in the underlying Carboniferous Limestone and adjacent Lias marginal facies. Their widespread misinterpretation as ‘serpulid reefs’ is a consequence of coarse replacive mineralisation by barite, which has largely obscured the diagnostic characters while simultaneously rendering the fossils highly conspicuous at outcrop. It demonstrates the importance of careful observation and a consideration of the effects of different preservational styles when interpreting the affinities of enigmatic fossils.

## Cladistic analysis of rudist bivalves

*an oral presentation by*

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The diverse and often bizarre morphologies of rudist bivalves present a good array of characters for cladistic analysis, though frequent homoplasy has caused some systematic confusion. Informative characters include: shell structures and relative thicknesses of the outer (calcitic), and inner (aragonitic) shell layers; valve asymmetry, and attachment to the substrate by either the left, or the right valve; form of the ligament; dentition; and arrangement of the internal shelly supports (myophores) for the adductor muscles, with various associated accessory cavities. The last character complex is especially important for discriminating a number of clades previously lumped into

paraphyletic (e.g. Diceratidae, Caprotinidae; in Skelton, 1978) or even polyphyletic (e.g. Caprinidae, in Moore, 1969) taxa in earlier schemes of classification. A suitable outgroup for the analysis is provided by the extinct megalodonts (which share the thick shells and massive dentition of the rudists). The diagnostic synapomorphy for the clade of all rudists is possession of an outer shell layer of fibrillar prismatic calcite. Within the group, two clades are distinguished according to the attachment of the shell-either by the left valve (including all 'diceratids', except for *Diceras* and *Valletia*, together with the monophyletic requieniids), or by the right valve (*Diceras*, *Valletia* and all other rudists). The monophyletic status of some long-established families is confirmed (e.g. Radiolitidae and Hippuritidae), while others are resolved into a number of distinct clades. An important 'Cinderella'-taxon to emerge from the analysis is that of the Polyconitidae MacGillivray, which has suffered undue neglect from having been ignored as a distinct taxon in the widely used 'Treatise' classification promulgated in Moore (1969).

Moore, R. C. (ed.) 1969. *Treatise on Invertebrate Paleontology, Part N, Mollusca 6, Bivalvia 2*, N776-817. University of Kansas, Lawrence, Kansas, and Geological Society of America.

Skelton, P. W. 1978. The evolution of functional design in rudists (Hippuritacea) and its taxonomic implications. *Philosophical Transactions of the Royal Society of London*, **B284**, 305-318.

## Wenlock Bryozoa from Wales and the Welsh Borderland

*a poster presentation by*

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The Much Wenlock Limestone Formation of Wales and the Welsh Borderland contains a diverse fauna of well over 600 species (mainly crinoids, corals, brachiopods, trilobites, algae and bryozoans) deposited during the early Silurian when this area was covered by a relatively warm, shallow shelf sea. However, the Wenlock bryozoans remain poorly studied and understood, even though they constitute an important part of the fauna. Species concepts are often insufficient, and there is a need for revised descriptions, incorporating thin-section work. Furthermore, phylogenetic, ecological and functional morphological studies also need to be carried out, as these areas have not been investigated in detail. Preliminary work on one particularly characteristic Wenlock bryozoan, *Ptilodictyalanceolata* (Goldfuss, 1829), a cryptostome, has revealed new information on its functional morphology, together with patterns of seasonal development based on zooid measurements. In addition, multivariate statistical analyses are currently being used to review the fenestrate species. Past workers have relied too heavily on the so-called 'micrometric formula' and, as a result, taxonomically important characters have often been overlooked, and little thin-section work has been carried out. It is hoped that this research, utilising a wider range of characters, will provide a reliable taxonomic platform for the study of Silurian bryozoan phylogeny and palaeoecology.

# **Grinding out the morphology-new approaches to three-dimensional reconstruction**

*an oral presentation by*

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The Herefordshire Silurian Lagerstätte presents problems in attempting to reconstruct and interpret its fossils, which are preserved three-dimensionally in sparry calcite in a calcareous matrix. The similar mineralogy of fossil and matrix makes chemical isolation of the fossils impossible; small specimen size (often a few mm) militates against mechanical preparation as routine; specimen size and susceptibility to cleavage renders serial sectioning impracticable. These problems have been overcome with a set of techniques based around serial grinding. Specimens are ground manually in 30-50  $\mu$ m increments, and at each stage photographed digitally. Data sets of photographs are then assembled by computer into three-dimensional, on-screen models, enabling direct visualisation of the fossil. Models are prepared using volume rendering algorithms which, in contrast to the geometry based approach used in the past to reconstruct fossils from serial sections, can be produced directly from digital photographs without the need for manual interpretation of the images. Models are complemented by computer based interactive video files assembled from the sequential photographs, which enable free movement backwards and forwards through the slices. These techniques have been used to obtain previously unattainable morphological information on polychaete-like animals from this Lagerstätte, and will prove fundamental to further study of the fauna.

