

# PALAEONTOLOGICAL ASSOCIATION

## 44th Annual Meeting

University of Edinburgh  
17-20 December 1999

### ABSTRACTS and PROGRAMME

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#### *Oral Presentations*

#### **BLUE POOL BAY ? A CORAL-REEF OF THE LOWER CARBONIFEROUS OF SOUTH WALES**

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Buildups with a rigid coral framework are generally rare in Lower Carboniferous time. An exception was found in the Hunts Bay Oolite-Formation at Blue Pool Bay (Gower Peninsula). This bioherm is intercalated in well-bedded oolitic limestones. It is about 25 meters in width and rises up to 10 meters in thickness. The coral association indicates an Asbian age of the bioherm. The core of the structure consists of large massive colonies of *Lithostrotion* and a small number of dendroid colonies (*Siphonodendron* and *Syringopora*). Most of the corals are preserved in living position. The density of the colonies is high, in many cases they grow upon each other. Dendroid corals become more common in the outer core. An increase of colonies, which are upside-down orientated, together with broken colonies and coarse debris describe the facies of the flanks. The general decrease of the amount of corals and the gradual increase of fragments of colonies in bioclastic rudstones to wackestones at the top of the structure characterize the end of the biohermal development.

Due to the appearance of a coral framework and its thickness, the bioherm is wave resistant. It is described as the first ecological coral-reef of the Lower Carboniferous of South Wales.

## **NORTH EAST ATLANTIC BENTHIC FORAMINIFERA: MODERN DISTRIBUTION PATTERNS AND PALAEOECOLOGICAL SIGNIFICANCE.**

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Microfaunal evidence is presented from a region in the northeast Atlantic Ocean characterised by well constrained and very uniform physiochemical water mass properties, but a significant gradient in surface ocean productivity. Notable changes in the species composition of benthic foraminiferal assemblages can be directly related to surface productivity and particulate organic matter supply to the deep ocean floor. Because of the labile nature of much organic matter as it reaches the sea floor, it is argued that benthic foraminifera, which exhibit a high preservation potential in most marine sediments, provide a better proxy for estimating past fluxes than bulk sediment organic carbon (OC) content. Three distinct assemblage groups are recognised: a *Cassidulina laevigata* group which is dominated by infaunal species and a relatively high sediment OC content; a *Rhizammina* spp. group which is also dominated by infaunal species; and an *Epistominella exigua* group dominated by epifaunal taxa and falling sediment OC content. Significant faunal assemblage changes appear to be independent of grain size.

## **THE PHYLOCODE IS COMING: LOOK OUT!**

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The Phylocode has now been published on the web <<http://www.uohio.edu/phylocode>>. It has been billed by its supporters as the most significant thing in systematics since Linnaeus. Others do not share that view. The Phylocode is a new legalistic set of procedures for the formal registration of all taxic names, not just species and genera, and for registration and stabilization of taxic definitions. It is the latter that may give pause for thought.

According to the authors of the Phylocode, all taxa, from the species upwards, require not only a name, but also a formal definition (either node-based, stem-based, or apomorphy-based), and the two will be forever firmly wed together. Revisions will not be possible other than through a lengthy

legalistic procedure. The first person to tie a definition to a name (whether a pre-existing name or a new name) will be credited with priority. The Phylocode concept has gained influential and enthusiastic supporters; I am not one of them, and I shall explain why. See also <http://palaeo.gly.bris.ac.uk/phylocode/>

## **A GLIMPSE OF THE "CHITINOZOAN ANIMAL?"**

Joseph Botting

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Chitinozoans are Lower Palaeozoic organic microfossils that occur either as single vesicles or chains, and are widely regarded as the egg cases of unidentified Metazoa. This interpretation is based on vesicle morphology, and rare chains enclosed within organic "cocoons." Very rare chitinozoan chains comprise compact helices, interpreted by some authors as the intra-oviduct state. Several groups have been considered as possible producers, including orthocones, conodonts, polychaetes and graptolites, based largely on partial stratigraphic correlation.

Collections of articulated sponges from Middle Ordovician mudstones of Central Wales have yielded abundant chitinozoans. Loose chains are rare, but several helices of *Desmochitina?* have been recovered, showing traces of a surrounding organic sheath in four specimens. Only the posterior region is seen, but this part is elongate, with fine transverse banding, and plausibly represents a nematomorph, annelid or arthropod with a lightly sclerotized, bi- or trilaminar cuticle. Similar specimens (Kozłowski 1963. Sur la nature des chitinozoaires. *Acta Palaeontographica Polonica* 8, 425-449.) have previously been described as cocoons; this idea is discussed, and the interpretation as chitinozoan body fossils presented in preference.

The common association of chitinozoans with hexactinellids is consistent with abundant endobiotic polychaetes and arthropods in modern sponges.

## **INTERPRETING AXIAL STRUCTURES IN BURGESS SHALE-TYPE FOSSILS**

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Three dimensionally preserved axial structures are characteristic of particular species in the Burgess Shale, Chengjiang and Sirius Passet biotas. In the Burgess they are phosphatic and have generally been interpreted as alimentary structures or contents. In the Chengjiang they are represented by clay minerals indistinguishable from the surrounding matrix, hence their interpretation as the ingesta of deposit feeders. In the Sirius Passet they are preserved in silica and, in some instances, have been

interpreted as the body wall of lobopod-like animals.

The Burgess Shale structures have proven to be permineralized, serially repeated midgut diverticula that preserve diagnostic sub-cellular detail. Insofar as the Chengjiang structures are three dimensionally preserved in shale, they too must have been mineralized prior to compaction, probably with phosphate; alteration to clay minerals presumably occurred during the severe weathering that removed all primary phosphate. In the Sirius Passet, the putative lobopod *Kerygmachela* shows marked similarities to Burgess Shale *Leanchoilia*, suggesting an alternative interpretation for its axial structure. I argue here that most three-dimensionally preserved axial structures in Burgess Shale-type arthropods can be interpreted as well developed midgut diverticula. Such a condition is characteristic of living carnivorous arthropods and provides a key to interpreting the ecology of ancient forms.

## **THE MIDDLE JURASSIC AMMONITES OF EAST GREENLAND.**

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The Middle Jurassic ammonites of East Greenland continue to epitomize the distribution in space and time of ammonites as a whole. Recent exploration has uncovered a veritable new fossil-trove ("Lagerstätte"), whose succession of ammonites provides unusually clear insights into their life-cycles, ecology and evolution. Some 35 faunal horizons, representing distinguishable evolutionary stages in one lineage, that of the family Cardioceratidae, can now be mapped in the interval from Middle Bajocian to Callovian. The faunas are endemically Boreal, widespread in the Arctic but unknown in classical Europe, and their existence provides one of the strongest counterarguments against a tenacious persistent myth, that of a great world-wide Bathonian regression.

## **BUILDING-UP OF COMPLEX MARINE FOODWEBS: NEW FOSSIL EVIDENCE FROM THE EARLY CAMBRIAN MAOTIANSHAN SHALE BIOTA**

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An updated and critical review is used to reassess the biodiversity of the early Cambrian Maotianshan Shale biota. About 60 genera and a total number of more than 100 species and unnamed new forms are represented. About 25 phyla or subphyla are present. The biota is largely dominated by arthropods, priapulids and sponges. Fossil evidence from body design, preserved appendages, feeding

apparatuses and digestive systems indicate an unexpected variety of life habits, feeding styles and trophic groups. A rich epifauna was present and included meiofaunal arthropods. The water column was occupied by active swimmers (e.g. *Waptia*, *Isoxys*, anomalocarids) and organisms probably able to regulate their buoyancy (e.g. *Eldonia*, *Rotadiscus*, *Vetulicola*). Feeding types comprised suspension feeders at Low and high level, numerous deposit feeders, possible scavengers, and predators (e.g. endobenthic priapulids and swimming anomalocarids). Preserved digestive systems such as those of naraoiids (diverticles for food storage and enzymatic breakdown) indicate complex feeding strategies in possible relation with scavenging. Another set of fossil evidence provided by coproliths and preserved stomach contents demonstrate the existence of prey/predator relationships and identify the epibenthic fauna as a major food source (including microarthropod bradoriids, macroarthropods *Waptia* and problematic hyolithids).

## **MORE MISSING MOLLUSCS: A FRESH LOOK AT THE LOWER LIAS**

Lesley Cherno, Peter Hodges *and* V. Paul Wright

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The Lower Lias in South Wales is a classic example of an inshore-offshore carbonate transition. Faunas in inshore bioclastic limestones contain abundant replaced, former aragonitic molluscs with a bivalve assemblage of encrusters and shallow burrowers (e.g. *Liostrea*, *Cardinia*), yet in offshore facies (Blue Lias) the bivalves are typically calcitic or former bimineralic forms from an ecological association of recliners and burrowers including deeper-burrowing forms (e.g. *Gryphaea*, *Plagiostoma*, *Pinna*). Arzani *et al.* have proposed that these Liassic offshore limestones are largely early diagenetic in origin, with a marine C and O stable isotope signature that suggests a marine carbonate source. Does the paucity of former aragonitic molluscs in offshore facies suggest that those may have sourced the diagenetic carbonate, and if so, what has been lost? Silicified faunas from offshore facies near Bridgend reveal an unusually diverse and abundant molluscan assemblage, predominantly bivalves and gastropods, including aragonitic groups otherwise absent or rare from offshore facies, such as arcids. The implication is that faunal distinctions regarded essentially as facies-controlled were greatly enhanced by a taphonomic gradient which resulted in loss of a large component of the mollusc fauna during very early burial.

