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Professor G. David Price, UCL

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Ecclesbourne Glen in the mid 1800s - military firing range can be seen on the east side of the glen

Volume 20 December 2014

Cover picture: Ecclesbourne Glen in the mid 1800s (see article on page 2)

Contributions for next year's Journal would be appreciated and should be submitted by the October 2015 meeting.
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Ecclesbourne Glen, Hastings

by Ken Brooks

Hastings Country Park consists of over 853 acres within an area of spectacular coastline and cliffs spanning 5 kilometres (3 miles) between Hastings and Pett. The majority of the park has been designated a Special Area of Conservation, a Site of Special Scientific Interest and is a proposed Nature Reserve.

Various pottery fragments and flint tools have been discovered here, including the remains of Stone Age, Iron Age and Romano-British settlements.

Ecclesbourne Glen is located within the Hastings Country Park, about 1.5 km (1 mile) to the east of Hastings Old Town. It is a steep valley with a stream that flows to the south-west and then over a small waterfall on to the beach.

In 1400 the stream was described as “the watercourse at Nepplisbourne”, and was probably named after the Efflesham (or Neplesham) family, owners of the estate which included the glen. Later, in a land deed dating from 1659, a part of the East Cliff is referred to as ‘Eaglesboorne’, suggesting that eagles could then be seen in this area. In fact, as late as January 1850, the Hastings and St Leonards News reported that an eagle had been shot in a glen to the east of Hastings. The bird had a wing-span of 2 m (6½ ft) and was l m (3 ft) in length.

History

In the 18th and early 19th centuries Ecclesbourne Glen was used as a landing place by smugglers. Contraband goods were carried along a path up the cliff, following the stream. From 1815, when smuggling became a more serious problem, the government built ‘watch-houses’ along the south-east coast. These provided accommodation for armed sailors from the Coast Blockade Service, later to become the Coastguards.

In 1819 the first watch-house in Ecclesbourne Glen was constructed on a small plateau at the foot of the cliff (Fig. l). This was later extended with a barrier to protect the building from the sea. Despite this, the house was damaged by storms and eventually destroyed by the sea. In 1864 coastguard cottages were erected on a concrete platform built into the western side of the glen (Fig. 2). The residents had gas lighting and fresh water, which was obtained from a well in the courtyard. Allotments known as ‘Strawberry Fields’ were worked on the slopes of the valley (Fig. 3).

Fig. 1. The Watch-house 1820.

Fig. 2. OS map 1908.

Fig. 3. Cottages and ‘Strawberry Fields’ 1909.

However, by 1932 the cliff edge was only 4.5 m (15 ft) from one of the cottages. Later, with increasing erosion and the danger of collapse into the sea, the properties were eventually abandoned. In 1963, with the cliff edge only inches from the buildings, the last occupant moved out. A few years later the derelict cottages were demolished and most of the rubble was scattered on the beach below (Fig. 4). Today, although the cliff now cuts through the middle of the site, part of the concrete courtyard and a retaining wall remain visible.

Fig. 4. Derelict cottages 1966.

Fig. 5. Firing range 1860.

The Volunteer Artillery Corps was established in 1859. In Diplock's *Handbook for Hastings 1864*, he describes Ecclesbourne Glen as "the practising ground" of the Hastings Rifle Corps (Fig. 5). Targets were set up on the eastern side of the cliff, and their concrete bases may still be found buried in the undergrowth.

On the western side of Ecclesbourne Glen are the remains of Wingate Rock, once a summer home of the wealthy Milward family. It was Edward Milward who leased the land below the cliffs for the first watch-house, with the condition that it should not be seen from his residence at the top of the glen. Wingate Rock later became a boarding school for young ladies, and today it is the site of a large caravan park known as Rocklands.

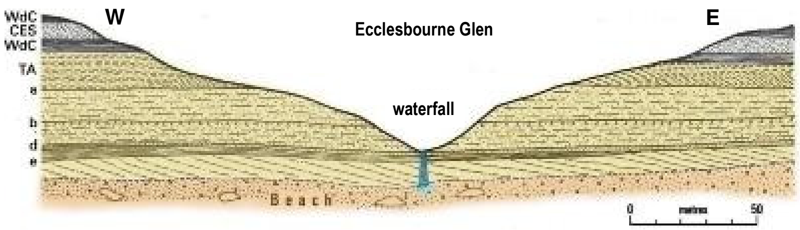
From the 1930s to the 1950s there were also cliff-top cafés and tea-rooms that were popular with visitors – until the cliff edge got too close for comfort (Fig. 6).

A cave, known as The Hermitage, was occupied for some years during the late 19th and early 20th centuries. When the last hermit lived in the cave, local rumours claimed that his wealth was hidden somewhere in the area. So far, however, it has not been found! This cave, and others in the glen, may have been excavated for sand to be used in building or glass-making. The caves would also have provided shelters for quarry workers.

Fig. 6. Ecclesbourne Café 1937.

Geology

The cliffs in this area are formed from Ashdown Sandstone overlain by Wadhurst Clay, which includes Cliff End Sandstone. These belong to the Hastings Beds within the Lower Cretaceous Series and have been dated at around 140 million years old.



Sketch section of cliffs at Ecclesbourne Glen. WdC: Wadhurst Clay, CES: Cliff End Sandstone, TA: Top Ashdown Beds, a, b, d, e: horizons in upper Ashdown Beds.

Fig. 7. Cliff section diagram.

Over thousands of years the Ecclesbourne stream, perhaps once a powerful river, has carved its way through local rocks to create the glen that we see today (Figs. 7 & 8).

Fig. 8. Aerial view 1950s.

Sea erosion has cut back the cliff to form a hanging valley, where the stream becomes a waterfall as it flows over a hard band of Ashdown Sandstone (Fig. 9). In the early 1900s a well-built step ladder provided access from the beach to the glen (Fig. 10).

Outcrops of Cliff End Sandstone are found all along the valley sides. It was also extracted in a large quarry at Fairlight until the 1950s. This sandstone is soft and easily sawn when first exposed, but soon hardens to make a good quality 'freestone' for building.

Fig. 9. Waterfall 2002.

The sandstones, shales and siltstones in the Hastings region contain fossils that are recognised as some of the best examples of their type in the world. A pterosaur wing bone which was found at Ecclesbourne Glen is now on display in the Hastings Museum.

According to the Met. Office the winter of 2013/14 was the wettest in England and Wales since records began over 250 years ago. This was the cause of two landslides that occurred in the glen earlier this year. The larger of these is on the western slope and extends into the Rocklands caravan park, while the smaller is to the east, adjacent to the stream near the foot of the glen. Several public footpaths crossing the area were either swept away by the landslides or have been closed by the Country Park.

Fig. 10. Waterfall steps, c. *1900.*

A survey, carried out in April 2014 by Coffey Geotechnics Limited for Hastings Borough Council, reported that:

a) The larger landslide is estimated to measure up to 80 m (260 ft) at its widest part and is about 100 m (330 ft) in length.

b) A very high level of groundwater saturation is considered most likely to have instigated the initial movement with both landslides.

c) Further landslides are likely to occur after periods of excessive rainfall.

As these are located within a Site of Special Scientific Interest, which is also a Special Area of Conservation, this may place restrictions on any remedial measures that could have a "significant effect" on the site.

Finally, a ghost story! A woman, sometimes with a child, has been seen floating in the air near the cliffs at Ecclesbourne Glen. Some witnesses have said that she appears to be walking on ground that is no longer there. No one knows whether she jumped, fell accidentally – or was pushed over the edge of the cliff!

Further reading: *The Archaeology and History of Hastings Country Park*, David Padgham, Hastings Area Archaeological Research Group, 2004.

Sussex Mineral Society goes to Maine, USA

by Trevor Devon

Maine, in the north-east of the USA, has a long history of attracting miners and mineral collectors to its rich occurrence of granitic pegmatite intrusions. For it is within these pegmatites that semi-precious gem minerals such as beryl and tourmaline are to be found. There are many historic quarries still actively mined for their minerals that are visited every summer by collectors ranging from day-trippers, serious amateurs to professional gem collectors. The Poland Mining Camp in Oxford County run by a delightful hostess and mineral collector, Mary Groves, provides an ideal base for collecting as it is located very near many of the historic quarries. The Warrington club had visited this camp back in 2001 and one of our party had in fact been on that trip and was looking forward to returning to the camp and meeting Mary Groves again.

This July (2014) a party of eight members of the Sussex Mineral & Lapidary Society (SMLS) travelled across the Atlantic to Maine via Boston. Our base for the seven day visit was the Poland Mining Camp, where we were accommodated in very comfortable rustic log cabins. Mary greeted us with cooked breakfast every morning and after making up our packed lunches we would head off in our hire cars (four-wheel drive essential!) with our two guides to the quarries for the day. In the evening we would return and sit down in the communal cabin to well-cooked dinners that Mary had prepared. Afterwards over a glass of wine we would reflect on the day's collecting and compare notes; one evening we were really spoiled with local food specialities New England clam chowder and Maine lobsters (two each!) (Fig. 1).

Fig. 1. Maine lobster dinner at the Poland Mining Camp: author featured eating with local Hastings mineral shop owner David Binns (smiling at camera).

We visited several pegmatite quarries during our week, all within an hour of the Poland Camp and all well-known to the mining and mineral community. Places like Mount Mica (Fig. 2) and Mount Apatite pretty much gave the game away, but they were all very interesting in different ways. Notable was the fact that they were mostly privately owned by entrepreneurial miners, several of whom we met on our trip. A common feature of these quarries was the granite rock, where we were able to find several varieties of quartz, mica and feldspars. The quartz can be found colourless, rose, smoky, milky, as purple amethyst and in different crystal forms (parallel growth, twinned and sceptre quartz). The mica is primarily colourless to silvery grey books of muscovite (aluminium-rich), but dark brown biotite and pale purple lithium-rich lepidolite were widely present. Pale tan platy cookeite, a silicate related to the micas, was found in some quarries and a clay mineral montmorillonite was found in attractive pink botryoidal clusters on the white albite. The feldspars almost invariably occurring as white microcrystalline masses varied from the potassium feldspar, microcline, to the sodium feldspar, albite, the latter sometimes found in a platy form called cleavelandite.

Fig. 2. Author extracting pink tourmaline from a pit dug in the floor of the Mount Mica quarry.

