FABULOUS FOSSILS: EXAMPLES OF EXCEPTIONALPRESERVATION

Abstracts of lectures at the Saturday School at Vaughan College, 7th March, 1998

Introduction by Andrew Swift

Exceptionally in the geological record conditions governing the fossilisation of organisms are suitable for the retention of greater detail than is usual. This can include the preservation of soft tissues which normally rot away or are scavenged. Also, entirely sodf-bodied organisms may be preserved, as in the famous Burgess Shale, giving a striking window on sections of ancient marine biotas which are normally not seen. Several of these soft-bodied organisms are still little known and take bizarre forms. Lightly articulated body parts, such as feeding structures, are usually dispersed by current and wave action, but these too may be found in life associations in certain exceptional deposits. Original colour is normally lost on fossilisation, but this too may be retained. Interaction between organisms is rarely recorded via fossils, but at certain horizons animals are preserved in associations which give special insights into their lifestyles.

Examples of several of these unique fossils were discussed by distinguished speakers form the world of academia. 440 million year old animals of unknown affinity, ancient carnivorous vertebrates, flying reptiles, early spiders, worms and shrimp-like creatures retaining non-biomineralised detail, colour-banded snails etc. were all on the agenda.

Setting the scene: an overview of exceptional preservation

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The tissues of animals and plants vary in their susceptibility to decay. The most labile, like muscle, are degraded very rapidly, normally within days. In order to be fossilised they must be replicated by minerals early enough to avoid the loss of morphological detail. This process is finely balanced because some decay is necessary to promote mineralization. In contrast, more decay resistant material, like the skeleton of arthropods, the periderm of graptolites, and the cuticles of plants, may survive and become fossilised as organic material, often with some chemical alteration. Exceptionally preserved fossils are a product of both these processes.

Soft-bodied fossils from a Silurian volcaniclastic deposit

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Fossil deposits preserving lightly sclerotized and soft-bodied organisms are fundamentally important to our understanding of the history of life on earth: they provide a much more complete record of ancient communities than does the normal shelly fossil record. Conditions during the Cambrian may have favoured the preservation of soft-bodied organisms. Burgess Shale-type and Orsten-type faunas are becoming increasingly known from this ca. 40 million year long period, for which we have an increasing body of data on the early metazoan radiation. Soft-bodied organisms are much less well represented in the 100 million years thereafter. The discovery of a new Silurian soft-bodied biota therefore has the potential to fill an important gap in our knowledge. The relatively deep water marine environment represented is dominated by previously undiscovered arthropods and polychaetes. This report of soft-bodied fossils from carbonate concretions within a volcanic ash identifies an important new source of soft-bodied taxa.

Fossil Spiders

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The fragile, squashable nature of spiders suggests that they would make poor fossils, and indeed it is the case that fossil spiders are rare. Even in beds where insects are common, spiders form only a small percentage of the fauna. For this reason, spiders are good indicators of Fossil Konservat-Lagerstatten deposits which are rightly famed for their exceptional preservation of soft-bodied plants and animals.

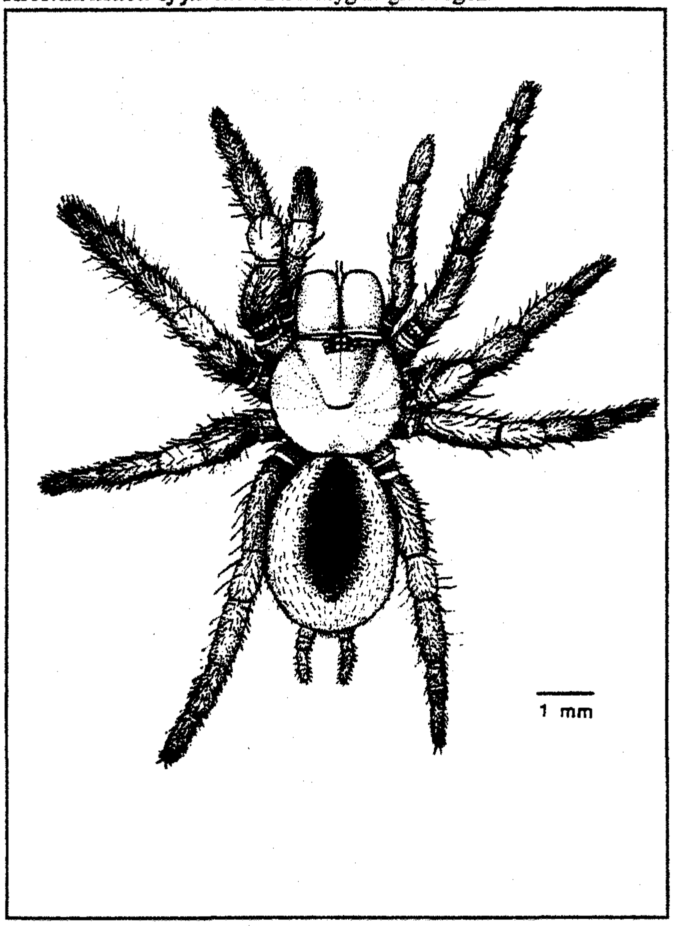
A glance at the fossil record of spiders indicates distinct concentrations in such Lagerstatten: Eocene Baltic and Oligocene Dominican ambers, and the Coal Measures of Europe and North America, for example. Relatively few spiders have been found in Mesozoic rocks, but recent finds are helping to change this picture.