## **GRADUALISTIC EVOLUTION IN *BELEMNITELLA* FROM THE MIDDLE CAMPANIAN OF LOWER SAXONY, NW GERMANY**

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The *Goniatites* belemnite stock dominated in the Lower Campanian of NW Germany. *Belemnitella* is virtually absent in the middle Lower Campanian, a period of about 2 m.y., but migrated into NW Germany in the uppermost Lower Campanian, where it co-occurred with *Goniatites quadrata gracilis*.

Nine samples of the *Belemnitella* lineage, including the uppermost Lower and lower Upper Campanian *B. mucronata* and the uppermost lower Upper Campanian *B. misburgensis* sp. nov., from the expanded succession of the Lehrte West Syncline east of Hannover, Lower Saxony have been subjected to univariate and bivariate statistical analyses. The succession consists of rhythmically bedded marly limestones and calcareous marls, which were deposited during 4-5 m.y. in a fairly stable environment. Three characters, the length from the apex to the protoconch, the slenderness of the guard and the alveolar angle, show evolutionary reversals (so-called zig-zag evolution) with net decreases or increase. The Schatzky distance shows stasis in *B. mucronata* and decreases in *B. misburgensis* sp. nov. The fissure angle displays unidirectional evolution and increases gradually. These morphological changes are interpreted as long term phyletic gradualism although this model of evolution has almost universally been depicted as one of unidirectional change.

## **HEAD FIRST; THE SKULL ROOF IN EARLY TETRAPODS**

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The distribution of sutural types in the skull roof of the Devonian tetrapod *Acanthostega* shows that, by contrast with animals of comparable skull shape and habitus from the Permian, its skull roof appears overengineered. It has complexly interdigitating sutures in the postorbital region (skull table) that are not found at all in the Permian temnospondyls and discosauriscids. In the snout and cheek it has deeply overlapping sutures (scarf joints) which are resistant to torsion, such as are created by biting forces. In all these animals the skull table is the most strongly sutured part, possibly in connection with attachment of axial muscles to raise the head. Two regions of the skull in Devonian tetrapods show the most interspecific variation - the dentition and the skull table. The skull table is not only associated with the evolution of a neck in tetrapods, but overlies the braincase, another region that undergoes changes across the fish - tetrapod transition. Changes to the skull table, as well as dentition, are seen between tetrapodomorph fishes and early tetrapods, as well as among early tetrapods themselves. They contrast with the snout, cheek and external jaw bones that remain essentially conservative.

## **TERRESTRIAL PALAEOENVIRONMENTAL RECONSTRUCTION USING CO-OCCURRING CAINOZOIC PLANTS AND MAMMALS : BIOTIC AND ISOTOPIC APPROACHES.**



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Cainozoic sequences in southern England are of international significance for terrestrial palaeoenvironmental analysis as they contain abundant plants and mammals. Late Eocene to earliest Oligocene plant assemblages represent an ancient coastal freshwater wetland with open water, marginal and marsh plant communities. Ecological diversity analyses of mammals indicate presence of relatively open wooded areas (supported by palynofloras) with mammalian diet including foliage and dry fruits/seeds but little fleshy fruit (with no grazers). Although preservational quality, assemblage diversity (size, taxa, habit etc.) and facies indicate minimal transport, rich plant and mammal assemblages rarely co-occur, limiting the detail of previous work. Recent sampling has yielded more co-occurring mammal and wetland plant assemblages and has provided unequivocal evidence of mammalian plant-feeding and the close association of mammals and water plants in the form of trace fossils of rodent gnawing on seeds. This close association of mammals and wetlands has enabled a new approach investigating palaeotemperatures using oxygen isotopes of mammalian tooth phosphates based on the following 1) fractionation between ingested water and body water is species dependent 2) mammalian phosphate is precipitated at constant body temperature 3) our new direct laser fluorination method allows analysis of small phosphate samples.

## **THE ANATOMY OF *TURINIA PAGEI* (POWRIE) AND THE PHYLOGENETIC STATUS OF THELODONTS**

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Thelodonts are enigmatic and extinct jawless vertebrates that possess a shark-like dermal skeleton composed of microscopic scales that were commonly dispersed after death and decay of the supporting soft tissues. Thus, little is known of their anatomy even though, paradoxically, thelodonts have figured extensively in scenarios surrounding the origin of jawed vertebrates. Although articulated remains of thelodonts have been known for over a century, anatomical details are limited to characters that are general to jawless and jawed vertebrates. A general lack of data together with the absence of characters shared by more exclusive vertebrate groups has led to a suggestion that thelodonts do not even constitute a natural group.

Ironically, *Turinia pagei*, the first articulated thelodont remains discovered, preserve more anatomical data than any subsequently discovered specimen. Thus, *Turinia pagei* remains the key to resolution of the status and affinity of the group. We have conducted a reinterpretation of all the available

material and incorporated this data into a cladistic analysis of lower vertebrates. Our analysis reveals that the thelodonts do indeed constitute a natural group, although this group is not diagnosable on any single uniquely derived character. Furthermore, our analysis reveals that thelodonts are only remotely related to jawed vertebrates, casting doubt on evolutionary scenarios in which they are implicated.

## **THE FOSSIL WATERFOWL (AVES, ANSERIFORMES) FROM THE TERTIARY OF ENGLAND**

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The taxonomy and phylogenetic relationships of the fossil waterfowl (Aves, Anseriformes) from the Tertiary of England are reviewed. Although a total of 6 species within 5 genera have been described, only the phylogenetic positions of the two taxa *Anatalavis oxfordi* Olson and *Headonornis* (Lydekker) can be hypothesised with confidence within the order Anseriformes. Contrary to previous treatments that have considered *Anatalavis oxfordi* closely related to the extant Magpie Goose (*Anseranas*), cladistic analysis shows that this material is the sister-taxon to a clade comprising the well-known fossil *Presbyornis* Wetmore, and the true ducks, Anatidae. *Headonornis hantoniensis* is placed within the Presbyornithidae Wetmore, and possible synonymy with the taxon *Presbyornis isoni* Olson is discussed. Additional fossil material referred to the genera *Proherodius* Lydekker, *Palaeopapia* Harrison and Walker and *Paracygnopterus* Harrison and Walker is considered either Anseriformes *incertae sedis* or Aves *incertae sedis* at present.

These records of fossil waterfowl from the Eocene of England are informative with regard to both the primary and historical taxonomy of named taxa from both the Cretaceous and the Tertiary of North America (e.g. *Presbyornis* Wetmore and *Telmabates* Howard). Phylogenetically informative material is used to estimate minimum-ages for the appearance of clades within the order Anseriformes, and imply the presence of this group of modern birds prior to the Cretaceous-Tertiary (KT) boundary.

## **HOLOCENE SHELF SEA EVOLUTION OFFSHORE NORTH-EAST ENGLAND, NORTH SEA**

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Vibrocore 54-02/97 (54°53.05'N, 1°3.88'W, water depth 55m) from offshore Northumberland, North Sea, represents a continuous Holocene marine sediment sequence. Sea-level, palaeoceanographic and biostratigraphic interpretation (Long 1991; Harland and Long 1996; Brew *et al.* 1998) indicate that it provides a Holocene record of sea-level change in the North Sea in response to glacio-hydro-isostatic adjustments.

Benthic foraminiferal assemblage and stable isotope data indicate changing marine conditions associated with the sea-level change. These are consistent with the onset and development of seasonal stratification in the region. The data are constrained by an age model derived from paired molluscan dates (Harland and Long 1996) and three new <sup>14</sup>C AMS Radiocarbon dates based on benthic foraminifera. Magnetic susceptibility compliments sedimentological patterns and bulk organic carbon measurements, showing a predictable change in depositional environment at ~6ka BP. These data provide an opportunity to test modelling results of Lambeck (1995) and Shennan *et al.* (2000) for the North Sea Basin.

## **A NEW CHILOPOD FROM THE PRAGIAN WINDYFIELD CHERT, RHYNIE, ABERDEENSHIRE**

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A new chilopod is described from the Windyfield Chert at Rhynie. The fossil record of chilopods or centipeds is sparse, the few Palaeozoic centipeds known have mainly been described from the Upper Pennsylvanian Mazon Creek site, the Middle Devonian Gilboa fauna and fragmentary elements from the Early Devonian Rhynie Chert and the Late Silurian Ludlow Bone Bed.

The elements discovered include articulated maxillipeds and a first trunk segment with attached appendages together with isolated trunk segments, disarticulated antennae and appendages. The tergites of the new animal display pleurotergy, to date unprecedented in the chilopod fossil record. Other chilopod remains within the same sample comprise articulated trunk and posterior segments and appendages of lithobiomorph origin. The first unequivocal evidence of fossil lithobiomorph-like tracheae is also recorded.

The terrestrial remains are associated with crustacean elements, charophytes and cyanobacterial-bound degraded plant axes within a 'mulm'-like texture, indicative of a subaqueous environment. Initial comparisons with modern day hot-spring systems such as those at Yellowstone National Park, Wyoming suggest deposition in a 'cool pool' capped at the surface by a cohesive microbial mat, capable of supporting small terrestrial invertebrates.

# UNDERGROUND PRECAMBRIAN ORGANISMS

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The peculiar three-dimensional preservation of *Pteridinium*, from the terminal Proterozoic sequence of Namibia, suggests that it was an immobile benthic organism, whose boat-shaped body was completely immersed in the sand. Membranous bodies of *Pteridinium* appear to have rheotropically grown within the loose sand in response to bottom current shear-stress, using it as a guide to reduce the risk of collisions and penetrations by growing parallel to each other. Another immobile benthic organism, *Inaria*, from the terminal Proterozoic sequence of the northwestern Russia, had its broad, bulb-like base completely submersed in the mud with only the tube protruding through the dense carpet of vertically standing filamentous algae. This makes *Inaria* similar in morphology and life-style to the recent infaunal sponges.