# **Rocks and other hard places: hard substrate palaeoecology in the Upper Cretaceous of the Oman Mountains**

*an oral presentation by*

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The Maastrichtian Qahlah Formation of the Oman Mountains is a sequence of coarse siliciclastic sediments deposited above wavebase in a shallow sea transgressing the obducted Semail Ophiolite close to the palaeoequator. Unusually for siliciclastic sands and gravels formed in environments with high levels of abrasion and sediment movement, the Qahlah contains a diverse hard substratum assemblage of encrusters and borers. This assemblage colonised a variety of substrate types, including carbonate hardground cobbles, limestone rockground pebbles, chert cobbles, and wood.

The Qahlah therefore provides a good opportunity for analysing patterns of substrate utilisation according to composition and location. Most of the biota can be categorised into: (1) robust skeletal encrusters (oysters and corals); (2) cryptic encrusters (bryozoans and serpulids found mostly on clast undersides, within vacated borings or pre-lithification burrows); and (3) endoliths (bivalves, sponges and barnacles). An agglutinating foraminiferan is anomalous in often occurring on exposed surfaces despite its fragile test. Fortuitous preservation of some weakly-mineralized encrusters by bioimmuration demonstrates taphonomic loss which limits palaeoecological reconstruction. Nevertheless, the range of taxa present in the Qahlah is broadly similar to that recorded from higher latitude hard substrate assemblages of the Cretaceous, except for the occurrence of several species of colonial corals.

## **Palaeoecology, preservation and the myth that fish are immune to mass extinction events**

*an oral presentation by*

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There is a widespread belief that ‘throughout their history fish have proved virtually immune to mass extinction events’ (Hallam & Wignall, 1997, p.71) . During the Permian-Triassic extinction event fish diversity seems to have increased, whereas all other marine groups declined sharply. This presents an ecological problem: how can organisms at the top of a food chain survive a widespread collapse in productivity and biomass at lower trophic levels? Good Permian-Early Triassic fish faunas are known only from a few areas worldwide: Madagascar, East Greenland and Spitsbergen. One possibility is that in these areas the extinction was less severe than elsewhere and thus the food chain remained relatively intact. However, palaeoecological data from East Greenland show that conditions were just as bad here as elsewhere. Instead, it appears that fish were better preserved in the Lower Triassic than in the latest Permian. This is due to widespread benthic anoxia, high sedimentation rates and rapid concretion formation in the narrow, fault controlled basin of East Greenland. In contrast, benthic invertebrate groups show much worse preservation in the Lower Triassic than in the Late Permian (due to a dearth of silicified faunas). When the number of Lazarus taxa are taken into account, fish diversity shows a similar pattern through the Permian-Triassic interval as all other marine groups. Hallam, A. & Wignall, P. B. 1997. *Mass extinctions and their aftermath*. Oxford University Press.

## **A new conodont fauna from the Servino Formation (Lower Triassic) of Lombardy**

*a poster presentation by*

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Northern Italy contains some spectacular and readily accessible strata of Upper Permian and Lower Triassic age. These rocks have proved crucial in our understanding of the nature of the Permian-Triassic extinction and recovery in western Tethys. In recent years, work has concentrated on the mixed carbonate-siliciclastic ramp facies of the Werfen Formation of the Dolomites, with only sporadic attention being directed to the Servino Formation further west. Fieldwork in the Upper Caffaro valley in 1998, funded by a Sylvester Bradley Award from the Palaeontological Association, revealed that the Servino Formation is just as fossiliferous as the Werfen Formation and was deposited in a similar, although slightly more proximal, ramp setting. A previously unrecorded Late Griesbachian to Spathian age conodont fauna was also recovered. Taxa present include *Pachycladinaobliqua*, *Hadrodontinaanceps*, *Ellisoniacf. aequabilis* and cf. *Foliellagardenae*. For the first time, detailed correlation between the Servino and Werfen Formations is possible. Element yields are also much greater than for typical Werfen Formation samples. The units which yield most conodont elements (>100 per kg) are sharp based, decimetre thick, microgastropod rich, silty pack-grainstone tempestites. Storm induced winnowing processes were probably responsible for concentrating the elements within these beds. In addition, the Servino Formation specimens have CAI values of 5, which shows that these sediments have suffered greater burial/heating than equivalent strata of the Werfen Formation (CAI 1.5-3).

