Manchester Geological Association
The Broadhurst Lectures

Many MGA members will remember Dr. Fred Broadhurst, a former member of staff in the Geology Department (as then was) of Manchester University, with great affection. Fred, a past-President and honorary member of the MGA, who died in October last year, gave great encouragement and support to the MGA and its members over many decades. In this day of talks, the MGA celebrates the life and work of Fred, by looking at some topics that he himself was interested in, given by people who knew and worked with him.

Saturday 13th November 2010 – Jurassic Seas, Jurassic Skies

10.30 – 11.15 Burrowing Bivalves and Shuffling Shrimps: What can Trace Fossils tell us about the Sediments in the Jurassic? – Dr. Peter Hardy, University of Bristol
11.15 – 12.00 Feeding Habits of Jurassic Ichthyosaurs and Sharks
Dr. John Pollard, University of Manchester

12.00 – 14.15 Lunch and Display of Jurassic Fossils in the Manchester Museum

14.15 – 15.00 Breathing New Life into Old Bones – bringing plesiosaurs to life
Dr. Leslie Noè, University of Cambridge

15.00 – 15.30 Coffee Break

15.30 – 16.15 Jurassic Pterosaur Diversity
Dr. David Martill, University of Portsmouth
16.15 – 17.00 The Life of Archaeopteryx – Dr. Derek Yalden, University of Manchester

In the Jurassic Britain lay about twenty degrees north of the Equator, enjoying a warm Caribbean climate. The sea level was much higher than today, so that most of lowland Britain was submerged. Forests of cycads, ferns and pines covered the land.

Marine life thrived in the warm seas – crinoids, corals, ammonites, belemnites and fish. A variety of predators, such as ichthyosaurs and plesiosaurs, hunted them. Ichthyosaurs, dolphin-shaped reptiles with long, tooth-lined jaws, extremely large eyes and flipper-like limbs, fed on fish and belemnites. Another group of predators, the plesiosaurs, had very long necks and two pairs of flippers used for swimming. Some species of ichthyosaur and plesiosaur grew to a very large size and would have been formidable hunters.

Pterosaurs also hunted fish – from the air! They were flying reptiles (in fact, the earliest known flying vertebrates) possessing long jaws lined with teeth, the front ones of which were usually longer than the others and ideal for impaling fish. The fourth digit of the forelimb had become greatly elongated, strengthened and covered by a membrane to form a wing. Also flying in the late Jurassic were the first birds, *Archaeopteryx*, which had wings and tail covered by feathers, whilst retaining some reptilian features, such as teeth-lined jaws and a bony tail.

Burrowing Bivalves and Shuffling Shrimps: what can trace fossils tell us about the sediments in the Jurassic? - Dr. Peter Hardy, University of Bristol

In the arenaceous sediments of the Upper Carboniferous there are very few body fossils, but relatively common occurrences of trace fossils, which allow an interpretation of the palaeoecology. Some of these trace fossils indicate that the sandy sediments were often deposited very rapidly, as much as two metres of sand within the lifetime of one individual animal was observed, thus suggesting dramatic flooding. The critical factor, which enabled this to be established was the recognition that many of the supposed burrows were actually escape structures, made by animals which were being rapidly buried. In one example a sequence of seven or eight alternating coarse and fine bands was penetrated by a community of animals, showing that the entire sequence was laid down within one animal's life-time. This suggested very strongly that the alternating cyclic units of sand and mud were of a seasonal, very probably annual nature.

There are many similarly cyclic units of clastic sedimentary rocks, and in the Jurassic they are often accompanied by limestone horizons. These were studied to attempt to establish whether they too might have a seasonal control. Commencing with the lowest Jurassic (White and Blue Lias) in north Somerset it became apparent that there were upward escaping organisms, probably shrimps, especially noticeable in the lime rich bands, but despite careful searching for sequential upward moving burrows nowhere could it be established that the successive bands were laid down on very short time scale. The search was then extended to the Blue Lias of Dorset where upward movement in the very common U-shaped burrows (*Diplocraterion*) of shrimps was found to be very common. It was clear that at times the shrimps had to burrow downwards to establish their 'homes' but at others they were required to migrate upwards or to perish. The evidence again failed to demonstrate any clear time scale for these banded units, which remained an elusive goal.

The final stage in this quest for a better understanding was conducted in the mid-Jurassic in beds known as the Corallian. These include sandstones, mudstones and various limestones, notably some large concretionary 'doggers' within the sandy unit and pelleted oolitic limestones, which were deposited as coarser-grained pisolite and smaller-grained oolite. In the latter there were found to be abundant shafts, which extended upwards from U-shaped shrimp burrows, just as in the Lias. In addition to these evident escape structures there were in the sand unit very common sub-horizontal burrows with clear evidence of a shrimp-like animal's work in the form of appendage scratch marks. The benthic community clearly lived in very turbulent waters and was apparently buried by rapid sediment accumulation on more than one occasion.