A switch to an immobile underground life-style requires unique adaptations for gas exchange and nutrition. It also poses certain problems of entering the sediment at a larval stage. All the same, infaunal life habit may have some advantages with regards to competition for substratum, and may also have sediment-stabilizing side-effects, thus facilitating the substratum for further benthic successions. "Infaunal" habit was initiated in late Precambrian times prior to evolution of burial behaviour, as documented by taphonomy and sedimentological context of the Ediacaran fossils.

## PRESERVING PLANTS IN PYRITE

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Pyrite permineralisations are an important source of information on plant anatomy including water-conducting cells in the earliest land plants and woody tissues in Eocene twigs and roots. Analysis of the fabric of pyrite, together with experimental data, has allowed elucidation of the different styles of preservation in the fossils and the processes involved. Textures include early microcrystalline and framboidal pyrite, and later polycrystalline and euhedral pyrite. Rapid precipitation of microcrystalline pyrite (within 80 days in microbial decay experiments) on cell walls is crucial for the preservation of fine anatomical detail. Chemical experiments with FeS-H<sub>2</sub>S to produce pyrite in *Apium petioles* (celery) formed amorphous iron (II) monosulphide, FeS<sub>am</sub> on the surface and within cellulose parenchyma cell walls, but not in the lignified areas of the xylem cell walls. This is consistent with the distribution of pyrite in Devonian plant fossils, and reflects the composition of the original plant tissues and their degradation history.

# DIVERSITY DYNAMICS OF THE ORTHIDE BRACHIOPODS

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The basic plan of the deltidodont articulated brachiopod, established by the early Cambrian, diversified into a range of morphologies, including those of the orthidines (impunctate orthides) and dalmanellidines (punctate orthides) during the early Ordovician radiation.

These groups gradually declined during the Palaeozoic from a maximum diversity in the Caradoc with sequentially lesser, yet marked, diversity spikes in the Wenlock and the Pragian. Turnover rates were particularly high during the early (Arenig) and later (Caradoc-Ashgill) Ordovician, the mid-Silurian (Wenlock) together with the early (Pragian-Emsian) and late (Frasnian) Devonian. Rarefaction curves for morphological aspects of the orthidine and dalmanellidine clades suggest that overall the orthidines developed a higher disparity than the dalmanellidines, particularly during the Ordovician but by the Devonian the dalmanellidines had exceeded them in both disparity and diversity. Many orthide groups apparently originated and developed in shallow-water environments at higher latitudes but radiated later within quieter, deeper-water habitats (mid-Ordovician), carbonate environments (mid-Silurian) and possibly more specialised cryptic niches associated with reefs and buildups (mid-Devonian). The pattern of radiations suggest step-wise waves of diversification simulating displacements by successive individual superfamilies within the Orthida through the early Palaeozoic; peaks in diversity are matched by expansions in morphological disparity in the orthidines but this correlation is less clear in the dalmanellidines, where generic distinctions are less marked.

## HUNTING THE KILLER OCTOPUS

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Modern octopods are voracious predators of a variety of invertebrate taxa (crabs, molluscs etc). However, as noted by Bromley (1993: *Bulletin of the Geological Society of Denmark*, 40, 167-173.), their extremely poor preservation potential has led to their presence and importance in ancient communities being almost totally ignored. One way, however, in which it might be possible to trace the fossil record of this group and its activities is from their habit of drilling holes in the shells of their prey. *Octopus* and *Eledone* produce distinctive oval, often guttered, drillholes (which are easily distinguished from the holes made by predatory gastropods) and show pronounced stereotypy in their behaviour. Recognition of these drillholes in Pliocene scallops led Bromley (1993) to erect the ichnospecies *Oichnus ovalis* to accommodate them, however, they have not been reported in the more

distant fossil record. This study presents evidence that this reflects a lack of familiarity leading to them being overlooked rather than a genuine absence.

I will examine predatory behaviour patterns in modern octopods, the distribution of *Oichnus ovalis* in the fossil record and the identity of possible culprits. Although, like all drillholes, taphonomic loss is probably high, evidence from well-preserved shell material indicates that this type of drilling predation occurred at least by the Albian.

## **PALAEOECOLOGY OF THE EAST AUSTRALIAN LOWER CRETACEOUS TOOLEBUC FORMATION: AN UNUSUAL ASSOCIATION OF *INOCERAMUS* AND OIL SHALE**

R.A. Henderson

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The Toolebuc Formation (Late Albian) is a thin unit (<25m) marking the maximum deepening of the Cretaceous epicontinental sea recorded by the infill of the Great Artesian Basin, eastern Australia. It consists of oil shale, with TOC ranging to 35%, and limestone as laminae and thin beds comprised of *Inoceramus*, and less commonly *Aucellina*. Finely interlayered oil shale and coquina are typical of the formation, resulting in a distinctively black-and-white laminated rock. *Inoceramus* valves are commonly disturbed by breakage, reorientation and imbrication and in many cases have disintegrated into prism horizons. Sedimentary laminae show that the seafloor was subject to some current activity but benthic scavengers are considered to have been an active agent of shell disturbance. Although shelly substrate suitable for encrusting epibenthos or colonization by endoliths was available in abundance, almost no other shelly benthic elements are represented. The formation contains diverse planktonic, pelagic and nektonic fossil remains attesting to deposition beneath a water column of normal salinity, supporting a complex food chain. *Inoceramus* and *Aucellina* represent ecological specialists, tolerant of anoxic bottom conditions. Their abundance in, and intimate association with, oil shale suggests a trophic link. It is suggested that sea-bottom boundary layer bacterial productivity, supported from the organic-rich substrate, sustained this unusual benthic community.

## **JURASSIC PALAEOHALINITIES: SURPRISING RESULTS FROM STRONTIUM ISOTOPES**

Chris Holmden (Saskatoon) *and* John Hudson\* (Leicester)

Attempts to determine palaeosalinities in the Bathonian Great Estuarine Group of the Inner Hebrides, specifically the Kildonnan Member on the Isle of Eigg, have hitherto told a consistent story. Initially based on molluscan faunas, the order of assemblages from freshwater-oligohaline to polyhaline has been supported by ostracods, palynomorphs, and carbon-oxygen isotopes; the last especially from the mussel *Praemytilus strathairdensis*.

Fish otoliths fall into two isotopic categories; some calcified at sea, and some in lagoons. The difficulty of distinguishing stable isotopic compositions resulting from seawater-freshwater mixing from those caused by evaporation and CO<sub>2</sub> exchange was recognised, but faunal data suggested that mixing was predominant.

We analyzed *Praemytilus* shells for <sup>87</sup>Sr/<sup>86</sup>Sr and Ca/Sr ratios. With seawater-freshwater mixing there should be a strong correlation; since seawater contains more Sr than freshwater, the marine component should dominate at intermediate salinities. In fact, <sup>87</sup>Sr/<sup>86</sup>Sr ratios are strongly radiogenic, Sr contents high, and there is only a weak correlation between them, or with δ<sup>18</sup>O. Geochemical interpretation is that lagoons were dominated by freshwater inflows, evaporating during dry seasons.

Palaeontological data, however, still demand a marine connection. These intriguing results will be discussed.

## **AMMONITE SOFT BODY PRESERVATION AND FUNCTIONAL MORPHOLOGY**

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Although ammonites occur commonly in Mesozoic marine sediments from all over the world, virtually nothing is known about the organic soft body. Preservation of soft tissues is relatively well known from Jurassic squid, but in ammonites is restricted to the siphuncle. The ammonite soft body and feeding habits have been reconstructed mainly from organic hard parts associated with the digestive system (the buccal mass), from indigestible (skeletal) remnants of crop and stomach contents preserved in the body chamber, and by comparison with *Nautilus*.

A microconch of the middle Jurassic (Callovian) ammonite *Sigaloceras* (*Catasigaloceras*) *enodatum* Nikitin, 1881 includes exceptionally preserved soft parts within calcite of the body chamber. This unique specimen has been subjected to a wide range of non-invasive analytical techniques (CT-scanning, X-ray, UV and fluorescence microscopy, SEM, EDAX) in order to image details of these soft tissues (muscles, digestive system, siphuncle, and their disposition within the shell. The ammonite soft body and functional morphology have been reconstructed, and also the taphonomy of the deposit.

## **MID CRETACEOUS FOSSIL FORESTS OF ALEXANDER ISLAND, ANTARCTICA**

Jodie Howe



Fossil plants and trees preserved in the Cretaceous rocks of Alexander Island, Antarctica are a crucial source of information on the palaeoenvironment, climate and palaeoecology of these mid Cretaceous fossil forests. They are evidence for warm equable conditions that supported temperate climate vegetation in the polar regions.

The fossil plants and trees are found preserved in sequences of fluvial sandstones, siltstones and palaeosols. Sandstones show features such as *in situ* fossil tree trunks and leaves, some current bedding and rip-up clasts of the palaeosol below. Thick siltstone units are horizontally laminated and contain an abundance of well preserved plant fossils. This sedimentary sequence represents flood plain and channel bar deposits of a braided river which evolved into a meandering river system. The sandstones were formed during flood events which deposited vast amounts of sand over the riverbanks, covering the soils and vegetation. Signs of deformation in underlying sediments suggest that deposition of the sands was rapid and therefore flood events were catastrophic. The siltstones were formed from suspension fallout in standing water pools. The palaeosols are immature but have an abundance of rootlets and plant material within them indicating that they supported vegetation. The palaeosols represent a period of emergence along a riverbank with enough time for colonisation of plants and trees. Sequences of palaeosols, sandstones and siltstones suggest that when water subsided, new soils formed and plant colonisation began again.