The pegmatites were encased in metamorphic country rock, mostly schists, which were not generally good sources for mineral collecting. In some quarries the outline of the lighter coloured pegmatite intrusion into the country rock could be clearly seen, and in some places, notably Emmons Quarry, zoning within the pegmatite could be discerned. These zones represent later hydrothermal processes where more complex minerals are created by introduction of rarer elements from the hydrothermal fluids, for example the caesium silicate, pollucite and the beryllium phosphate, hydroxylherderite. Other rare minerals are also present, but only found as microminerals. Collecting at this quarry was fun, particularly the exciting drive in and out on a steep mountain track criss-crossed with water culverts and hair-pin bends!

Within the pegmatites are found the gem minerals of primary interest, beryl and tourmaline, as well as gemmy apatite. These occur either encased in the quartz and feldspar (Fig. 3) or more rarely in open pockets where they can grow to great size and clarity. The problem with embedded minerals is extracting them from the matrix without fracturing the gemstone crystal – a delicate and painstaking job. If you are fortunate enough to find a piece of rock with a cavity containing some gem mineral, it is still tricky separating a specimen piece from the parent boulder without crystals pinging off!

Fig. 3. Self-collected pink tourmaline (40 mm) on feldspar and lepidolite from Mount Mica.

Berylium aluminium silicate, beryl, has been collected in Maine for over 150 years and can be found in different colours, sizes and varieties. The most famous find was in 1989 when a 30 cm wide diameter pinkish gem-quality morganite beryl crystal was discovered in the Bennett quarry that became known as “The Rose of Maine”; the brothers who found it decided to break it into pieces (allegedly after an argument) and the largest fragment can now be viewed (on request) at the Harvard Museum. There is also another sizeable piece for sale at a nearby mineral store – only “sensible offers considered” says the sign in the display cabinet! “The Peach” was another large morganite crystal found at the Bennett quarry, only 7 cm in size it displayed fine crystal faces and was a deeper colour as its name implies. Our group didn’t quite get to the Bennett quarry because when we were in the adjacent Orchard quarry a torrential thunderstorm that lasted several hours sent us scurrying back to our cars and off to visit the home and collection of local Maine miner and collector Frank Perham.

Rather more famous than beryl, the chief mineral of interest to collectors in Maine is tourmaline. This is also much more complex chemically than beryl, being a group of several borosilicates containing a variety of metal ions; in fact as of today it is recognised as 14 different mineral species, but theoretically there could be more. Three species are found in Maine – iron containing schorl, magnesium containing dravite and lithium containing elbaite. In the areas we collected dravite has not been found, but black schorl was very common, often as quite large crystalline masses in the white feldspar. Elbaite is found as green, blue, pink and red columnar crystals; of particular beauty are the polychrome specimens where the colour changes along or across the crystal in distinct zones. The pink and green variety of elbaite is known as “watermelon” tourmaline. In our collecting we did find red, green and pink elbaite (Fig. 4) – not very gemmy it has to be said, but nevertheless the real thing.

Fig. 4. Self-collected pink elbaite tourmaline crystals (50 mm) on feldspar from Mount Mica.

One rather attractive rock we found in some of these pegmatite quarries is a form of quartz that ripples through feldspar called graphic granite, presumably because of its aesthetic appearance. It is often found in mineral shows as cut and polished stone. We also found quite a lot of raspberry-red almandine garnets that were embedded in the white feldspar – a lot were fractured remnants but intact crystals did occur too, some up to 1 cm in diameter. A number of other minerals were collected during the week, including columbite, siderite, bertrandite, apatite, goyazite, nontronite, phosphoferrite, manganese dendrites and the rare calcium aluminium silico-phosphate perhamite, named after Frank Perham, a legendary Maine miner.

Fig. 5. The curator at the Harvard Museum shows us the largest remaining fragment of the morganite beryl "Rose of Maine".

I mentioned above that we encountered a dramatic thunderstorm one day and so escaped to the comfort of Frank Perham's house nearby. Frank is the son of the equally renowned miner and collector Stanley Perham and brother of the late Jane Perham. The Perham family ran the famous "Perham's of West Paris" rock shop which sadly closed a few years ago. Frank's large basement housed museum quality mineral specimens mostly from New England, but Maine especially, and so we learned a lot from his mining stories and collecting triumphs. Frank's expertise with explosives and choosing the best places to blast uncovered several famous gem pockets over the years, including some massive tourmaline pockets in Newry. While there we got to see the world's largest perhamite crystal, which is of course in Frank's collection.

During the week we also had an excursion to the pretty New England town of Bethel, where the new Maine Mineral Museum is being assembled. The Curator and Director showed us around the spacious building, explaining the philosophy behind the planned themes and exhibits which aim to illustrate the Maine mining and mineralogy heritage. We got to see several of the mineral exhibits stored in the basement, including of course lots of quartz, beryl and tourmaline.

Finally, on our last day in New England, we spent some time visiting the world-famous Harvard Museum of Natural History in Cambridge, Massachusetts. Our host was Curator of Minerals, Kevin Czaja (Fig. 5) who took us through the mineral exhibits of Maine and the other New England states. Not only did we see the public specimens, but also many down in the reserve collections in the cellars. We got to see the large remaining piece of the famous morganite crystal "Rose of Maine" and "The Peach" morganite, both discovered at the Bennett quarry. "The Peach" is a beautiful, gemmy, complete 7 cm morganite crystal with an attached spray of cleavelandite (a lamellar variety of albite). While in the museum we also took the opportunity to view the unique and stunning collection of some 3,000 botanical and zoological specimens made entirely in glass over fifty years by Leopold Blaschka and his son Rudolf under commission of the Harvard Botanical Museum. This had to be one of the most astonishing museum displays I have ever seen and well worth visiting if you happen to be anywhere near Boston.

Fig. 6. Self-collected green tourmaline (40 mm) on mica from Haved quarry, Maine 2014.

Our nine days went very quickly, packed as it was with a rich variety of activities, some wonderful memories of people we met in Maine and Cambridge, and not a few specimens brought home in our luggage (Fig. 6) or despatched home courtesy of UPS.

Bexhill dinosaur – an update

by Peter and Joyce Austen

In last year's Journal (see 'Dinosaur found at Bexhill', *HDGS Journal*, Dec 2013, Vol. 19, p.36–37) we reported on the discovery of the partial skeleton of a juvenile iguanodont in a quarry in Bexhill. Excavations have continued throughout 2014, and following examination of the bones by Dr David Norman of the University of Cambridge (one of the world's leading authorities on iguanodonts), it now appears that we have the remains of two individuals. Dr Norman believes they are from a juvenile and a sub-adult, most likely of the species *Hypselospinus fittoni,* and he will be including this new discovery in the definitive monograph he is currently preparing on iguanodonts. Excavations will continue into next year under the direction of Dave Brockhurst who, along with occasional assistance from Andy Ottaway, continues to prepare the bones ready for donation to Bexhill Museum where a number are already on display. More than 100 bones have been prepared so far, with as many still to be worked on. Once again, we are grateful to the quarry manager for allowing continued access to the site.

Dave Brockhurst (R) and Andy Ottaway (L) with femur - September 2014.

Photo: Peter Austen

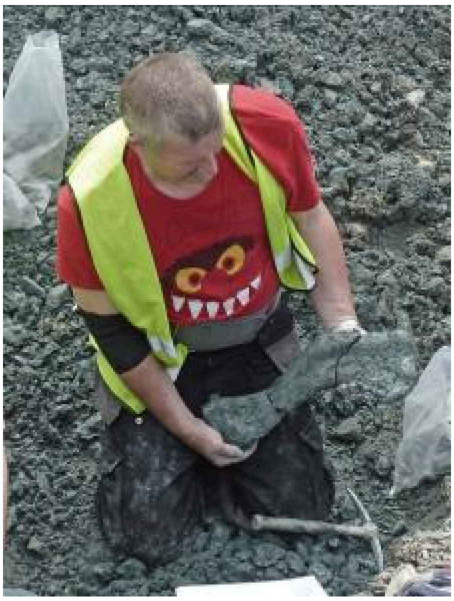
HDGS members working at excavation face - June 2014. *Photo: Peter Austen*

Excavating a metatarsal from the face - June 2014.

Photo: Peter Austen

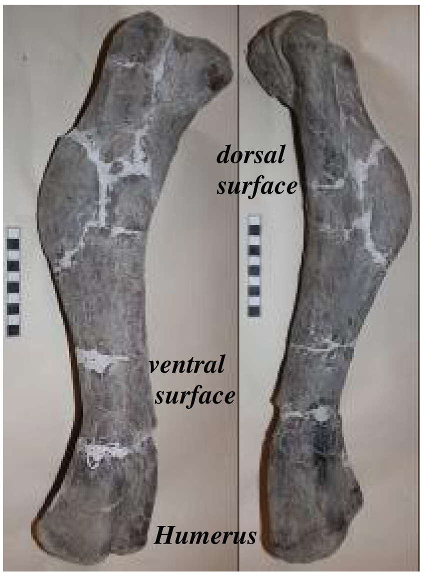
Derek Payne with section of vertebral neural spine - May 2014.

Photo: Diana Nichols



Dave Brockhurst with humerus - May 2014.

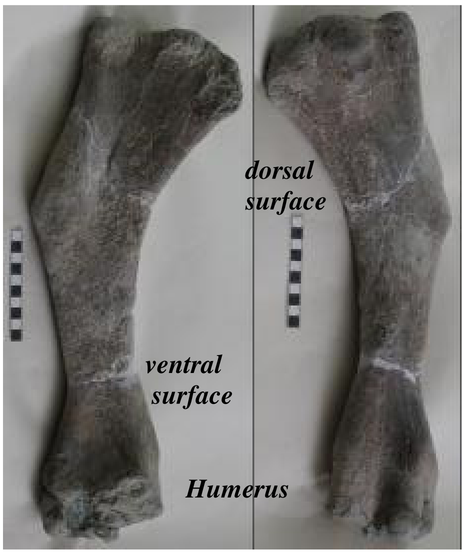
Photo: Diana Nichols



Iguanodont bones

All scales in cm.

Photographs by Dave Brockhurst.