Feeding Habits of Jurassic Ichthyosaurs and Sharks
Dr. John Pollard, University of Manchester

This is a detective story! In April 1963 while on a student field trip to Dorset with Fred Broadhurst, we found the skeleton of a small ichthyosaur in the Lower Lias near Lyme Regis. Once exposed we had to extract the specimen rapidly in advance of the incoming tide! When we prepared the specimen back in Manchester we discovered that it had a dense gastric mass of cephalopod hooklets associated with the ribs.

Then followed detailed analysis of the specimen and visits to other UK museums to examine other ichthyosaurs with gastric contents, Liassic coprolites and complete ’belemnites’ with arm hooklets. This led to conclusions on the prey, feeding habits and digestive mechanism of Liassic ichthyosaurs in comparison with living Sperm Whales, all published in the journal “Palaeontology” in 1968.

In 1979 while on a research visit to museums in south Germany to study Triassic trace fossils, I saw a fossil shark in the Stuttgart museum from the Upper Liassic shales of Holzmaden which had 200 belemnite guards in its stomach contents. This reawakened my interest and was followed up by Peter Doyle (1993) in his study of “Belemnite Battlefields”. Meanwhile, in the 1970s and 1980s German palaeontologists studied the gastric contents of Holzmaden ichthyosaurs and contemporaneous coleoid cephalopods, so refining the understanding of the nature of the hooklet bearing cephalopod prey.

Recent re-examination of the ‘Manchester’ ichthyosaur, and those in other UK museums, by Manchester students using modern techniques of computer enhanced photography, SEM and geochemical analysis, has clarified problems remaining from my original study.

All this has advanced our understanding of these fascinating predators, their prey and feeding habits in Jurassic seas.

Lunch Break and Display of Jurassic Fossils in the Manchester Museum

Lunch can be obtained at a number of places near to the Williamson Building, for instance: - in the refectory in University Place, which is next door to the Williamson Building; in Café Musé, which is within the museum on the opposite side of Oxford Road; or in Kro Bar, opposite the Students’ Union.

During the lengthy lunch break there will also be an opportunity to see the displays of Jurassic fossils in the Fossil Gallery of Manchester Museum and in the Williamson Building. Some of the speakers will be on hand to discuss these and answer any questions.

Breathing New Life into Old Bones – bringing plesiosaurs to life
Dr. Leslie Noè, University of Cambridge

The exceptional marine reptiles of the Mesozoic Era, the plesiosaurs, have been known for less than 200 years. Plesiosaurs were first recognised on the south coast of England, initially reconstructed from isolated remains, but shortly afterwards Mary Anning of Lyme Regis in Dorset found the first complete skeleton, which amazed the men of science of the time. A little later, Thomas Hawkins of Street in Somerset purchased specimens from local quarry owners, which he prepared out from their limestone matrix. Hawkins privately published two books on his fossils, and later sold this collection to the British Museum (now the Natural History Museum, London) for a substantial sum. In this way plesiosaurs rapidly captured the public imagination.

Today, plesiosaurs remain enigmatic animals. They have a unique body plan and understanding them as living, breathing animals remains a challenge. However, by looking in detail at their anatomy, and comparing them to living reptiles, we have been able to glean much from their fossils. Plesiosaurs were highly successful during the Jurassic and

Cretaceous, with a range of shapes and sizes, including the ‘typical’ long-necked small-headed plesiosaurs, and the generally larger short-necked large-headed pliosaurs. We will investigate some plesiosaurian anatomy and find evidence for their way of life to try and discover what they ate, how they swam, the injuries they sustained, the diseases they suffered, and how they might they have reproduced. We will also attempt to trace their evolutionary history, and explore their distribution in both space and time. We will also explore their extinction, at the end of the Cretaceous.

Manchester has its very own Jurassic plesiosaur. It was discovered in the 1960’s by a party of undergraduates on a field trip to the Yorkshire coast led by Fred Broadhurst, after whom these lectures are named. The majority of the specimen was later successfully excavated in atrocious weather conditions and now resides on permanent display in the Manchester Museum. A description of the ‘Manchester Plesiosaur’ has recently been submitted for publication in the scientific literature, and we will look at some of the features that make it such an important specimen.