The fossil plant assemblages suggest that a thick canopy of araucarian and *Elatocladus* conifers with an understorey of ferns and the small shrub *Taeniopteris*, dominated the vegetation within these Cretaceous fossil forests. Other minor components of the vegetation included liverworts, angiosperms and *Ginkgo*.

## **GORGONOPSID ECOMORPH NICHE-FILLING AFTER THE P-TR EXTINCTION BY 'AELUROMORPH' MOSCHORHINID THEROCEPHALIANS: A FINITE ELEMENT APPROACH.**

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A biomechanical analysis of craniodental anatomy and function in synapsid ('mammal-like') reptiles across the Permo-Triassic boundary has elucidated unique feeding mechanisms in these very ancient specialised carnivores. A multidisciplinary approach demonstrates that the trophic ecological niches - based on models of skull function - occupied by the plentiful and highly successful predatory gorgonopsids of the Late Permian, were filled after the end-Permian extinction event by the Moschorhinidae (= Akidnognathidae), members of the therocephalian synapsids. Use of modern anatomical data from various fields allows a rigorous appraisal of functional cranial anatomy in these

animals. The hypotheses of function generated by this modern anatomical information is tested, and corroborated by the application of Finite Element Analysis (FEA), a 3-D computer modelling technique used by engineers to solve problems of structural mechanics. Therocephalian predators of the Permian Period such as the Lycosuchidae and Scylacosauridae show subtly different craniodental adaptations to those of the contemporaneous Gorgonopsidae, but the 'gorgonopsid ecomorph' niche that was left vacant by the P-Tr extinction event was filled by the moschorhinid therocephalians during the earliest Triassic. Moschorhinids partially re-evolved the gorgonopsid cranial type in a previously unrecognised example of convergent evolution, whilst still retaining elements of the characteristic skull mechanisms of therocephalian carnivores. Moschorhinids also show some craniodental adaptations that are only seen in modern felid carnivorans; details which are closely associated with the characteristic feline behavioural approach to predation. As such, these features represent a unique, and exceptionally early example of the 'aeluromorph', carnivore ecotype and provide robust indications to the predatory habit of these early Mesozoic carnivores.

Alongside these similarities, are some aspects of moschorhinid dental morphology that are entirely unique to these therapsid carnivores; these features may be rigorously assessed using the approaches in this study to generate a biomechanical model of craniodental function in moschorhinids and hence refine our current knowledge of Permo-Triassic carnivore guilds. Biomechanical models such as this are dependant upon a synthesis of engineering principles alongside detailed and rigorous experimental anatomical techniques familiar to clinical and veterinary anatomists.

## **HOT STUFF IN THE NEOTETHYS: LATE CRETACEOUS HYDROTHERMAL VENT COMMUNITIES FROM CYPRUS AND OMAN**

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The Kinousa, Memi, Kambia, Kapedhes, and Sha massive sulphide deposits located in the Troodos ophiolite, Cyprus, contain fossils from Late Cretaceous hydrothermal vent communities that lived on a spreading ridge above a subduction zone in the deep (>2.5 km) Neotethys ocean. The fossil vent assemblages are of low diversity; they contain numerous vestimentiferan worm tubes, uncommon cerithioid and epitoniid gastropods, and rare (?)serpulid worm tubes. Among the reported modern and ancient vent communities the presence of epitoniid gastropods is unique to Cyprus. At least three of the Troodos vent communities were living on the sea floor around the same time and were as closely spaced as vent communities on modern fast-spreading ridges. Together with slightly older vent worm tubes from the Semail ophiolite of Oman, currently 2500 km from Cyprus, the Troodos fossils show that hydrothermal vent communities were present in the Neotethys ocean from the Cenomanian to the Turonian, a time span of ~5 m.y. The presence of deep water vent communities during this time period may have implications for the theory that the Cenomanian-Turonian extinction event was caused by an oceanic anoxic event (OAE), as vent communities are dependant on well-oxygenated seawater for their existence.

## **FIRST RESULTS ON THE PHOSPHATOCOPINA (CRUSTACEA) OF THE UPPER CAMBRIAN 'ORSTEN' OF SWEDEN**

Andreas Maas

## **REEVALUATION OF CYTTAROCRINUS ONTOGENY (CRINOIDEA, CAMERATA): IMPLICATIONS FOR DISPARID CRINOID PHYLOGENY**

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It is thought that ontogenetic pathways of the Palaeozoic crinoid Order Monobathrida (Subclass Camerata) and Subclass Disparida were virtually identical, and that these ontogenies showed a common ancestor may have given rise to both groups. This assumption was mainly based on ontogenies proposed for *Cyttarocrinus* (Camerata, Hapalocrinidae), allagecrinacean crinoids (Disparida), and *Synbathocrinus* (Disparida). Reexamination of *Synbathocrinus* ontogenies shows that juveniles currently assigned to this genus are most likely allagecrinoids, and therefore, ontogenetic patterns within the Disparida may vary. Reexamination of original specimens from the ontogenetic series assigned to *Cyttarocrinus* also shows that the juveniles are most likely allagecrinoids, and that camerate crinoid ontogeny may not resemble that of disparid ontogeny as previously thought. Juveniles assigned to *Cyttarocrinus* show a pattern of development of arm facets, narrow, rounded arm facets, and oral plates that very closely resemble those of *Litocrinus*, an allagecrinoid. In addition, there is a large size gap between the largest "juvenile" and *Cyttarocrinus* adults. Adult *Cyttarocrinus* have flat arm facets, and an oral surface with many more plates than that of the supposed juveniles. Other known camerate ontogenies do not resemble those of the allagecrinoid disparids, therefore a common ancestor for these groups is cast into doubt.

## **MACROEVOLUTIONARY PATTERNS OF TRIASSIC AMMONOIDS: CLADE SHAPE ANALYSIS**

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Mass extinctions have the potential to be major factors in altering macroevolutionary patterns. The

Triassic ammonoids represent an excellent group for investigating the effects of the Permo-Triassic and End-Triassic mass extinction events on the macroevolution of a single higher taxon. After the Permo-Triassic mass extinction ammonoid diversity rebounded from a few surviving genera to pre-extinction levels by the Middle Triassic. The End-Triassic event then lowered diversity to Early Triassic levels. During the Jurassic and Cretaceous the ammonites recovered and reached their peak diversity. This raised the question of whether the Mesozoic ammonoids were characterized by a single macroevolutionary pattern. Alternatively, was there one pattern for the Triassic ammonoids, and another for the Jurassic and Cretaceous ammonites?

This study applied clade analysis methods, originally used by Ward & Signor (1985) upon Jurassic and Cretaceous ammonites, to the Triassic ammonoids. The clade statistics for 30 Triassic ammonoid family spindle diagrams, comprising 334 genera, were calculated and compared to the results of Ward & Signor (1985). Mesozoic ammonoids as a whole showed similar macroevolutionary patterns. Within the Triassic there were differences between families from the lag/rebound period after the Permo-Triassic event, and families from the rest of the Triassic.

## **BILLFISH ARE MONOPHYLETIC AND SCOMBROID: THE FOSSILS SAY YES!**

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Billfishes are large teleosts with a conspicuous, long snout. Recent billfishes are swordfish, marlin and sailfish. Fossil taxa assigned to billfishes are those such as *Palaeorhynchus* and *Blochius*. The billfishes are normally associated with the suborder of Scombroidei, the mackerel-like fishes. According to recent cladistic hypotheses, the phylogenetic position of billfishes is unresolved: they are considered either distantly related to, basal, or advanced scombroids. Fossil taxa that are normally associated with billfish are sometimes referred to blennies or needlefish. A cladistic analysis of fossil and Recent scombroids results in the hypothesis that billfish are an advanced, monophyletic clade within scombroids. A key fossil in this hypothesis is the London Clay fish *Eothynnus*, which appears to be the immediate sister group of billfishes. Many of the fossil taxa normally assigned to billfish form part of that monophyletic clade. There are reports of some fossil spines which some consider to be billfish rostra. I reject this, but am unsure of the identity of these spines. I consider these results as an encouragement to combine Recent and fossil data in order to reconstruct the history of biodiversity.

## **THE IMPACT OF TAPHONOMIC INFORMATION LOSS ON THE DISPARITY EXHIBITED BY FOSSIL ARTHROPODS**

Patrick J. Orr <sup>1</sup> and Derek E.G. Briggs <sup>2</sup>

The well-preserved parts (valves, 2nd antennae, mandibles, claspers, trunk and telson) of spinicaudatan conchostracans from the Castlecomer Fauna, a Konservat Lagerstätte from the Upper Carboniferous of Ireland, are virtually identical to their equivalents in extant relatives. This supports the widely held view that branchiopods are an example of evolutionary conservatism. In marked contrast the 1st antennae, maxillae, and posterior trunk appendages are either poorly preserved, or, more usually, there is no evidence of their presence, in the >200 Castlecomer spinicaudatans studied. Decay experiments confirm that there is a strong dichotomy in the preservation potential of different appendages, presumably reflecting differences in the decay resistance of the non-biomineralized cuticle; certain appendages decay completely before appreciable deterioration in the morphology of others. The fidelity of a fossil to the original organism is a function of the preservation potential of its different parts under a given set of conditions (taphonomic thresholds). In the case of arthropods the cuticle of the exoskeleton is all-important in preserving appendage morphology, but the degree of sclerotization, and hence resistance to decay, may differ markedly even within an individual. Thus some of the disparity exhibited by exceptionally preserved arthropods may be taphonomic rather than biological in origin.