Report on the visit by a group of HDGS members to the Bexhill to Hastings Link Road (under construction)

Thursday, 11th September 2014

Reporter: Jim Simpson

1. Introduction

The visit was arranged by our Society Chairman, Ken Brooks, and the County Archaeologist of East Sussex County Council, Casper Johnson. The party, which had to be restricted to 10 visitors and two guides (the Project Manager, Bob Pape, and the County Archaeologist), were transported around the site by mini-bus.

We were most grateful for the opportunity to see the works at a particularly relevant phase where rock and subsoil were exposed. The archaeological dig in progress was an unexpected and exciting addition to the visit.

It is hoped that this report will serve as consolation for those unable to attend. In this respect the reporter wishes to acknowledge that were it not for the careful research by Peter Austen and his provision of maps on which he was able to record our stopping locations along the route, this report would have fallen well short, particularly in relating the photographs to the topography.

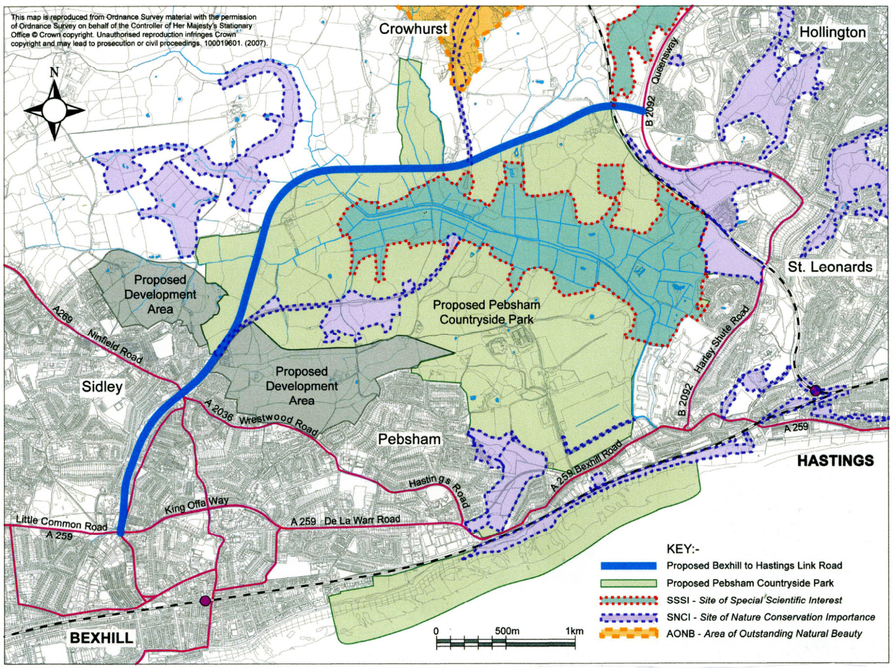


Fig. 1. Plan of route of new Link Road.

2. The guided tour of the site

The route of the new Link Road is shown in figure 1. The route of our site visit was essentially alongside the route of the Link Road, which has been marked on a geological map (Fig. 2) on which the following stopping points on the tour have been marked.

2.1. Stopping Point 1

A singular advantage of this location on the top of the southern side slope of the cutting was the opportunity to get an overview of the undulating terrain being crossed by the new road and the three cuttings yielding some insight into the geology (Fig. 3).

The concept of balance

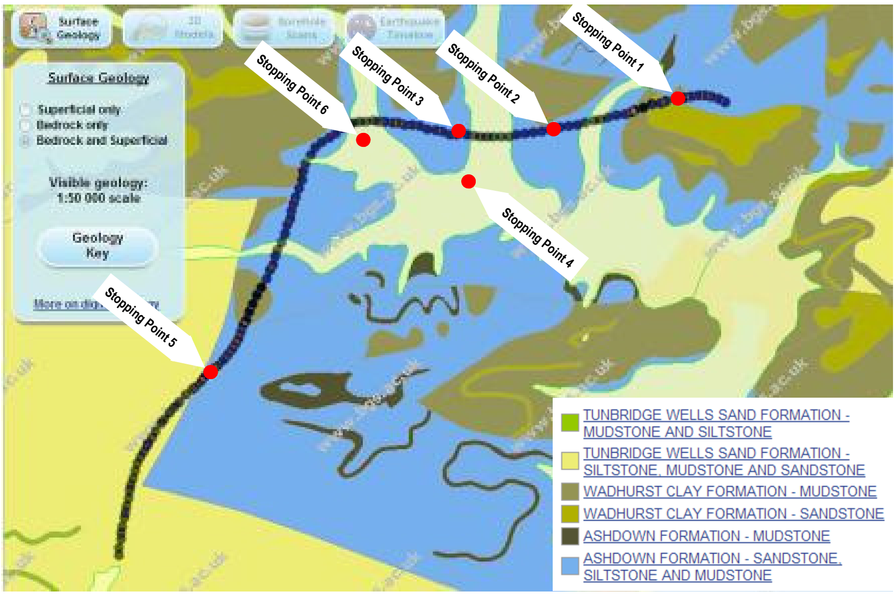


Fig. 2. Line of tour of the works with stopping points indicated.

between cut and fill in the earthworks along the route can also be appreciated from this vantage point.

The cutting has been formed and a dozer is at work bringing the floor to formation level. The material being dozed is soft, possibly sandy Wadhurst Clay. However, one large piece of siltstone is lying on the formation (Fig. 4) as an indication of harder material encountered in forming the cutting. A minor disadvantage of this location is not being able to see the face below as it would have been trimmed and dozed at this stage. However, this is more than compensated for at the next stop.

We were told of archaeological interest both previously on this site and remaining in the wooded areas on the far side of the cutting in the form of prehistoric iron works, including the finding of the distinctive blue colour in the soil from the bloom discarded in the iron making process.

2.2. Stopping Point 2

In this case, (the second cutting as seen from Stopping Point 1), we parked on the cutting floor (Fig. 5) and enjoyed the complete freedom of the exposed surfaces of the completed cutting. As can be seen from figure 6, a wall of Siltstone was left uncut, either as a sample for visiting geologists or, as is more likely, a traffic separator for the earthmoving plant. Either way it was a most welcome discovery for us. (The "wall" is recorded in figure 7.)

An observant member of the group noticed evidence of a fault in the clay on the north side slope. This was a revelation to your reporter, who (in his ignorance) would not have expected this in soft rocks. The fault is displayed on figures 8 (distant) and 9 (close up).

The embankment of the disused railway can be seen in cross section where this was intersected by the new road (Fig. 10).

2.3. Stopping Point 3

This was the site of a new bridge but there did not seem to be a geological interest although, had we been there at excavation of the foundations, there would have been in the rock exposed.

Looking from this location further along the roadworks, a lighter coloured material could be seen to be being deposited. This, it was

Fig. 3. Stopping Point 1 - View west along route of new road.

Fig. 4. Stopping Point 1 - View north across cutting. Hard siltstone (foreground) encountered in soft clays.

Fig. 5. Stopping Point 2 - View back to Stopping Point 1 (on the horizon).

Fig. 6. Stopping Point 2 - View from north slope of cutting showing siltstone "wall" left exposed.

Fig. 7. Stopping Point 2 - Members of the group examining siltstone samples from the "wall".

Photo: Bob Pape

Fig. 8. Stopping Point 2 - Fault in north face of cutting seen from road formation level.

Fig. 9. Stopping Point 2 - Fault on north slope seen close up. Note the faint blue clay band which is broken and displaced downhill on the right.

explained, was imported material, stronger than the existing soil which was removed.

Interestingly it was noticed that a sheep's-foot roller was being used in the compaction of fill material. This traditional equipment may have been selected as suitable for dealing with material including lumps of weak rock or stiff clay, which can be broken down by the "feet".

Fig. 10. Stopping Point 2 - Embankment of disused railway in cross section.

2.4. Stopping Point 4 – The "pond area", site of an archaeological dig in progress.

This came as a complete but exciting surprise to your reporter. Having later learned that HDGS is to enjoy a lecture on the archaeological aspects of the project from Casper Johnson, I hope that the shortcomings and unanswered questions herein, which the reader may have, will be forgiven. We were fortunate to be given a guided tour of the excavation site by the site director, Mike Donnelly of Oxford Archaeology (Fig. 11).

This site of human activity from the Palaeolithic to Neolithic periods was discovered when an archaeological survey using Lidar (ground-penetrating radar) was carried out prior to works commencing on the site to construct a pond for drainage water from the new road.

The overall impression of the archaeological excavation can be gained from figure 12.

The surface of interest, a silty sand, has been exposed by removal of the peat (the original surface of the ground) and the site marked out in a grid.

As each square is excavated in stages, each to a depth of one "spit" which represents a trowel blade length, the excavated material is collected in the small white boxes and the locations recorded on each box. The locations of finds are marked by yellow flags.

The main type of relic of human activity found were hunting spear heads formed by chipping off suitably shaped and sized pieces from flints. In one area, two piles of flint tools and worked flakes were found facing each other, one pile of better craftsmanship than the other, seeming to indicate that tuition had been in progress: this area has been designated the "crèche" by the team, thought to be where young children were taught the art of flint knapping, a crucial survival skill .

Another tool produced from flint was the scraper, probably for preparing animal skins. An example is shown in figure 13.

Fig. 11. Stopping Point 4 - Mike Donnelly of Oxford Archaeology explaining the importance of the site to HDGS members. Photo: Bob Pape

Fig. 12. Stopping Point 4 - Overview of archaeological dig.

Fig. 13. Stopping Point 4 - Flint scraper from the dig. Photo: Peter Austen

Fig. 14. Stopping Point 4 - Tree trunk uncovered - slot cut for sample.

Several pieces of timber were found in the dig, some showing evidence of having been positioned for a purpose and possibly worked. In this respect beware – the neatly-cut slot in the tree trunk (Fig. 14) is modern, having been made to provide a sample for testing.

2.5. Stopping Point 5 – The site of the former Sidley railway station.

The new road will follow the line of the disused railway through Sidley Station. This is of interest geologically since this is also the line of the Sidley Fault. Figure 15 shows the lighter coloured fill or sub-base material already laid for the new road.

The aperture of the existing road bridge of the former railway (Fig. 16) is of course totally inadequate for the new road. However, the outer abutments of the old bridge will be incorporated in the new bridge.

The layered siltstone exposed on the east face of the trench alongside the formation of the new road would appear from the geological map to be the Ashdown Beds. The dark red discolouration of the water seeping into the trench I take to indicate iron oxide (Fig. 17).