## **The Solana dragon: a giant pterosaur from the Late Cretaceous of Spain**

*an oral presentation by*

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Fragmentary, disarticulated remains of a new pterosaur have been recovered from the Limestones and Marls of the Sierra de Perenchiza Formation, a sequence of Late Cretaceous (Campanian-Maastrichtian) swamp/lacustrine deposits that outcrop at the locality of La Solana near Valencia in south-east Spain. The material consists of cervical vertebrae and limb bones representing a number of individuals of an azhdarchid pterosaur that appears to be most closely related to other azhdarchids from northern Spain and Uzbekistan. Comparison with other pterosaurs indicates that one, or more individuals from La Solana are at least 10 per cent bigger than *Quetzalcoatlusnorthropi*, currently the largest known flying vertebrate. New estimates of the size of *Q.northropi*, known only from an incomplete forelimb, indicate a wing span of about 10 m rather than 11-12 m as previously suggested. On this basis, the La Solana azhdarchid is likely to have had a wingspan of at least 11-

12 m. Very large and giant azhdarchids are now known from localities in North America, Europe and the Middle East and appear to have been typical components of Late Cretaceous terrestrial tetrapod faunas.

## **SEM-observation of the ultrastructure of late Palaeozoic Foraminifera**

*a poster presentation by*

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During the late Palaeozoic, the four most important suborders of the Foraminifera were the Textulariina (= agglutinate), the Fusulinina, the Miliolinina (= porcellaneous) and the Rotaliina (= hyaline). Although these microfossils are extensively studied, little is known about their ultrastructure. In this study, observations with the Scanning Electron Microscope of polished, slightly etched sections of very well preserved late Carboniferous and Permian foraminiferan specimens from Russia, Ukraine, Mexico, Tunisia and Afghanistan are presented. These observations concern: *Hemigordiopsis* (porcellaneous), *Pachyphloia* (Rotaliina Nodosariacea), the Fusulinina Staffellacea (with recrystallized wall), and the Fusulinina Schwagerinacea (i.e. keriothecal forms). The structure of *Hemigordiopsis* is an homogeneous arrangement of very small calcite crystals, while *Pachyphloia* bears a fibrous wall which can be readily distinguished. The wall of the Staffellacea is completely recrystallized due to a primary aragonitic composition. A particularly interesting ultrastructure is observed in some taxa of the Schwagerinacea: the keriotheca of genera such as *Paraskinnerella* and *Eopolydiexodina* bears a very characteristic flower-like structure which we refer here as 'anthotheca' (or 'flower structure'). However, it seems absent in other genera of the Schwagerinacea, like *Montiparus* (this study), or *Triticites* and '*Schwagerina*' sensu Thomson (Hageman & Kaesler 1998).

## **Biotic interactions in Wenlock Crinoidea**

*an oral presentation by*

**Rosanne Widdison**

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The Much Wenlock Limestone Formation of Britain reveals one of the most diverse, and well-preserved fossil assemblages known, with well over 600 species of invertebrates recorded. The

Crinoidea account for around 10% of this number with an estimated 35 genera and 56 species. The high quality of preservation has revealed a range of small-scale morphological features among the aboral surfaces of the arms and calyces of this group. Small, circular to sub-circular depressions and parabolic traces are randomly situated in the calcite plates of a number of the crinoid taxa. A small number of these features indicate *invivo* formation through the presence of rims and gall-like features surrounding the trace. These structures are interpreted as a response by the crinoid to the presence of another organism through either a mechanical or a chemical stimulant. The lack of penetration into the body cavity and the extent of the reaction structures suggest a symbiotic relationship existed between host crinoid and trace maker. A high degree of host-selectivity is observed with only 15% of crinoid species being affected. This number includes some of the most abundant crinoid species in fossil collections as well as a number of much rarer species. Work is now commencing on the taxonomic identity of the pit-producing organisms.

## Coccolithophore life-cycles, biomineralisation and sexuality

*an oral presentation by*

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Data on coccolithophore life-cycles has long been confined to a few case studies. These were individually complex and showed few common features. They fueled speculation that the group was polyphyletic and that coccolith-based taxonomy was intrinsically artificial. New data is now available from our research on analysis of biomineralisation modes, molecular genetics of the group, further life-cycle studies and particularly the discovery of combination coccospheres bearing coccoliths of radically different types. These diverse observations can be synthesised into a simple model. We predict that haplo-diplontic life-cycles are universal in the group with heterococcoliths characterising the diploid phase and holococcoliths the haploid phase. Moreover, it seems clear that coccolithophores are a non-polyphyletic group and that coccolith morphology provides a robust taxonomy. Finally, it appears likely that genetic recombination is a universal feature within the life-cycles of this group, removing one more textbook example of ‘asexual’ organisms.

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