## **SNOUTS AND MOUTHS: HETEROSTRACAN FEEDING AND EARLY VERTEBRATE EVOLUTION**

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Did heterostracans have nostrils? Did they bite? Not burning issues in twenty first century palaeontology, you might think, but these questions are in fact central to understanding early vertebrate evolution. For more than 140 million years jawless vertebrates (agnathans) were the dominant forms of vertebrate life and, of all the armoured agnathans, heterostracans were the most diverse. There is a long history of research in this group, yet the structure of the heterostracan snout and how the mouth was used in feeding are the subjects of long-standing and heated controversy. One consequence of this unresolved debate is that the literature contains a wide range of contradictory interpretations of heterostracan feeding, with no sign of consensus.

Acid preparation and scanning electron microscopy of exceptionally preserved articulated heterostracans and isolated oral plates have revealed new details of oral structure and of recurrent patterns of surface wear that provide significant new constraints on these anatomical interpretations and functional hypotheses. These results have a direct bearing on aspects of the heterostracan controversies, but they also have broader implications for scenarios of early vertebrate evolution and models of skeletal development and the origin of teeth.



# **THE BIOGEOGRAPHY OF LARGE PLEISTOCENE CARNIVORES IN EUROPE**

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The majority of detailed studies of the European mammalian fauna are site-based or have a regional or national context. This paper has drawn together these reports to produce a cohesive pattern of change in the biogeography of larger carnivores within the last 2 million years. Thirty species of larger carnivores have been used, ranging in size from bears to the wolverine. Information has been taken from faunal lists in the literature and covers all European countries with sites of these dates.

The study shows that incidents of faunal turnover may have taken longer than had at first been thought and that species may have survived much later in some areas in comparison with others. Evidence for the migration and co-existence or exclusion of taxa can also be deduced from this study and can be tested by the use of Multivariate statistical techniques.

The implications of this study will be discussed, as will the prospect of future research.

## **SOMETHING OLD? SOMETHING NEW? THE MYSTERY OF THE LINCOLN CAVE, STERKFORTEIN.**

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The Lincoln Cave is a lesser-known cave deposit at Sterkfontein Caves in Gauteng, South Africa. Uranium Series dating yielded an age of mid to late Pleistocene for the deposit excavated within the cave, however certain fossil hominids (such as *Homo cf. ergaster* and *Paranthropus* sp.) and artefacts recovered from Lincoln Cave suggest that older material has been incorporated into a much younger deposit. Comparisons between the Lincoln Cave material and a sample of fossils and artefacts from the main Sterkfontein excavation, point to a link between the two cave systems through which this material would have passed. A mixture of Earlier Stone Age and diagnostic Middle Stone Age artefacts suggests erosion of archaeological material out of an older deposit, namely the Member 5 West deposit of the Sterkfontein Formation dated at *ca.* 1.5 million years. These findings serve act as a cautionary tale of deposition, erosion and re-deposition within the dolomitic cave environment.

# **DO REGIONAL POOL HISTORIES HOLD THE KEY TO GLOBAL BIODIVERSITY THEORY? GEOLOGICAL CONTROL OF AVAILABLE HABITATS IN THE CENOZOIC HISTORY OF REEF CORAL DIVERSITY IN THE INDO-WEST PACIFIC**

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Analysis of 'wobble-ogram' plots of biodiversity and extinctions through time, for one or more groups of taxa, has long been a popular component of palaeontological research, especially since Sepkoski published his celebrated 'curve'. However, diverse explanations are available for these 'wiggles', and a unified theory of biodiversity on geological time-scales, stills seems a long way off. Given the probably ever-shifting balance within the synergistic cocktail of likely relevant processes, as well as data-sampling factors, this is hardly surprising. On the other hand, ecologists are finding that habitat-level studies do not lead to a satisfactory theory of biodiversity either. Bridging these two extremes lies the less-explored potential of analysing the history of regional pools of taxa. Such studies have also been popular, but under a palaeobiogeographical umbrella. The wealth of knowledge now available about how different regions at different times have been affected by particular combinations of 'TECO' factors (tectonics, eustasy, climate, oceanography) gives us 'natural experiments' which allow enigmatic global patterns to be dissected, and local patterns to be put into wider context. I shall illustrate this argument by reference to our continuing work on the Cenozoic history of the Indo-West Pacific coral fauna, in relation to contemporaneous global and regional patterns.

## **THE PURBECK AND WEALDEN BLATTODEA - OPENING A CAN OF COCKROACHES.**

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Fossil cockroach (Insecta: Blattodea) remains are abundant in the non-marine Purbeck Limestone Group and Wealden Supergroup (Lower Cretaceous) of southern England. The toughened forewings are the most abundant remains, primarily preserved in micrites, siltstone and sandstone basin casts, and sideritic and phosphatic mudstone lenses. The first Purbeck specimens were figured in 1845, and from then up to 1939, 43 species were named. Unfortunately early workers were not aware of the high degree of intraspecific variation and virtually every wing studied was given a new name. Early figures were inaccurate which resulted in parts and counterparts being named separately and some specimens being named twice. A re-examination of the type and recently collected material (total about 2000 specimens) has resulted in the re-description (with much synonymy) and description of

23 species, belonging to 4 families- Blattulidae, Mesoblattinidae, Blattellidae and Polyphagidae. 7 of the species have remarkably long ranges, ranging from the Purbecks to Upper Weald Clay.

## **SILURIAN DENDROID GRAPTOLITES: A REVIEW**

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Dendroid graptolites have received less study than graptoloid graptolites or contemporary benthic organisms. Hundreds of monographs have been published on graptoloid graptolites; however, only a handful of studies have been undertaken on dendroids and most of these were conducted several decades ago. This study has investigated the palaeoecology, taxonomy and biostratigraphy of Silurian dendroid graptolites.

SEM studies of isolated material from two Konservat-Lagerstätten in the USA (the Racine Dolomite Formation (Wenlock), Thornton Quarry, Illinois and the Brandon Bridge Formation (upper Llandovery), Waukesha Lime and Stone Quarry, Wisconsin) have determined the thecal arrangement and morphology of some species. For example, it has revealed that *Acanthograptus aculeatus* (Poëta) may have an encrusting habit and therefore may represent a new genus or a different order.

Silurian Konservat-Lagerstätte containing diverse and abundant dendroid graptolites and dendroids occurring in other depositional environments have been reviewed. They grew in 'meadows' in oxic environments within the photic zone at depths of 1?100 m.

Stratigraphically, some Silurian dendroids appear to span 'short' periods, whilst others are relatively 'long' ranging. This suggests that with further research, dendroid graptolites may be stratigraphically useful in some areas. Evidence suggests that some genera were slow to recover after the end Ordovician extinction.

## **GLOBAL FIRE AT THE K/T BOUNDARY: MYTH OR REALITY? ?NEW EVIDENCE FROM NORTH AMERICA.**

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Several authors have proposed that there was a global wildfire at the K/T boundary following a bolide impact. Data have come mainly from scattered marine sites based upon chemical and carbon flux data. It is in the terrestrial realm that the impact of such a global fire should be seen with the deposition of charcoal deposits and an extensive erosion/depositional cycle. Charcoal data from Europe and North America suggest that wildfires were a common element of Cretaceous and earliest Tertiary ecosystems. Furthermore a study of the K/T boundary at Sugarite New Mexico, which occurs within a 2 m thick coal seam, shows that fires are common throughout the sequence. These data, plus the absence of major changes in sedimentation at the K/T boundary for Sugarite and other sites in the Raton Basin and elsewhere in North America, indicate that biomass burning at the K/T boundary must be considered within a broader ecological context of common wildfires. We have used global climate models to model the amount of carbon burnt in the late Cretaceous and early Tertiary and compared these with our charcoal data in order to investigate the effect that events at the K/T boundary may have had upon global fire regimes.

## **THE CHARACTER AND EPISODIC HISTORY OF CRETACEOUS CARBONATE PLATFORM SYSTEMS**

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Cretaceous carbonate platforms are typically made up of tabular cyclic beds. There is usually a gradation from low energy inner platform deposits ? often with metre-scale peritidal cycles ? to thicker outer platform cycles (generally < 10m), incorporating higher energy deposits. Low-angle slope deposits may follow distally, though tectonic steepening sometimes occurred. Outer platform rudist and/or coral lithosomes comprise tabular to lenticular biostromes intercalated between bioclastic units. Biostromes may extend laterally for hundreds of metres, even kilometres, but are rarely more than a few metres thick. Constructed ('reefal') rims are rare ? *pace* frequent misrepresentations in the literature ? though some karstic rims have been recorded. Thin rudist biostromes of the inner platform are typically pauci- to monospecific. Two historical contingencies of the Cretaceous are evident. First, predominant relative sea-level rise left little scope for antecedent karst surfaces (in contrast to the effect of Pleistocene glacioeustasy on modern reefs). Secondly, the typically small ('greenhouse'-style) increments of accommodation promoted rapid shoaling and lateral redistribution of bioclastic sediment. Consequently, platforms tended to a flat-topped profile, with broad outer zones across which bioclastic debris was swept both inward and outward. The platform ecosystems were dominated by sediment-dwelling shelly benthos, especially rudists. These periodically formed vast 'meadows' of clustered shells both supported by, and contributing to, the ambient sediment. Coral carpets developed downslope from them. Platform development was episodically interrupted, with mass extinctions preferentially affecting outer platform taxa. Climatic perturbations and oceanic anoxic events appear to have been involved, though causes and effects remain unclear.