2.6. Stopping Point 6 – Dense concentration of late Mesolithic and Neolithic flints.

After Sidley Station the mini-bus returned to the site office. However, en route Casper Johnson pointed out an archaeological excavation where a dense concentration of late Mesolithic and Neolithic worked flints had been found. Although we were unable to stop, a dense concentration of yellow flags, marking each flint found, could clearly be seen from the moving vehicle (Fig. 18).

Fig. 15. Stopping Point 5 - Site of former railway station at Sidley.

Fig. 16. Stopping Point 5 - Existing road bridge of former railway at Sidley. Photo: Peter Austen

Fig. 17. Stopping Point 5 - Iron oxide discolouration in trench at Sidley Station. Photo: Bob Pape

Fig. 18. Stopping Point 6 - Dense concentration of late Mesolithic and Neolithic flints, each find marked by a yellow flag. Photo: Peter Austen

3. Concluding remarks and recommendations

Although ever aware of Alexander Pope's warning that "A little learning is a dangerous thing" I find myself drawn to make some observations arising from the visit in the hope that the more knowledgeable among us could take them forward:

3.1. Comparisons drawn between the geology of the Link Road site and that of other parts of the Hastings area.

Even cursory examination of the geological map (Fig. 19) shows the ubiquitous presence of the blue and olive green of the Ashdown and Wadhurst beds respectively, throughout. Examples are given in the following table:

Geology of Link Road and Eastern Hastings.

Bexhill	Eastern Hastings
Link Road through Points 1 to 3 (see fig. 19)	Ecclesbourne Glen–East Hill–Castle (see fig. 19)
Crossing from Wadhurst Clay (olive green) to Ashdown Beds (blue)	Crossing from Ashdown Beds (blue) to Wadhurst Clay (olive green) and back to Ashdown Beds.

Leading to the impression that the geology is the same throughout.

The appearance of the terrain in the two areas has some similarities, e.g. undulating topography intersected by valleys and bournes. These features are much more pronounced in the case of Hastings

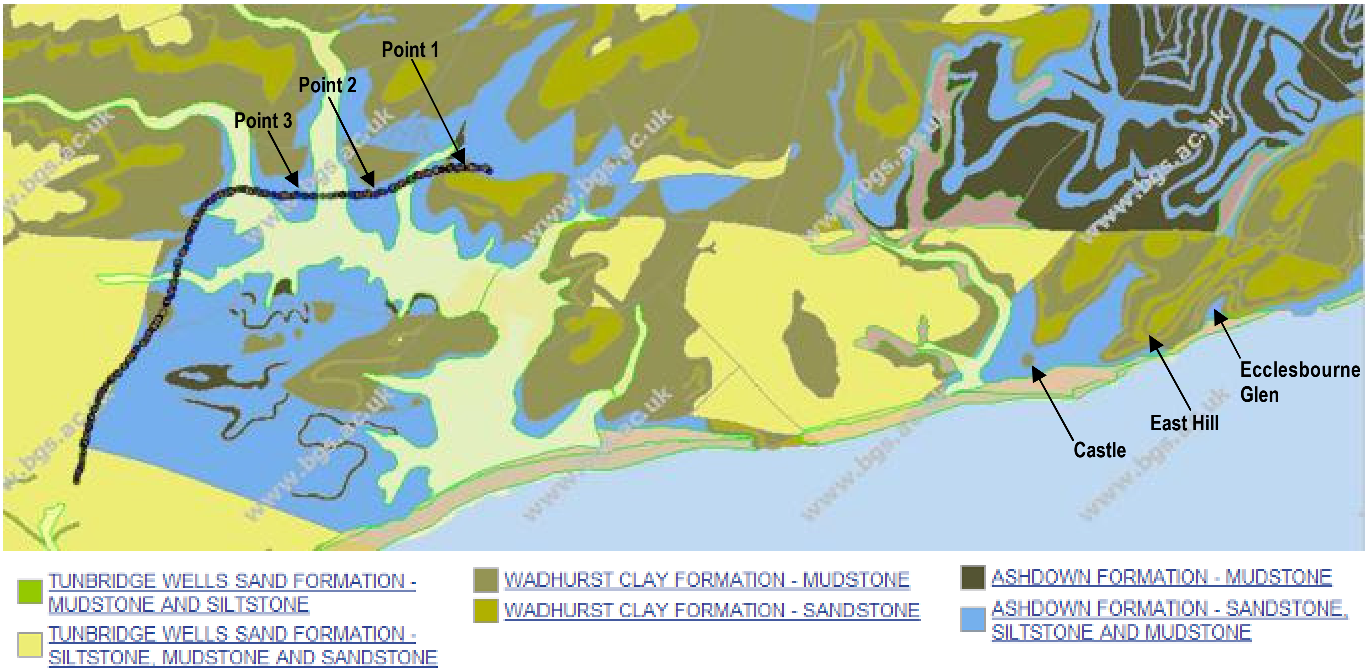


Fig. 19. Geological map of Link Road area and eastern part of Hastings for comparison of geological strata.

due to the greater elevation of the present ground surface. Additionally there is much evidence, some clear as in the case of the cliffs of strong sandstone at the castle; others hidden in outcrops on the flanks of the valleys. The difference can be explained from the geological map, which shows the area to be heavily faulted. The underlying sandstone which has been upthrust at east Hastings does not appear on the Bexhill site. It would be most illuminating to see if the boreholes sunk for the Link Road were taken into the underlying sandstone stratum.

3.2. Borehole Data.

The borehole records for the project, which will show rock deeper than exposed in the course of the construction work, would provide completely new data hitherto unseen and from depths possibly well below that seen on the visit, possibly into different previously unrecorded strata. There is therefore an opportunity which might never return to add to the body of knowledge of the complex geology of our area in Hastings/Bexhill.

3.3. Archaeological finds.

The evidence in the dig at the pond site of activity on spear or arrow heads must be significant in Man's development. Professor Brian Cox in his current TV programme "The Human Universe" sees the production of spear heads from flint (in his case obsidian) in Ethiopia as a trigger to accelerated development in Man's technical skills. His point was not so much the spear head but its attachment to the shaft.

He puts this event at 250,000 years ago, when our brain size was the same as it is today.

There is thus much interest to be pursued both worldwide and locally in this subject which could be regarded as the penultimate chapter of geology.

4. Acknowledgements

The Society would like to thank Bob Pape (Link Road Project Manager – East Sussex County Council), Casper Johnson (County Archaeologist – East Sussex County Council) and Mike Donnelly (Site Director, archaeological excavations – Oxford Archaeology) for their efforts in arranging such an interesting and informative tour of the site, for which the HDGS members were most appreciative.
The geological maps shown in figures 2 and 19 are courtesy of the British Geological Survey's OpenGeoscience website at: http://www.bgs.ac.uk

All photographs by the author unless otherwise stated.

Behind the scenes at the Natural History Museum

Wednesday, 18th June 2014

Type specimen (skull and mandible) of the marine crocodilian Metriorhynchus cultridens *(Andrews 1913) from the Oxford Clay of Peterborough, Cambridgeshire. [Specimen no. R.3804 from the Leeds Collection]* *Photo: Diana Brooks*

Dale Smith (HDGS) alongside the NHM's largest ammonite. *Photo: Jim Simpson*

Original claw of theropod dinosaur, Baryonyx walkeri, *found at Smokejacks Brickworks, Walliswood, Surrey in 1983. In the excavation following its discovery around 70% of the skeleton was recovered, making it one of the most important European dinosaur finds of the 20th century.* *Photo: Diana Brooks*

Lower jaw of the herbivorous dinosaur Scelidosaurus harrisoni *(Owen 1861–1862) from the Lower Lias of Charmouth, Dorset. [Specimen no. R.1111 from the Harrison Collection]*

Photo: Diana Brooks

Geology of The Azores, Portugal

by Margaret A Dale

The Azores is situated roughly a third of the way across the North Atlantic Ocean about 1,100 miles from Lisbon and 2,500 miles from New York. Its archipelago of nine islands extends for more than 370 miles and lies in a northwest-southeast direction.

The islands are grouped geographically as the Western Islands of Flores and Corvo; the Central Islands of Faial, Graciosa, Pico, Saõ Jorge and Terceira, and the Eastern Islands of Saõ Miguel and Santa Maria (Fig 1).

The oldest island of Santa Maria, in the Eastern Islands, was created approximately 7 million years ago and is the only island to contain a significant number of marine fossils, which indicates at some stage in its history it resided below the seas. The youngest island of Pico, in the Central Islands, was formed approximately 300,000 years ago. A tenth island, Sabrina, appeared near the Eastern Island of Saõ Miguel, in 1811, but vanished a few months later just after the British tried to lay claim to it.

The Azorian Islands were created by the outpourings of lava from divergent plate boundaries (constructive plate margins) and hotspots. There are about twenty four significant volcanoes visible on the islands and considerably more smaller ones.

The archipelago lies near the boundary of three of the world's largest tectonic plates: the North American Plate, the Eurasian Plate and the African Plate (Fig 1). The boundary is known as the active Azores Triple-Junction. As is the nature of tectonic plates, each plate is not just on the move, but moving in different directions - the North American plate is moving west; the Eurasian plate is moving east and south and the African plate is moving east and north.

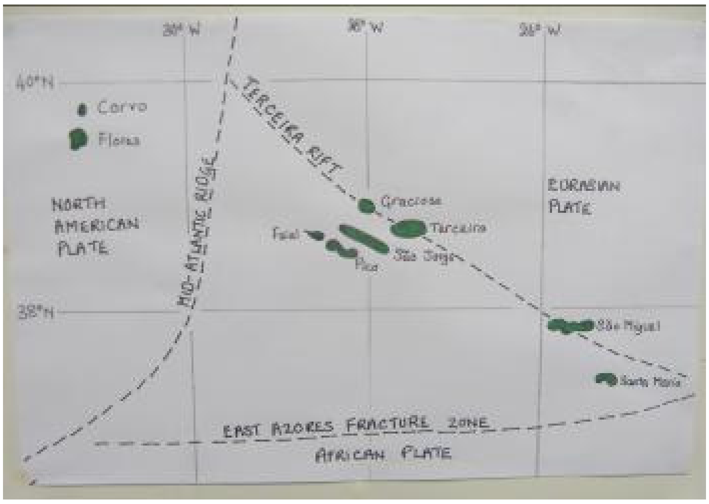


Fig. 1. A diagram showing the positions of the islands, the Tectonic Plates, The Mid-Atlantic Ridge, Terceira Rift and East Azores Fracture Zone.