Tertiary spiders are quite similar to those of today, the exquisitely preserved amber fossils look as though they could have been alive just hours ago. One strange genus, *Archaea*, was first described from Baltic amber and later found alive in Madagascar! Limestone fossils also occur in the Tertiary, and one spectacular fossil from the Bembridge Marls of the Isle of Wight shows respiratory organs both book-lungs and tracheae preserved in fine detail in calcite.

Fine limestones are also responsible for the preservation of spiders from the lowermost Cretaceous of north-east Spain which show remarkable preservation of the foot-claws and spinnerets. These features enabled the specimens to be identified as belonging to modern families of spiders which weave the familiar orb webs seen in gardens today. Imagine dinosaurs brushing past orb webs stretched between cycads! Many spider fossils are now being discovered in Cretaceous rocks of Brazil, but amongst them occur other arachnids such as the solpugid or camel-spider. This fearsome animal occurs in deserts today and the Brazilian specimen was the first to be found in Mesozoic strata. Only one species of fossil spider has so far been described from Triassic rocks: *Rosamygale*, from the Vosges mountains of France (below). This is the oldest known mygalomorph spider, and belongs in the primitive, present-day family Hexathelidae, which includes the venomous Sydney Funnel-web spider. Mygalomorphs also include bird-eating and tarantula spiders, and are sister-group to the more familiar araneomorphs. The two groups together are sister-group to the most primitive spiders of all, the mesotheles. Newly discovered specimens from the Triassic of South Africa and Virginia, and soon to be published, are the oldest known araneomorphs.

Permian rocks have so far yielded no fossil spiders, and there are, as yet, no proven mygalomorph or araneomorph spiders known from rocks of Palaeozoic age. Indeed, lack of characteristic features such as spinnerets on the large number of generally well-preserved Carboniferous spiders makes one wonder whether they were, indeed, spiders at all. However, in the last few years, a couple of specimens from the Autun coalfield in central France have been discovered which show spinnerets as well as other characteristically primitive features of mesothele spiders, such as two pairs of book-lungs. The most primitive spiders alive today belong in this group and are found in south-east Asia. However, a spider showing even more primitive characters, *Attercopus*, has been described from older, Devonian rocks from the Catskill Mountains, New York. Known only from scraps of cuticle, the tell-tale spinneret revealed its spidery heritage.

Reconstruction of juvenile Rosamygale grauvogeli.



Finally, whilst *Attercopus* is the oldest known spider, excavations a few years ago in Silurian rocks in Ludlow, Shropshire, revealed the oldest known terrestrial animals yet discovered. These included various kinds of centipedes and a trigonotarbid. Trigonotarbids are very closely related to spiders but lack spinnerets. It would not be surprising if true spiders were also to be found amongst the earliest animals to have walked on land, some 414 million years ago.

Colour preservation in the fossil record: new tales from old snails

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Actual colour pigment preservation in the fossil record is rare, although retention of degraded pigment and colour pattern can be more common locally. Pigments in modern gastropods are usually melanin or tetrapyroles (either biliproteins or cyclic porphyrins). Preservation of colour pigment in fossils is aided by early diagenetic cements encrusting the fossil, or, in the case of neritid gastropods, having the original pigment secreted under a diagenetically stable outer shell of calcite. Late Palaeozoic, Mesozoic and Tertiary archaeogastropods with retained colour patterns have been examined. Colour patterns within the thin-shelled pleurotomariids appears not to have changed through time but they have radically changed their mode of life putatively because of the Mesozoic marine revolution and the rise of durophagous molluscivores such as callapid crabs - a case of move or become extinct. Neritid gastropods on the other hand maintained their habitat preferences (shallow marine/intertidal/brackish/freshwater). Marine neritids have thick, globular shells, often with a thick periostracum, and show colour patterns with no change through time. However, in the thin-shelled intertidal and brackish neritids it is a different story. These small gastropods have a thin transparent periostracum and the colour pigment is readily visible. They have evidently adopted a different adaptive strategy which can be documented through time. Early representatives (Late Triassic - Middle Jurassic) have simple colour patterns but subsequently the pattern becomes progressively more complex. Extant representatives such as *Neritina communis* and *Theodotus (Clithon) oualenensis* have complex colour patterns and no two individuals are identical. Such is the complexity of the patterns that only computer generated programmes with a randomised element can mimic the variation. It is believed that this increase in variation is actively selected for and prevents the acquisition of predator search patterns. As such, it documents the progress of reflexive evolution and predator - prey selection pressures.