# **CYCLES OF DIVERSITY IN EARTH HISTORY: THE ROLE OF SURFACE AREA**

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Patterns of origination, extinction and standing diversity through time have been inferred from tallies of taxa preserved in the fossil record. This approach assumes that sampling of the fossil record is effectively uniform over time. Although recent evidence suggests that our sampling of the available rock record has indeed been very thorough and effective, evidence will be presented that the rock record available for sampling is itself distorted by major cyclical biases. Many of the taxonomic patterns that have been described from the fossil record can be explained as a species/area effect. Whether this arises from changing surface area of marine shelf seas through time and its effect on biodiversity, or because of sampling bias, remains problematic.

## **PHYLOGENETIC RELATIONSHIPS OF WENLOCK FENESTRATE BRYOZOA**

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The Wenlock Bryozoa of Wales and the Welsh Borderland are a relatively unknown and poorly understood group of animals, despite the wealth of material that exists. Indeed, previous taxonomic concepts have been based on insufficient criteria and species descriptions are often lacking. This is especially apparent in the Wenlock fenestrates, a major component of the bryozoan fauna from the Much Wenlock Limestone Formation. The fenestrates are a distinctive order, characterised by their narrow, unilaminar, erect branches, which bifurcate at regular intervals giving the colony an overall cup-shaped or fan-shaped form. Nevertheless, at species level they are extremely homeomorphic, which has caused a great deal of controversy among researchers. Furthermore, this problem has been heightened by the weak and inconsistent methods used to study the fenestrates over the years. However, the fenestrates, as with the other bryozoan orders, possess a large number of exterior and interior characters which make them ideal for phenetic and cladistic means of classification, as has recently been shown by Hageman (1991) and Pachut *et al.* (1994). Both of these methods are employed in order to resolve species concepts and interrelationships, and to compare results from the two techniques.

## **A SOFT-BODIED MOLLUSC PRESERVED IN THREE DIMENSIONS, FROM THE SILURIAN OF ENGLAND**



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The Herefordshire Lagerstätten of England contains a fauna dominated by soft-bodied marine invertebrates, which can be reconstructed in three dimensions by serial grinding. The first animal to be described using this technique is a vermiform mollusc of bizarre morphology, that appears to have been a member of the vagile epibenthos. The animal bears a dorsal scleritome comparable to that of polyplacophorans (=chitons), and is closely related to three genera of isolated 'polyplacophoran' dorsal valves known from penecontemporaneous deposits of Gotland. However soft-part characters revealed in the Herefordshire material, including the absence of a foot and the presence of a posterior mantle cavity, suggest that these genera are related rather to caudofoveate aplacophorans, a group otherwise unknown from the fossil record. In addition to its aplacophoran and polyplacophoran characters, the new genus possesses unique 'collar and lobe' structures. These are serially repeated, at a frequency three times higher than the polyplacophoran-like serial repetition of dorsal valves. This 'metamerism' is the most striking yet discovered in a fossil mollusc, and may represent the primitive molluscan state.

## **PALYNOZONATION OF LOWER TERTIARY SEDIMENTS OF WESTERN RAJASTHAN, INDIA, WITH REFERENCE TO AKLI LIGNITE**

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The paper presents the first account of palynozonation of Akli Lignite. The palynological assemblage of the lignite is recovered from the subcrop lignite of Girla Mine section situated near Barmer city, Barmer District, Rajasthan, India.

This palynological assemblage consists of 99 species belonging to 69 form genera. Laboratory investigations have revealed that palynological assemblage of Akli Lignite is dominated by angiosperms followed by pteridophytes, while algae, fungal elements, gymnosperms, and microforaminiferal linings are present in subordinate quantities.

It is possible to subdivide the Akli Lignite succession into seven Spore-Pollen Assemblage Zones viz. 1) *Aklipollis indica*-*Matanomadhiasulcites maximus*, 2) *Palaeomalvaceapollis rudis*-*Retitetradites nairii*, 3) *Schizaeoisporites eocenicus*-*Laricoidites magnus*, 4) *Barsingsarpollenites indicus*-*Acanthotricolpites bulbospinosus*, 5) *Jafariapollis indica*, 6) *Palmaepollenites minor*-*Clavadiporopollenites raneriensis*, 7) *Gleicheniidites senonicus*-*Inapertisporites kedvesii* and four Dinoflagellate Assemblage Zones viz. 1) *Cordosphaeridium-Operculodinium*, 2) *Spiniferites*

*pseudofurcatus-Heterasphaeridium difficile*,3) *Leptodinium sp.*,4) *Cordosphaeridium inodes-Operculodinium centrocarpum* on the basis of First Appearance Datum(FAD) and Last Appearance Datum(LAD) of significant palynomorph taxa.

The overall assemblage recovered at this investigation suggests a Palaeocene-Eocene age for this lignite sequence.

## **'WAPTIID' ARTHROPODS AND THE SIGNIFICANCE OF BIVALVED CARAPACES IN THE LOWER CAMBRIAN**

Rod S. Taylor

In 1912, Charles D. Walcott erected the Family Waptiidae to accommodate *Waptia fieldensis*, a still poorly understood bivalved arthropod from the Middle Cambrian Burgess Shale of British Columbia, Canada. Several other bivalved arthropods seemingly similar to *Waptia* have since been discovered, such as the Lower Cambrian taxa *Paulotermimus spinodorsalis* (*nomen nudum*) from the Sirius Passet fauna of North Greenland and *Chuandianella ovata* from the Chengjiang fauna of southwest China.

Despite their overall waptiid-like appearance, however, each of these animals possesses features which suggest their apparent similarity to *Waptia fieldensis* may be superficial. Variability in segment number, limb number and limb type between these taxa, for example, suggests these animals may not in fact be closely related.

Other non-waptiid Cambrian arthropods also possess bivalved carapaces, including the Burgess Shale taxa *Canadaspis perfecta* and *Plenocaris plena*. This indicates two alternative evolutionary scenarios. First, the relatively common occurrence of bivalved carapaces may indicate a stem-group clade of bivalved arthropods in the Cambrian, united (at least) by their possession of this specialized carapace. A second, perhaps more likely, possibility is the occurrence of evolutionary convergence, resulting in the presence of a bivalved carapace in multiple unrelated Cambrian arthropod taxa.

## **MINERALIZATION OF FOSSILS FROM THE HUNSRUCK SLATE, GERMANY**

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The Lower Devonian Hunsrück Slate comprises a series of metamorphosed distal turbidites containing exceptionally preserved fossils. These show pyritization of soft parts, to an extent known from only two other deposits world-wide, indicating that a rare combination of mineralization processes was responsible. Since pyrite is very common in mudrocks, it is important to understand

why pyrite has not preserved soft parts more frequently.

The recent excavation of part of the sequence in the Eschenbach quarry (Project *Nahecaris*) has provided a previously unavailable stratigraphic context for studying the mineralization processes. Documentation of the fossil content and sedimentology of the excavated sequence has revealed horizons with distinctive faunal and taphonomic assemblages, leading to predictions about conditions required for different modes of preservation.

The fossils have been examined using SEM and microprobe (elemental mapping). Pyrite is dominant, occurring mainly as infills showing framboidal and euhedral habit. There is generally no preservation of cellular structure; the exceptions are microscopic vascular plant fragments and spores that show preservation of organic walls in addition to pyrite cell lumen infills. Calcite, phosphate and quartz are also present in other taxa.

The spectacular preservation of these fossils is the result of a number of contributing factors, most notably the activity of sulphate reducing bacteria and the high Fe and low total organic carbon content of the sediment.

## **COELOBIONTIC COLONIZATION OF CRYPTIC CAVITIES IN THE LOWER CAMBRIAN PEDROCHE FORMATION (OSSA-MORENA, SOUTHERN SPAIN)**

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A well-preserved coelobiontic biota of early Ovetian age (Early Cambrian; Moreno-Eiris *et al.* 1995. Paleozoic Cnidaria and Porifera from Sierra Morena. Field Trip D. In PEREJÓN A. (ed.). VII International Symposium on Fossil Cnidaria and Porifera, Madrid, 1-68) is found near the city of Córdoba (Ossa-Morena, southern Spain). Cryptic cavities occur at the unconformable boundary between an eroded, andesitic paleotopography, which belongs to the Neoproterozoic San Jerónimo Formation, and the giant reef complex of the Lower Cambrian Pedroche Formation (Zamarreño and Debrenne 1977. *Sédimentologie et biologie des constructions organogènes du Cambrien inférieur du Sud de l'Espagne. Mémoires du BRGM*, 89, 49-61; Moreno-Eiris 1988. Los montículos arrecifales de algas y arqueociatos del Cámbrico Inferior de Sierra Morena. *Publicaciones Especiales del Boletín Geológico y Minero*, 98, 1-127). The cavities exhibit several phases of growth, in some cases tectonically induced. The coelobiontic biota is preserved on the cavities (i) attached to the walls or encrusting previously attached organisms, and (ii) within the sediments that fill the cavities. The biota was diverse and consisted of encrusting, self-supported calcimicrobes, chancelloriids and archaeocyaths, found attached to walls and roofs of the cavities. Other reworked organisms preserved within the cavities are trilobites, brachiopods and hyoliths derived from the overlying open-sea

communities.

## **SPORE ASSEMBLAGES FROM THE LOWER DEVONIAN SEQUENCE OF THE RHYNIE OUTLIER: EVIDENCE FOR THE PALAEOECOLOGY OF THE RHYNIE CHERT PLANTS**

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The Rhyinie cherts preserve the oldest known example of an *in situ* terrestrial ecosystem. They represent siliceous sinters derived from a hot spring system, that periodically inundated land surfaces preserving *in situ* soil profiles, flora and fauna. The fossils are remarkably preserved due to the novel silicification process that incarcerated them. Analysis of the Rhyinie cherts provides an unprecedented insight into the nature of terrestrial ecosystems at a critical time in the early evolution of life on land.