Ponta do Pico, Pico Island. With an elevation of 2350m, this stratovolcano is the highest point of Portugal and the highest elevation of the Mid-Atlantic Ridge.

The two Western Islands of Flores and Corvo sit on the North American Plate. The seven Central and Eastern islands sit on the Azores Plateau or Azorian Micro-Plate, which is drifting westwards (Fig 1). This plateau is thought to have been formed by the Azores Hotspot about 20 million years ago. If the hotspot had been responsible for the creation of all the islands, the oldest one would be in the east and the youngest in the west. This is not the case. In fact, younger islands are mixed in amongst the older ones. Faial in the Central Islands is currently nearest to the hotspot.

The Mid-Atlantic Ridge forms the boundary between the North American Plate and the other two plates (Fig 1). It crosses the Azores Plateau between the islands of Flores and Faial. It is believed to be responsible for the main volcanic ridges of the archipelago. In addition, its interaction with the Azores Hotspot may have resulted in the elevated sea floor of the Azores Plateau.

The Terceira Rift extends south-eastwards from the Mid-Atlantic Ridge and forms the main boundary between the Eurasian and African Plates (Fig 1). It developed from a transform fault and is now the world's slowest spreading plate boundary.

The areas' volcanism and seismic activity are linked to the rifting along the Active Triple-Junction, principally in the region of the Mid-Atlantic Ridge and the Terceira Rift, where submarine and subaerial volcanic rift zones and central volcanoes extend along their lengths.

The Azores Fracture Zone covers a relatively inactive area to the south of the Central and Eastern islands.

Over thirty important earthquakes and innumerable seismic events have been recorded since the islands were settled in the middle of the 15th Century. The most recent significant earthquakes are one with a magnitude of 7.2 that affected the Central Islands of Graciosa, Saõ Jorge and Terceira in 1980 and one with a magnitude of 5.8 that affected the Central Islands of Faial and Pico in 1998. Whilst writing this article, an earthquake with a magnitude of 4.5 was recorded near the Western Island of Corvo on 26th October 2014.

Almost thirty volcanic eruptions of different nature and magnitude have occurred on the plateau since the islands were settled. The majority of subaerial events were of Strombolian and Hawaiian eruptive styles. However, more explosive eruptions involving magmatic and hydromagmatic eruptions, with pyroclastic surges have occurred.

Capelinhos Volcano ("Little Cape"), Faial Island.

The Caldera of Cabeço Gordo ("Fat Mountain"), Faial Island. This stratovolcano has an elevation of 1,043m and its caldera is 2 kilometres wide and 400m deep below the crater rim.

A considerable number of eruptions have been submarine in origin; notably more recently, the volcanic eruption of Capelinhos Volcano on the island of Faial in 1957-58. This started with Surtseyan characteristics but changed to Strombolian and Hawaiian styles as ashes built up around the vent and prevented further seawater entering the crater. Ironically, "Surtsey" from where the definition arises, erupted five years after Capelinhos. In 1998, a submarine eruption near Terceira Island produced basaltic lava balloons.

Landslides on the islands are triggered quite frequently by earthquakes, volcanic eruptions, extreme meteorological events and coastal erosion. In addition to causing local damage, they have triggered tsunamis. Small tsunamis have also been produced by local earthquakes.

The interactions between the Mid-Atlantic Ridge, Terceira Rift and the Azores Hotspot are responsible for the unique geomorphological characteristics of the Azores Plateau.

The multitude of geological features of the archipelago includes shield volcanoes, stratovolcanoes, Hawaiian and Strombolian scoria cones, Surtseyan cones, slag and spatter cones, lava domes, evidence of fissure eruptions, craters (including one of the largest on earth), calderas, subterranean lava tubes, coulees, tuff rings, pillow lava, fumaroles, Geysers, hot springs and steaming grounds.

Lagoa do Fogo (Lagoon of Fire), São Miguel Island. This is a crater lake within a stratovolcano.

Hot-springs in the village of Furnas, São Miguel. The village is situated in the caldera of the Furnas Volcano and considered to be the most dangerous place to live in the archipelago.

The Caldera of the Furnas Volcano, São Miguel. The village of Furnas can be seen in the central right hand side.

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200 Years of William Smith's Momentous Map

by Anthony Brook

Every year the Geological Society arranges the prestigious William Smith Meeting in remembrance of the life, career and achievements of William Smith (1769–1839), the pioneer geologist to whom Adam Sedgwick gave the epithet the 'Father of English Geology' when awarding him the Society's first Wollaston Medal in 1831. The next William Smith Meeting will take place on 23–24 April 2015, with the theme '200 Years of Smith's Map', to celebrate the publication, in August 1815, of the very first, national, geological map (opposite), an early issue of which hangs on the lower staircase of the Burlington House apartment of the Geological Society in Piccadilly.

This two day, International Conference is being organised by HOGG, the History of Geology Group of the Geological Society, and will cover many aspects of Smith's career, concepts, collecting and cartography, in particular, the production of his momentous map in 1812–1815. As well as lectures in the Janet Watson Lecture Theatre, there will also be posters on display in the Lower Library for people to view and consider. I submitted a proposal for a 2-board Poster on Smith's survey work in Sussex and the Weald for the Trans-Wealden Extension of the Upper Ouse Navigation in 1810, which, I am very pleased to report, was accepted: the Abstract I had to submit for approval is reproduced below. Since then I have been asked for an illustration to accompany the Abstract in the Conference publication, and am currently working to show the route of this proposed waterway on the earliest O.S. map of the area, with the various strata of the High Weald outlined, so as to demonstrate the physical difficulties of terrain and topography confronting this engineering project of the Canal Era.

William Smith and the Trans-Wealden Extension of the Upper Ouse Navigation

East Sussex Records Office holds an historic document of considerable significance to the History of Geology: a large-scale, meticulous survey of the proposed Trans-Wealden extension of the Upper Ouse Navigation, undertaken in summer 1810. It is recorded in volume 87 (2003) of the Sussex Record Society, with 'Surveyor not stated': it is believed that William Smith supervised the surveying of this project.

During the opening decade of the 19th century William Smith had to earn his living as a freelance, itinerant Surveyor. Upon the death of the previous Surveyor of the Upper Ouse Navigation, reputable and experienced William Smith was appointed, in May 1808, to the position on a retainer basis, and visited Sussex regularly over the next four years. One of his early duties was to prepare plans to link the Upper Ouse Navigation with Sir John Rennie's grandiose Grand Southern Canal, from the Medway to the Arun.

Although William Smith explicitly wrote, in a 1839 letter to John Phillips, that he "took the levels for a line to connect this [Rennie's Canal] with the Ouse navigation up the Balcombe Valley, by a tunnel through the forest ridge, and spent some time unprofitably in preparing a plan of it, which was deposited with the Clerk of the Peace at Lewes", (which is confirmed on the document itself), it would appear, from his correspondence of the time, that he only masterminded the surveying and later verified the details and draughtmanship of the Plan before submission. William Smith was, nevertheless, responsible for this legal document.

This 1810 Survey lists riparian landowners along the 22 miles of the proposed canal, which would have needed 18 locks, a long tunnel and an extensive watershed reservoir. The route is marked on a modern version of contemporary maps for 1813–19.

William Smith relinquished his role as Surveyor in April 1812, just when John Cary, accomplished mapmaker, indicated his willingness to proceed with Smith's grand project.

Opposite: *William Smith's 1815 geological map of 'England and Wales with part of Scotland'*
Downloaded from: http://eoimages.gsfc.nasa.gov/images/imagerecords/8000/8733/strata_england_wales_1815.jpg
A half scale reproduction (1330 x 930mm) of William Smith's famous 1815 geological map is available from the British Geological Survey online shop at http://shop.bgs.ac.uk/Bookshop/product.cfm?p_id=WS1815


STRATA
ENGLAND AND WALES,
SCOTLAND;
VARIETIES OF SOIL
T H E
G E R M A N
O C E A N
I R I S H S E A
S T G E O R G E ' S C H A N N E L
B R I S T O L C H A N N E L
T H E E N G L I S H C H A N N E L

William Smith and the Castle Hill Section

by Anthony Brook

This is another little 'historical mystery' which I hope HDGS members can help resolve, in time for the bicentenary celebrations of William Smith's innovative Map.

L. R. Cox, in his comprehensive listing of all William Smith's written works, including all his books, pamphlets, maps, sections, etc., that was published in the *Proceedings of the Yorkshire Geological Society*, Vol. 25 (1942), comments, on pages 8–9, that "Other sections dating from a comparatively early period in Smith's career show . . . . the section at Castle Hill Cliff, Newhaven (1808)". That was repeated, word for word, by John Challinor in the *Annals of Science*, Vol. 26 (1970) in his section on William Smith, Early Manuscript Sections, *c*. 1794–1809 (p. 179). The Palaeogene deposits resting unconformably upon the Chalk at Castle Hill, West Beach, Newhaven were first described in print by William Buckland in 1817, and first illustrated as the frontispiece to Gideon Mantell's *Fossils of the South Downs* (1822), as lithographed by Mary Ann Mantell in May 1818. This Section of Castle Hill Cliff by William Smith would therefore precede these by almost a decade and be very historically significant, to the History of Geology in Sussex in particular. The problem is where is this Section now? Is it even still extant?; if so, in which Archive or Records Office? What happened to this invaluable historic document? I would love to know.

Geology Group Beach Barbecue

by Kay Wilks

I think it was on the field trip to Fairlight when I was hanging from a blue rope half way up the cliff that someone mentioned a beach barbecue for this year's summer get together. It seemed like a good idea at the time…but then I think anything would have done, considering my predicament!

Initially there was some interest, but as the weather forecasts worsened our numbers dwindled, and on Sunday, 17th August just five intrepid Geology group members met up, Derek, Sue, Val, Christine and me. Armed with our disposable barbecues and bags of goodies we headed for Pett Level where we all admitted to never having lit a barbecue before, but nothing ventured nothing gained and despite a gale force wind, we all set to. What a spread of food and drink we enjoyed, and a good laugh into the bargain. The weather was kind to us and didn't start raining until we were in the car on the way back home.