Jurassic Pterosaur Diversity

Dr. David M. Martill, School of Earth and Environmental Sciences, University of Portsmouth, , PO1 3QL

The first pterosaur remains appear in late Triassic strata as fully flying animals with few anatomical clues to identify their non-volant ancestors: the pterosaurian missing link remains a palaeontological Holy Grail. Furthermore, pterosaur remains are extremely rare and often fragmentary hampering studies of their evolution. The first Jurassic pterosaur, *Dimorphodon macronyx* from the Lower Jurassic Lias (Hettangian/Sinemurian) of Lyme Regis was probably an arboreal, forest dwelling animal, despite occurring in fully marine strata alongside ichthyosaurs and ammonites. Despite more than 200 years of searching, no other species of pterosaur have been found in rocks of this age anywhere. By late Lower Jurassic (Toarcian) times pterosaur diversity had increased somewhat, with the genera *Campylognathoides* and *Dorygnathus* occurring in the Posidonia Shale of Germany, *Parapsicephalus* in the Lias of Whitby and possibly *Rhamphinion* in the Kayenta Formation of India.

Even fewer pterosaurs are known from the Middle Jurassic. *Angustaripterus* is a spectacular animal from the Middle Jurassic of China, while *Rhamphocephalus bucklandi* is known by fragmentary jaws and wings bones from the Stonesfield 'slate’ of Oxfordshire. A fragmentary pterosaur, first thought to be dinosaurian, from the Callovian of Argentina was named *Herbstosaurus*, but its affinities are obscure; but clearly, by the end of the Middle Jurassic, pterosaurs had a world-wide distribution.

Pterosaurian diversity increases dramatically in the Late Jurassic, although this is almost certainly an artefact of the so-called ‘Lagerstätte effect’. The Tithonian Solnhofen Limestone of Bavaria yields some of the most exquisitely preserved examples of pterosaur known. Mostly small forms with wing-span less than 2 metres, hundreds of examples are known from Solnhofen, including the genera *Anurognathus*, *Rhamphorhynchus* and *Scaphognathus* among so-called stem group pterosaurs, and *Pterodactylus*, *Cycnorhamphus*, *Ctenochasma*, *Gnathosaurus* and *Germanodactylus* in the Pterodactyloidea.

In Kazakhstan, the Karatau Lagerstätte yields *Sordes pilosus* (the hairy devil) and *Batrachognathus volans* (the flying frogmouth), while in China, the Tiaojishan Formation of Middle to Late Jurassic age yields *Changchengopterus* and *Fenghuangopterus* both basal forms and *Darwinopterus,* a form with some pterodactyloid features, but retaining the long tail and other features typical of the basal forms.

An un-named dsungaripterid has been described from the Late Jurassic of Germany, but as yet no azdarchoids have been reported from the Jurassic: cladistic analyses predict a pre Cretaceous origin for the group, as they do for ornithocheirids, but as yet, their remains are proving elusive.

The Life of Archaeopteryx - Dr. Derek Yalden, University of Manchester

While Archaeopteryx is well known as the classic non-missing link, sharing anatomical features of birds and reptiles, its own life and ecology has been less discussed. There are though debates over its ability to fly (or not), over its ability to climb, and about its ecological placement - a woodland animal in a desert landscape?

I will discuss these questions and review the evidence. Personally, I think it was well adapted to both flying and climbing.

Further Browsing

General Information: -

http://www.jurassiccoast.com

Ichthyosaurs: -

http://www.ucmp.berkeley.edu/diapsids/ichthyosauria.html
http://www.ucmp.berkeley.edu/people/motani/ichthyo/
http://dinosaurs.about.com/od/aquaticdinosaurs/p/ichthyosaurus.htm
http://sedgwickmuseum.org/research/Mepal_Ichthyosaur.pdf

Plesiosaurs: -

http://www.plesiosaur.com
http://www.plesiosauria.com

Pterosaurs: -

http://www.pterosaur.net
http://www.pterosaur.co.uk
http://palaeo.gly.bris.ac.uk/Palaeofiles/Fossilgroups/Pterosaurs/index.html
http://www.ucmp.berkeley.edu/diapsids/pterosauria.html

Archaeopteryx: -

http://palaeo.gly.bris.ac.uk/Palaeofiles/History/archa.xhtml

Ammonites: -

http://www.discoveringfossils.co.uk/ammonites.htm
http://gwydir.demon.co.uk/jo/fossils/ammonite.htm
http://easyweb.easynet.co.uk/~gcaselton/fossil/ammonite.html
http://www.ukfossils.co.uk/guides/ammonites.html

Belemnites: -

http://gwydir.demon.co.uk/jo/fossils/belemnite.htm
http://www.ukfossils.co.uk/guides/belemnites.htm
http://home.btconnect.com/fossilgallery/html/belemnites.html
http://palaeo.gly.bris.ac.uk/Palaeofiles/Fossilgroups/Cephalopoda/belemnites.html
http://www.bgs.ac.uk/education/Fossilfocus/belemnite.html
http://www.oum.ox.ac.uk/thezone/fossils/inverts/belem.htm