Boreholes have yielded well preserved palynomorph assemblages from throughout the sequence of the Rhyinie outlier. The palynological preparations contain spores and phytodebris (including arthropod cuticle). They all belong with the *polygonalis-emsiensis* Spore Biozone indicating a Pragian (Early Devonian) age. Detailed examination of *in situ* spores preserved in the Rhyinie chert plants permits their identification in the dispersed spore assemblages. Analysis of the distribution of spores throughout the Rhyinie sequence (particularly those deriving from the Rhyinie chert plants) is shedding light on the palaeoecology of the Rhyinie flora. It is suggested that the spores derive from a relatively low diversity vegetation developed in an inland intermontaine basin, but the actual Rhyinie plants are typical of this vegetation and are not highly adapted plants thriving in the peculiar hot spring environment.

## **PHYLOGENETIC POSITION OF THE PALAEOZOIC ARTHROPLEURIDEANS**

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The Arthropleuridea are a group of enigmatic Palaeozoic terrestrestrial myriapodous arthropods whose affinities have been debated since the description of the first member of the group in the 1850s, the Coal Measures giant *Arthropleura armata* Jordan and Meyer which reached lengths of over 2 metres. *Arthropleura* has been allied with almost every conceivable arthropod group, though most recently with the Myriapoda. A new minute arthropleuridean, *Microdecemplex rolfeii* Wilson and Shear, has recently been described from the Devonian of New York State. While reaching lengths of only a few millimetres, *Microdecemplex* is big news for arthropleurideans as cephalic material is preserved, confirming a millipede identity. Based on a combination of cephalic, trunk and

appendicular characters, it is suggested that Arthropleuridea is the sister group to chilognath millipedes (Diplopoda = Penicillata + (Arthropleuridea + Chilognatha)).

## *Poster Presentations*

### **MOLLUSCAN COMPOSITION AND PALAEOENVIRONMENTAL INTERPRETATION OF LATE PLEISTOCENE AND HOLOCENE COASTAL DEPOSITS ALONG THE GOLFO SAN JORGE (CENTRAL PATAGONIA, ARGENTINA)**

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A rich macroinvertebrate fauna of bivalves and gastropods associated with cnidarians, brachiopods, crustaceans and echinoids is preserved within Late Pleistocene and Holocene coastal deposits from Golfo San Jorge (Patagonia). The Holocene ridges (+8-12m a m.s.l.; 2-6 Ka, Marine Terrace VI) correlate with those from the Bonaerensian littoral (northern Argentina) and Uruguay, Brazil and Surinam. Differences refer mainly to preservation, composition and palaeobiogeography of the taxa identified within the Patagonian assemblages. The late Pleistocene assemblages lack typically warm-water species, show greater abrasion and fragmentation and greater height (+15-30m a m.s.l.; minimum 25-35 ka; Marine Terrace V) than approximately synchronous shelly concentrations from the Bonaerensian littoral (+3-10m a m.s.l.) and Uruguay (+1-4m a m.s.l.). Differences between marine terraces V and VI and with synchronous Bonaerensian deposits in the north can be explained in relation with environmental conditions and neotectonic uplift. The late Pleistocene and Holocene molluscan assemblages suggest a shallow, high-energy, hard-substrate palaeoenvironment similar, but less diverse, than the modern littoral (Magellanean Province). The lowest diversity in deposits assigned to the Last Interglacial (IS5e) (aminoacid racemization, ESR) and the lack of typically warm-water taxa needs to be explained if they accumulated during a global maximum sea-level stand of higher temperature than present. This, together with the Holocene Hypsithermal recorded in the Bonaerensian littoral but not as yet in Patagonia, are problems under current study.

### **NEW FOSSIL FINDS FROM THE MIDDLE DEVONIAN (EIFELIAN) ACHANARRAS QUARRY FISH BED, SPITAL, CAITHNESS, SCOTLAND**

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The Achanarras fish bed (late Eifelian) of the Middle Old Red Sandstone at Achanarras Quarry, Caithness contains the most diverse fauna described from any ORS fish bed, including a minimum of 16 fish genera. The faunal diversity, combined with excellent preservation of complete carcasses, make this site one of the most important Middle Devonian fish localities in the World.

Two recent fossil discoveries made by collectors have further enhanced the palaeontological importance of Achanarras. We report a new chasmataspid chelicerate (the first arthropod fossil from the site) and a basal Hypoartian closely related to the lampreys. Chasmataspids show affinity to eurypterids and less so to the extant Xiphosura or horseshoe crabs. Both of these fossils point to the existence of conditions at the site amenable to the preservation of unmineralised tissues other than the previously reported skin impressions of the fish.

The finds also illustrate the value of keeping important sites open to the public, providing on-site interpretation and allowing responsible collecting to continue.

## **A NEW, ENIGMATIC ORGANISM FROM THE EARLY DEVONIAN (PRAGIAN) RHYNIE CHERTS, ABERDEENSHIRE, SCOTLAND**

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The Early Devonian Rhynie hot spring complex (including the nearby Windyfield sinter pile) yields exceptionally preserved early terrestrial and aquatic plants and animals enclosed in cherts.

We illustrate new organisms that are broadly ovoid in form (length 1.4 mm, width 0.66 mm) and occur closely spaced in groups of up to 20 individuals. There is a preferred orientation to individuals in a group. Internal structures are preserved in some examples and consist of a serially divided central tube. The tube has up to 12 segments that fit together like a stack of whisky tumblers. The 'body' or test of the object is divided ventrally, but the dorsal surface is continuous suggesting a univalve test. There are the suggestions of thin, ventrally positioned jointed appendages. The textural association of the fossils strongly suggests that they were aquatic organisms that colonised the axes of the submerged plants during times of inundation.

Two alternative interpretations are suggested. This may be the earliest fossil occurrence of cladoceran crustaceans, a group typified by the extant form *Daphnia*. Alternatively, given the grouping and orientation of the objects, they may represent egg capsules of an unknown animal fossilised in the

process of development.

## **A PALAEOENVIRONMENTAL ANALYSIS AND INTERPRETATION OF JURASSIC (BAJOCIAN) LIMESTONE SEQUENCES NEAR PETERBOROUGH, CAMBRIDGESHIRE**

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Palaeoenvironmental facies associations are established for the Lower Lincolnshire Limestone Formation of the Middle Jurassic (Bajocian), as exposed in King Street Quarry, near Peterborough. Four individual facies are identified: pelagic, barrier bar, tidal inlet and lagoonal, which were set in a calm and equable environment, punctuated by seasonal storms. A prograding shoreline within the palaeoenvironmental system is indicated, which was migrating southwards out to sea. Evidence was derived from detailed logs of ten sections from around the quarry perimeter, which show facies that vary from massive fine grained mudstones to 'fining upwards' sequences of oolitic and bioclastic packstones and grainstones. Environmental facies interpretation was aided by the study of abundant and diverse ichnofauna, macrofauna and microfauna, which were extracted from the quarry face. A palaeoenvironmental interpretation of the environments of deposition for the Lower Lincolnshire Limestone is given in this study, by establishing the relationships between laterally and vertically variable facies.

## **CONTEMPORARY BENTHIC INTERTIDAL FORAMINIFERER AND THEIR ENVIRONMENTAL PARAMETERS: A CASE STUDY**

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Foraminiferids *Protelphidium anglicum*, *Ammonia beccarii* and *Trochamina inflata* are studied within a contemporary low energy coastal setting on the River Alt estuary at Hightown, on the north Merseyside coast. A comprehensive range of benthic environmental facies have been identified in the study area, which include beach, channel, mudflat, intertidal pools, salt marsh and brackish marsh. Foram distributions, relative abundances and living/dead ratios for each facies are assessed over a twelve month period. Environmental parameters such as substrate salinity/oxygenation, intertidal exposure times, sediment grainsize and altitudinal range are used to identify 'signature' relationships between the forams and their local environment. Transfer functions can be derived from such a data

base, for future use in the interpretation of Holocene sequences and sea level changes.

## **SILURIAN AND DEVONIAN STRATIGRAPHY IN THE DORNES AREA, CENTRAL PORTUGAL**

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The Silurian and Devonian sequence of the Dornes area is about 740m thick and divided into six formations. The Vale da Ursa Formation (10-26m), includes quartzites, sandstones and siltstones, resting on the Ordovician Casal Carvalhal Formation which includes glacial tillites of early Hirnantian, Ashgill age. The Serra dos Aguilhões Member of the Vale da Ursa Formation is of early Llandovery age. The Foz da Serta Formation (140-200m) consists of dark grey mudstones, siltstones and some thin-bedded sandstones at least of late Llandovery to early Ludlow age. The condensed early Llandovery succession contrasts with the much thicker Wenlock sequence where most of the graptolite biozones are represented. The Vale do Serrão Formation (c. 77m), includes laminated to very thinly bedded quartzites with mudstone laminae, of apparently early Ludlow age. The Serra da Mendeira Formation (52m), is composed dominantly of fine- to medium-grained, light grey quartzites in thin to medium beds. The Serra do Luação Formation (195m), is heterolithic, with grey and beige-brown, fine- to medium-grained sandstones in thin to medium beds, with packages of quartzites up to 9m thick and siltstones up to 5m thick.. Acritarchs from 25 and 110m suggest a late Ludlow to Prídolí age, though the formation probably ranges from mid or late Ludlow to late Lochkovian or early Pragian. The Dornes Formation is a heterolithic limestone, sandstone and mudstone sequence at least 215m thick, with a Pragian brachiopod fauna.