Val, Sue and Christine enjoying the shelter from the wind.

Cheers Derek!

HDGS/GA field meeting: Covehurst Bay to Fairlight Cove

Sunday, 20th July 2014

by Ed Jarzembowski, Peter Austen and Ken Brooks

In the second of three field trips covering the 8-km Hastings coastal section, some 26 members and guests assembled at 1030 in the car park of the Hastings Country Park Nature Reserve on a warm, cloudy day. Regular GA members were joined by members of the local Hastings & District Geological Society. This excursion was to traverse a 3-km section east from Fairlight Glen to the west end of Fairlight Cove (the finishing point of last year's field trip: Austen *et al*. 2013), examining the lower part of the Ashdown Formation, which includes the plant-bearing 'Fairlight Clays'. The cliffs here form part of the Hastings Group (latest Berriasian-Valanginian, Lower Cretaceous, *c*. 133-140 Mya), and together with the cliffs east to Cliff End and west to Rock-a-Nore, are regarded as the best section of the lower part of the Wealden Supergroup in south-east England. They display a succession of intermittently faulted sandstones, siltstones and mudstones that extend from the Ashdown Formation (including the plant-bearing 'Fairlight Clays') to the lower part of the Wadhurst Clay Formation. These beds were deposited in fresh-brackish water and originated as great quantities of sand, silt and mud carried down by rivers into the Wealden lowland area from the London massif to the north and, to a lesser extent, from the Armorican massif to the south (Normandy) and Cornubia to the west (Cornwall). The cycles of sandstones and clay sedimentation reflect the tectonics of the London massif to the north. The London area was bounded by active faults causing uplift of the London platform. At times of high relief, sands would have been deposited followed by clays as the London area was eroded to a lower relief, followed again by sands after renewed uplift. Present day analogues of the Wealden landscape include the Okavango Delta in Botswana and the Maracaibo Basin, Venezuela. The entire 8-km section from East Cliff to Cliff End has been long renowned for its diverse assemblage of early Cretaceous plant and animal fossils (Brooks 2014; Batten 2011; Batten and Austen 2011).

After an introduction to the geology and fossils of the area, the party carefully walked down the atmospheric Fairlight Glen over sandstones of the lower Wadhurst Clay on to the Ashdown Formation. On the beach, Lower Wealden fossils and lithologies were readily found including Tilgate and Cyrena stones, Bone Bed, plant debris beds, and an uncommon ironstone with a small beetle elytron and non-marine ostracods.

The party then headed east along the shore to Warren Glen where examples of the common Wealden fern *Onychiopsis psilotoides* (Brooks 2014, p. 32, pl. 15) were collected from a landslip of grey mudstone, together with examples of the much rarer fern *Ruffordia goeppertii* (Austen & Batten 2011, p. 611, text-fig. 32.3F–G). En route were seen ferruginous sandy river channels in the Ashdown Formation, some with abundant plant fragments and displaying current bedding, ripples, sedimentary deformation and brecciation, and Liesegang rings (Figs 1, 2). Also seen was evidence of emergence on the Wealden floodplain including purple-mottled mudstone and lycopod? rootlets in sandstone (Fig. 3). A theropod dinosaur foot cast was noted on an upturned, fallen block of sandstone as well as *Beaconites*

Fig. 1. Large Liesegang rings in Ashdown sandstone, Warren Glen. Scale bar 10cm. (Photo: PA)

Fig. 2. Liesegang rings in Ashdown sandstone pebble on storm beach, Goldbury Point (adjacent sea heart 4.5 cm across; this Caribbean seed shows how far some plants can travel by sea). (Photo: EJ)

Fig. 3. Lycopod? traces in a fallen block of Ashdown sandstone. 10 cm scale bar. (Photo: PA)

Fig. 4. Theropod foot cast in fallen block of Lee Ness Sandstone. (Photo: Siân Evans)

barretti burrows. Further east, winter storms had eroded the Lee Ness Sandstone and various ornithopod *Iguanodontipus burreyi* tracks were seen (Parkes 1993; Pollard & Radley 2011) ending in dinoturbation just before Goldbury Point. Occasional theropod foot casts (Fig. 4) were also seen and one series of blocks displayed a track-way of five small–medium size *I. burreyi* casts, together with the first recorded sauropod tracks from the Hastings section (Figs 5A, B- note crescentic handprint; Fig. 6). A sauropod footprint top was spotted on the foreshore as the tide turned (Fig. 7). Promptly rounding the point, the party assembled at the foot of the Fairlight landslip and then ascended the low cliff to Fairlight village for transport home.

Our thanks to Stu Pond, John Pollard and Jon Radley for commenting on the sauropod prints and Fred Clouter for help with imaging.

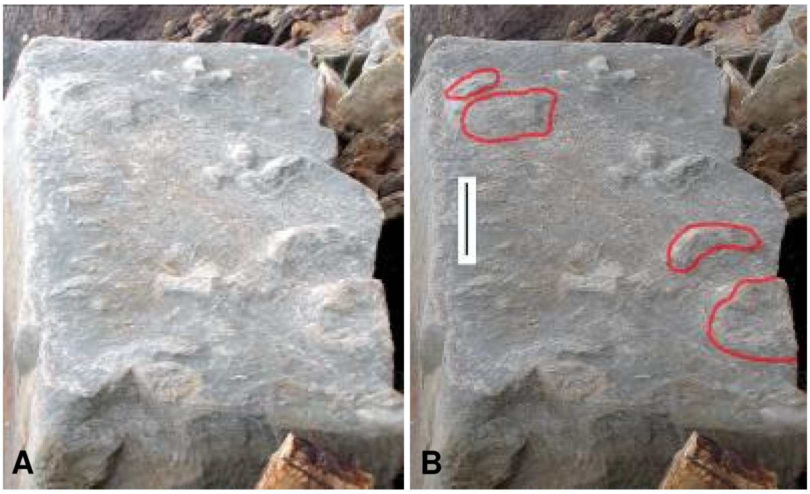

Fig. 5A, B. Upturned base of Lee Ness Sandstone with ornithopod and sauropod (circled) tracks. Scale bar 0.5m. (Photo: EJ)

Fig. 6. Continuation of ornithopod trackway from figure 5. Arrowed block in background contains ornithopod and sauropod trackways seen in figure 5. (Photo: Gerald Lucy)

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Fig. 7. Isolated sauropod foot cast cf. Deltapodus *Whyte and Romano, 1994. (Photo: EJ)*

A shorter version of this report has been submitted to the Magazine of the Geologists' Association *for inclusion in a future issue. There will be a further joint HDGS/GA field trip in July 2015 covering the final coastal section from Fairlight Glen to Rock-a-Nore.*

Cliff fall at Rock-a-Nore, Hastings

HDGS members will doubtless be aware from the local and national news coverage at the time of a major cliff fall at Rock-a-Nore on the 3rd January 2014. No one was hurt in the fall, but it was caught on film by local resident, Dan Crouch (see below). A video film of the cliff fall can also be found on YouTube at http://www.youtube.com/results?search_query=rock-a-nore+cliff+fall&sm=3.

South-east England had been suffering its stormiest weather for several decades, and our Chairman, Ken Brooks, explained to the *Hastings Observer* "Although cliff falls can occur at any time, they are far more likely after several days of heavy rain. Excessive water adds greater weight to the sandstone through saturation. The resulting build-up of pressure and tension causes the vertical fissures to expand until sections of cliff break away and fall on to the beach." The severe weather also caused several cliff falls along the section at Cliff End, Pett.

Dramatic pictures of the cliff fall at Rock-a-Nore, Hastings. Photos: Dan Crouch

Devonian – "The Age of Fishes"

Discoveries and pioneering studies of Devonian fossil fish

Report on a talk given to the Hastings & District Geological Society on 17th February 2013 by Dr Peter Forey, former Head of the Vertebrates and Anthropology Division, Natural History Museum, London.

Reported by Peter and Joyce Austen

Introduction

The Devonian Period, which dates from 419 to 359 million years ago (International Commission on Stratigraphy 2014), is known as "The Age of Fishes". It was during this Period that fish began to diversify, evolving into the separate groups we see today, and also when one lineage of the bony fish began to evolve into a form which would eventually move from life in water to life on land, giving rise to all land-dwelling vertebrates (tetrapods). Much of our current knowledge of early fish and their evolution is based on the pioneering studies of professional and amateur palaeontologists from the mid-19th century, and their significant contributions are discussed below.

Distribution of Devonian rocks in Britain

Most rocks of Devonian age in Britain are known as the Old Red Sandstone (ORS), a suite of sedimentary rocks representing freshwater rather than marine deposits, and are found in three main areas (Fig. 1):-

Lower Devonian rocks can be found in Cornwall in south-west England, although these deposits have been considerably disturbed by the Hercynian Orogeny. Much better preserved Lower Devonian rocks can be found across the Bristol Channel in the Welsh Borderlands – many fossil fish were found in the quarries and cuttings here in the early part of the 19th century.

Middle Devonian rocks can be found in Caithness and along the north-east coast of Scotland, and also in the Orkney and Shetland islands.

Upper Devonian rocks can be found in the Midland Valley of Scotland.

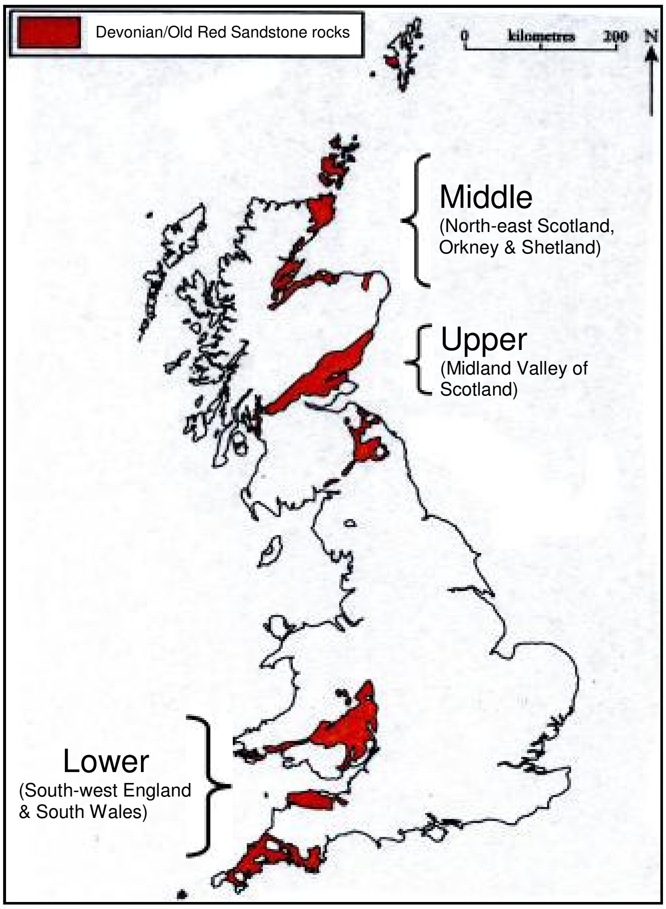


Fig. 1. Map of Britain showing distribution of Devonian/ Old Red Sandstone rocks.

Vertebrate family tree

Peter Forey began with an illustration of the Vertebrate Family Tree (Fig. 2) showing how the vertebrates evolved through time and emphasising the key role played by Devonian fish in this development. It's actually a 'spindle' diagram, with the thickness of the spindles representing the number of families known for each group. The land-dwelling vertebrates, or tetrapods, are represented by the pale blue spindles to the right of the diagram, with the four separately coloured spindles to the left representing the fish. The groups alive today are shown at the top of the diagram and the number of species known for each group is given in the oval boxes – it is worth noting that there are almost as many fish (23,960) as there are of all the land-dwelling vertebrates (24,000) and in fact bony fish provide one third of the world's protein today.

The Age of Fishes

Peter then highlighted five main points which illustrate why the Devonian Period is regarded as "The Age of Fishes":

1) the diversification of fishes – although fish first appeared in the Ordovician, it was in the Devonian that they began to diversify and separate into the groups we see today.
2) it was the heyday of the jawless fishes – these were numerous in the Devonian but are now only represented by the hagfishes and lampreys.
3) it was the Age of the placoderms (or armoured fish, arrowed in fig. 2) – this group of fish was totally extinct by the end of the Devonian.
4) it marked the beginnings of the fishes that have come to dominate the modern world – the Devonian saw the emergence of the sharks and bony fish which today dominate the seas and in the case of the bony fish, also dominate lakes and rivers.
5) it marked the Age of the evolution of fishes that would give rise to land-dwelling vertebrates – some fish in the Devonian evolved into forms that would move from life in water to life on land, giving rise to all the land-dwelling vertebrates (tetrapods).

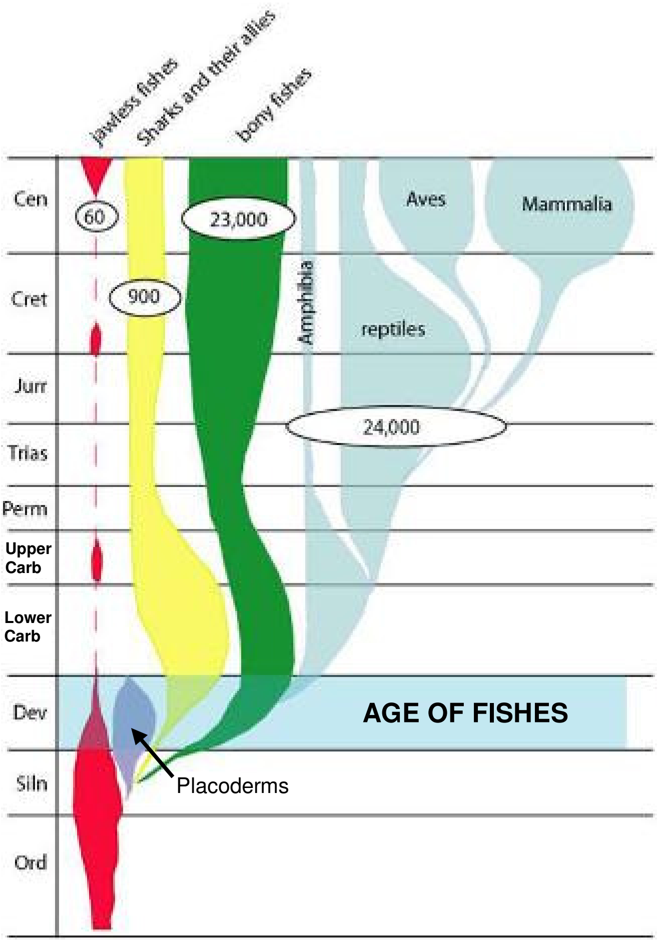


Fig. 2. Vertebrate family tree, showing the radiation of fishes during the Devonian Period.

Peter then moved on to discuss the various discoveries and contributions made by early researchers, also illustrating the worldwide distribution of Devonian fish and the search for the fish ancestor of all land-dwelling vertebrates.

Louis Agassiz 1807-1873

Louis Agassiz (Fig. 3) was a Swiss born palaeontologist, glaciologist and geologist. He is perhaps best known for his work on glaciers, but he was one of the first people to seriously study fossil fish and is regarded as the Father of this discipline. His knowledge was immense as he visited most of the principal European museums to study their fossil fish collections, and was able to examine most of the fossil fish that had been found up until that time. Between 1833 and 1844 he produced *Recherches sur les Poissons Fossiles* ('Research on Fossil Fish'), an immense work consisting of five volumes describing many hundreds of fish species (Agassiz 1833–1844). Throughout his career he classified more than a thousand species of fish. Agassiz was also the first person to classify both recent and fossil organisms together, establishing that a lot of the animals found in the fossil record were related to species alive today, and he argued that fossils should not be studied in isolation. All five volumes of Agassiz are freely available on the internet in high definition, both Text and Atlas (see references for detail).

Fig. 3. Louis Agassiz.

Agassiz also produced a supplement to *Recherches sur les Poissons Fossiles* on the fossil fish of the Old Red Sandstone of Britain and Russia (Agassiz 1844–1845). He had visited Britain, bringing with him his talented artist Joseph Dinkel, with the intention of describing the Lower Devonian fish. It was said that Agassiz kept his artist a virtual prisoner in the Geological Society apartments while he made lithographs of all the specimens! Dinkel did produce some excellent lithographs – figure 4A shows his lithograph of the Lower Devonian fish *Cephalaspis lyelli* compared with the actual specimen (Fig. 4B). Figure 4C is a reconstruction of *Cephalaspis* – Agassiz identified a hypersensitive area near the front of the fish (shaded area along lower 'jaw') which acts in a similar way to the lateral line in present-day fish. *Cephalaspis* had a mouth but no jaws, so probably fed by sucking-in food.

Agassiz's studies took him all over the world, and in 1846 he moved to the United States, where in 1859 he founded the Museum of Comparative Zoology at Harvard, serving as the museum's first director until his death in 1873. Interestingly, although Agassiz was a contemporary of Charles Darwin, he never adopted the theory of evolution.

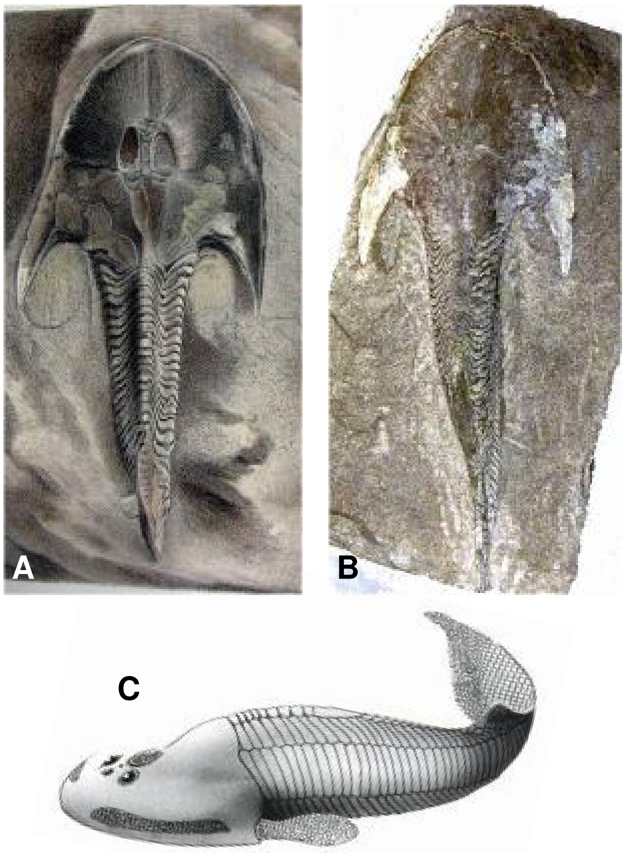


Fig. 4. Cephalaspis lyelli. *A, Lithograph by Joseph Dinkel. B, Specimen from which lithograph was taken. C, Reconstruction.*

Thomas Henry Huxley 1825-1895

Another scientist to make a significant contribution to the study of Devonian fish was Thomas Henry Huxley (Fig. 5), an anatomist who, through his support of Charles Darwin, became known as Darwin's Bulldog. Figure 6A shows a fossil from the Lower Devonian that had long puzzled palaeontologists, many of whom thought it was some kind of mollusc, but Huxley made a section of the fossil and found it was actually made of bone and that the white lines visible across the surface were part of the lateral line system. It wasn't until complete specimens were found in quarries in Herefordshire that it was possible to know the actual form of the fish when it became clear that the strange fossil was in fact a shield covering the front of the fish. This new fossil fish was named *Pteraspis,* belonging to a group known as the pteraspids, which were similar to the cephalaspids in having a mouth but no jaws, and with a different type of bone structure. Figure 6B shows a complete specimen of *Pteraspis*, together with a reconstruction (Fig. 6C). Generally the headshields of *Pteraspis* were around 4 cm long although some

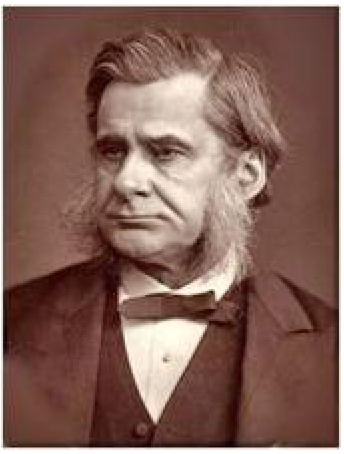
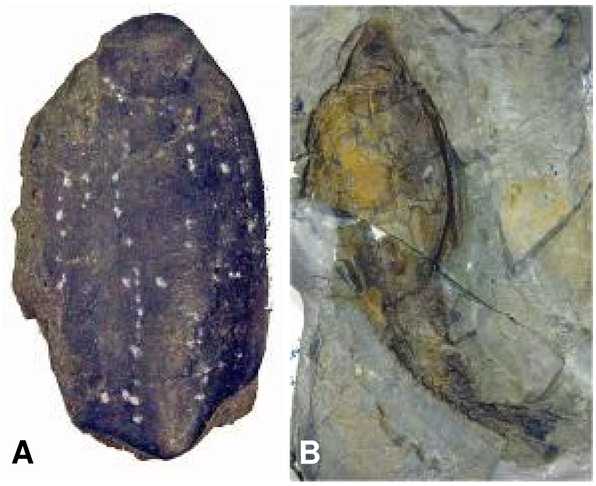


Fig. 5. Thomas Henry Huxley.