## ***EUTHACANTHUS* SPP, A MUCH CLONED DEVONIAN ACANTHODIAN FISH**

R. G. Davidson and M. J. Newman.

The acanthodian fish genus, *Euthacanthus*, from the Lower Devonian of Scotland was erected, as 5 species on the basis of comparative morphology, by James Powrie in 1870. Despite cautious observations by previous workers, as to the unsafe nature of Powrie's classification, no further taxonomic work has been published and these descriptions stand to the present day.

As a result of a review of specimens after a sedimentological study at the type locality in 1996, one of

these species is confirmed to be unrelated and past doubts as to the evidence of species diversity in the other four are consolidated in this work. New material of two of the forms has been collected and histological analysis of thin sections of scales is under way. The morphology of all the available type material has been re-evaluated and as a result a synonymy of characters is proposed. It is possible that only two species exist and that features regarded as specific are due to ontogenetic changes and differences in preservation. This work in progress deals with the paucity of evidence upon which the original species were raised, diagnostic features previously overlooked or misinterpreted, and the stratigraphical relationships of the various taxa.

## **EXQUISITELY PRESERVED MIDDLE ORDOVICIAN CRINOIDS FROM WALES AND THE WELSH BORDERS**

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The fossil record of complete crinoids in the Palaeozoic of Britain is patchy. In the Ordovician, only the Ashgill Lady Burn Starfish Bed of Girvan, southeast Scotland, has yielded a truly diverse fauna of crinoids. Although a moderate diversity of crinoids has been documented from various horizons in Wales and the Welsh borderlands, most species were based on one or a few poorly preserved specimens, with some type localities no longer accessible.

We report a new crinoid-bearing locality in the Shelve Inlier which has yielded the *cladids* *Merocrinus salopiae* Bather and *Pandoracrinus mincopensis* Ramsbottom. Both species were hitherto known only from incomplete holotype specimens collected from Mincop Farm quarry (now infilled) in the 19th century. The new material includes multiple specimens and were collected by W. F. The preservation of specimens from this locality is exquisite, including juveniles and attachment structures, and is amongst the best echinoderm material known from the Ordovician of the British Isles.

Similarly, N.G. has found specimens of an unusually well-preserved camerate from the Middle Ordovician of Wales. With the exception of the distalmost arms, the specimen is complete and suggests a close affinity to *Trochocrinites laevis* Portlock from the Upper Ordovician of Ireland.

## **STRANGE SILURIAN STARFISH**

Liam Heringshaw

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Starfish, or asteroids, are rare as fossils since they rapidly disarticulate after death and the ossicles which make up the exoskeleton are dispersed. It is primarily through exceptional events of rapid burial (obration) that they are preserved intact. The Much Wenlock Limestone Formation is the only British horizon of confirmed Wenlock age to have produced asteroid fossils, and the mode of preservation is unique amongst British Silurian starfish-bearing localities, as the specimens are preserved as skeletal fossils rather than moulds.

The last piece of work to have examined the asteroids of the Wenlock Limestone was Spencer's Monograph of the British Palaeozoic Asterozoa (1914-40) and re-examination of that work in the light of new specimens and techniques has led to the discovery of four new species, two of which belong to new genera, as well as a reappraisal of a number of Spencer's interpretations regarding affinities and functional morphology.

The most intriguing of the asteroids is *Lepidaster grayi* Forbes, 1850. All specimens known have more than five rays, and the maximum number seen is 13, suggesting that not only does the species deviate from the normal five-rayed arrangement of asteroids but also from the pentaradial symmetry cited as typical of the echinoderm body plan. This is the first example of multiradiate asteroids in the fossil record, and suggests that that state has evolved independently more than once in starfish history.

## **EVIDENCE FOR OXIC DEPOSITION DURING THE CENOMANIAN/TURONIAN (CRETACEOUS) BOUNDARY EVENT**

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The Cenomanian/Turonian (C/T) boundary has traditionally been considered as a period when anoxic or dysoxic conditions were globally dominant, and British C/T deposits have largely been interpreted as reflecting deposition under oxygen-restricted conditions (e.g. Jarvis et al 1988; Bralower, 1988). Gale et al. (2000) reinterpreted the sequence at Beachy Head, Sussex, in terms of oxic depositional conditions; the presence of complex, diverse multi-tiered ichnocoenoses supports this interpretation, indicating that sea level and substrate stability were the dominant controls on the trace-producing organisms. The C/T sequence ("Black Band") at South Ferriby, Humberside, can also be reinterpreted as reflecting oxic conditions on the basis of evidence from sediment fabric and pyrite petrography. Sediments previously described as laminated (Dodsworth, 1996) are shown to be bioturbated, while SEM analyses show that pyrite framboids, expected under oxygen-restricted conditions, are absent. These data indicate that sites within both the Anglo Paris and North Sea Basins were subject to oxygenated conditions during the C/T boundary event. In contrast, a local deep-water site in north west Germany provides evidence for deposition under alternating dysoxic and oxic conditions.



## **ENHANCED SEM IMAGING OF *UINTACRINUS* SOFT TISSUE USING BSE (BACK SCATTER)**

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Used in standard chemical analysis of material, BSE (back scatter) shows differences in average atomic number as differences in brightness on a grey level scale for digital images. In order to produce meaningful results the specimen surface must be completely smooth. In the absence of a flat surface topographic features are accentuated.

Images of exceptionally preserved soft tissue (anal tube) in *Uintacrinus* are greatly enhanced when viewed in BSE mode. A combination of the composition of this material, calcite plates overlaying a carbonaceous lining, and the topography produces the effect. Detail of anal tube microstructure is shown for the first time. Analysis of the tegmen shows the presence of pyrite framboids, which are easier to identify in BSE and the black carbonaceous lining which underlies the calical plates is shown to be replaced by filamentous and rod-shaped cyanobacteria.

This poster describes the method for preparation of materials and displays contrasting images of *Uintacrinus* soft tissue in secondary emission and back scatter mode. Such a simple technique may be appropriate for analysis other fossil soft tissue. Thus improving the quality of the SEM image and therefore understanding of the soft tissue morphology.

## **A STATISTICAL APPROACH TO CLASSIFY THE CAMBRO-ORDOVICIAN GALEATE ACRITARCH PLEXUS**

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The Cambro-Ordovician galeate acritarch plexus includes all hemispherical acritarchs with a large polar excystment opening closed by an operculum. According to the distribution pattern of the processes and ornamentation, the plexus is divided into 4 genera, of which over 90 species have been erected so far. By considering the large variability in the galeate populations it has been attempted to research the important morphological parameters using statistical approaches (multivariate analyses)

based on large populations of the well preserved material from the Late Cambrian-Early Ordovician of the Algerian Sahara. Continuous and discrete parameters can be delimited. The factor and cluster analyses reveal that the length of processes is the significant parameter. In a lesser extent, the structural ornamentation can be useful for taxonomical distinction. The results show that the traditional view of galeate acritarch taxonomy necessitates a serious revision and indicate that statistical investigations of large populations appear to be able to provide new insights for the understanding of the spatial and temporal distribution of the galeates.

## **MOLAR SHAPE, POPULATION STRUCTURE, AND POST-GLACIAL RECOLONIZATION IN BRITISH *SOREX ARANEUS* (LIPOTYPHLA, EUTHERIA): TOWARDS A PALAEOPHYLOGEOGRAPHY**

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Phylogeography is a relatively new term applied to within-species phylogenetic and geographic divergence. Within-species divergence has usually been the domain of molecular biology, because molecular markers record population structure at a finer level than do traditional morphologic traits. Because of this, palaeontological studies have usually been limited to among-species biogeography or species range shifts. But advances in geometric morphometrics now allow very complex morphologies to be quantified. In at least some mammals, dental variance is indicative of population structure that is beyond the resolution of traditional morphologic traits. Extant populations can often be matched to palaeontological samples, even based on data from single teeth.

Landmarks representing cusps and other structures on lower first molars were collected from British populations of the Common Shrew, *Sorex araneus*. This species is divided into numerous karyotypic or "chromosomal" races. Morphological distinction is difficult even between *S. araneus* and sister-species *S. coronatus* and *S. granarius*, whose identification requires multivariate discriminant analysis of numerous mandibular measurements. Shape analysis of the lower first molar distinguishes these species, as well as the chromosomal races within *S. araneus*. In Britain, there are three races: the Hermitage race (south of the Thames and along the Welsh borderlands), the Oxford race (north of the Thames to the Forth valley), and the Aberdeen Race (in Scotland and Wales). The Hermitage is more similar to continental races than to either of the other two British races; however, shrews from the Late Glacial Ightham Fissures, Kent (within the current geographic range of the Hermitage race) are more similar to the Oxford and Aberdeen races. This suggests that the Hermitage race entered Britain during the Holocene, probably trailing a northward expansion of a proto-Oxford/Aberdeen race following deglaciation.

**FILLING THE MESOZOIC GAP: TERRESTRIAL ARTHROPODS FROM THE CRATO**

## FORMATION OF BRAZIL

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The Nova Olinda Member of the Lower Cretaceous Crato Formation of northeast Brazil is a fossil Konservat-Lagerstätten famous for the exceptional quality of preservation, abundance and diversity of its arthropod fauna. The Nova Olinda member is comprised mostly of limestone laminated on a millimetre scale and many of the fossils appear to be preserved as a goethitic replacement, probably after pyrite. The arthropod fauna of the Nova Olinda Member is most widely known for its winged insects, however other terrestrial arthropods occur infrequently. These include apterygote insects (Diplura), centipedes (Chilopoda), whip scorpions (Uropygi), whip spiders (Amblypygi), sun spiders (Solifugae), scorpions (Scorpiones), spiders (Araneae) and harvestmen (Opiliones). These specimens are significant in that many of them represent the only known Mesozoic members of their respective orders.

Compiled and Edited by [Phil Donoghue](#)

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