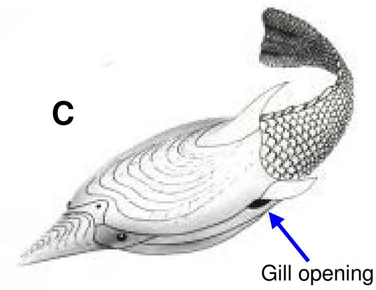


Fig. 6. Pteraspis.
A, Headshield.
B, Complete specimen.
C, Reconstruction.

were larger. The hole seen at the side of the fish in the reconstruction (arrowed) is thought to be the gill opening. Pteraspids originated in the Ordovician and are classified as heterostracans, a now extinct sub-group of the jawless fishes.

Christien Heinrich Pander 1794-1865

Fig. 7. Christien Heinrich Pander

Christien Heinrich Pander (Fig. 7), a biologist and palaeontologist from Baltic Germany, also studied Lower Devonian fish. He was perhaps better known for his work on chick embryology, the subject of his PhD thesis. He discovered the germ layers (i.e. three distinct regions of the embryo – the ectoderm, endoderm and mesoderm – that form the basis of the specific organ system), and was regarded as the "founder of embryology". However, he also produced a number of monographs on fossil fish and one of these included a study of the scales of an unusual fish from the island of Oesel (now known as Saaremaa, off the Baltic coast of Estonia). Thousands of these scales were discovered in the Silurian rocks of Oesel, taking on a variety of different forms. The scales were made of bone and were believed to have come from thelodont fishes, another now extinct sub-group of the jawless fishes. Pander described the various different scales as a number of different species (Pander 1856) - it was only after Pander's death that complete specimens were found and it was realized that they all came from the same thelodont fish, *Phlebolepis elegans* (Fig. 8). The fish itself looked like a loose bag of scales, with no jaws and a small mouth.

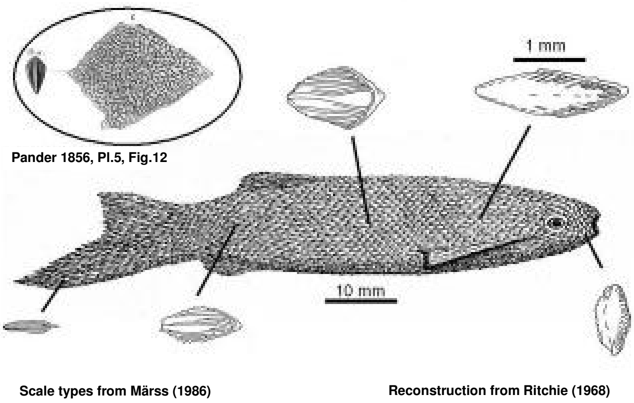


Fig. 8. Reconstruction of thelodont, Phlebolepis elegans*, showing different scale types associated with the same fish.*

Pander was also the first person to recognize and describe the conodonts (vertebrates resembling eels, until recently only known from their teeth) as a previously unknown, separate group of animals (Pander 1856; see also Sweet and Cooper 2008 for summary) – these were later used as useful stratigraphic indicators. Lower Devonian fishes were also excellent stratigraphic indicators and were used to correlate beds from around the world until fossil spores began to be used in stratigraphic correlation instead.

Devonian Jawless Fish

Agassiz, Huxley and Pander were key to the understanding and interpretation of Lower Devonian fish. *Cephalaspis* and *Pteraspis* were just two of the many different jawless fish present in the Lower Devonian – figure 9 C-L shows the wide variety of species present in both Devonian and the earlier Silurian rocks. However, these were all extinct by the end of the Devonian Period, and the only jawless fish to survive through to the present-day are the hagfishes (Fig. 9A) and the lampreys (Fig. 9B), with around 30 species of each.

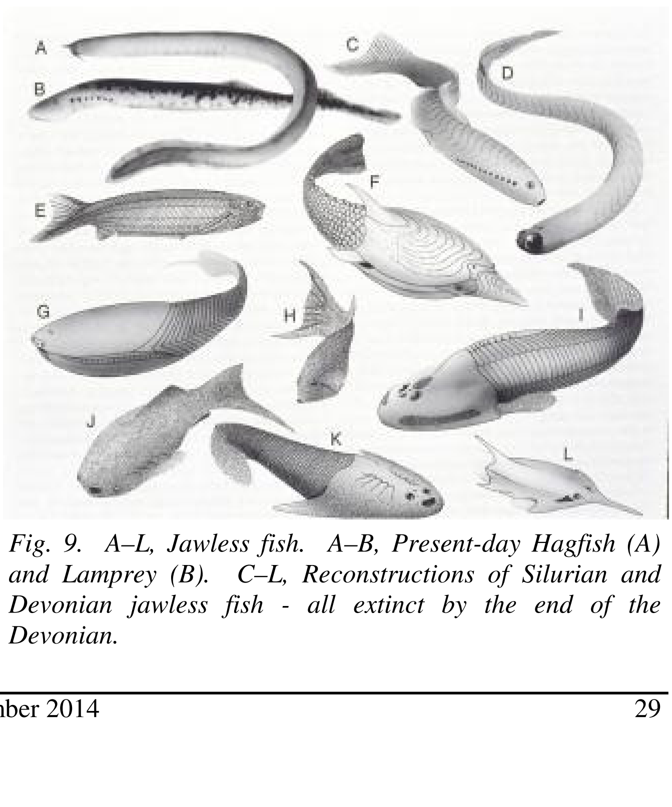


Fig. 9. A–L, Jawless fish. A–B, Present-day Hagfish (A) and Lamprey (B). C–L, Reconstructions of Silurian and Devonian jawless fish - all extinct by the end of the Devonian.

Hugh Miller "Old Red" 1802-1856

Fig. 10. Hugh Miller - Stonemason of Cromarty.

Fossil fish from the Middle Devonian were not as easy to interpret as those from the Lower Devonian. One of the pioneering workers on Middle Devonian fish was Hugh Miller (Fig. 10). Miller was born and educated in Cromarty, Scotland, where at the age of 17 he was apprenticed to a stonemason, which, together with his regular walks along the Cromarty shoreline, led him to an interest in geology. He discovered a tremendous array of fossil fishes. At first he found only individual plates from which he tried to reconstruct the whole fish – figure 11 shows one of Miller's early reconstructions based on these plates. Known as Miller's 'rude drawing' (for 'rude' read crude), he had actually mistakenly combined the plates from two separate fish – the plates outlined in yellow are from *Pterichthyodes* and those in red are from *Coccosteus*, something that would only become apparent once complete specimens of these fish were found. Figure 12A shows a later reconstruction of *Pterichthys* (now *Pterichthyodes*) by Miller made from cardboard, together with his pencil sketch of the underside (Fig. 12B), and an actual specimen (Fig. 12C). *Pterichthyodes* and *Coccosteus* (Fig. 13A-B) were both armoured fish belonging to a group called the Placoderms. In the case of *Pterichthyodes* the 'wings' were actually made of bone and were possibly used to anchor it to the Devonian lake bed. The placoderms became extinct at the end of the Devonian Period.

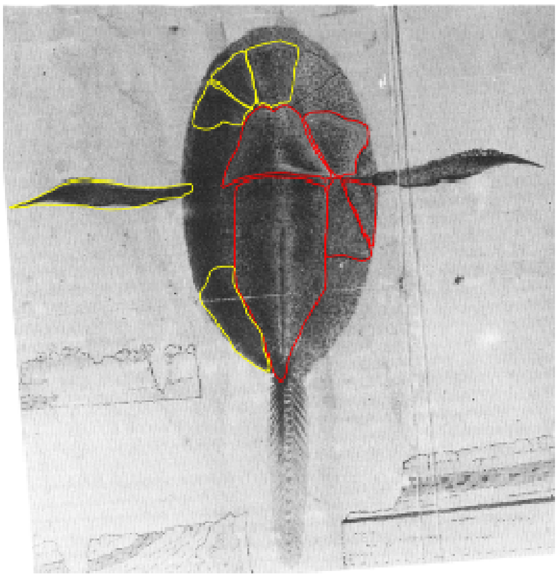


*Fig. 11. Hugh Miller's 'rude drawing' of '*Pterichthys*' in which he had mistakenly combined the plates of* Pterichthyodes *(yellow) and* Coccosteus *(red) in his attempt to reconstruct the fish from isolated plates. At that time complete specimens were unknown.*

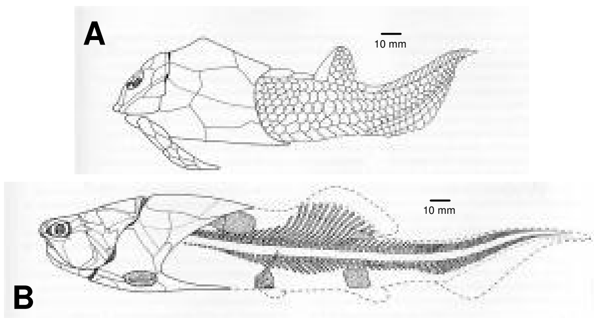


Fig. 13. Present day reconstructions of Pterichthyodes *(A) and* Coccosteus *(B).*

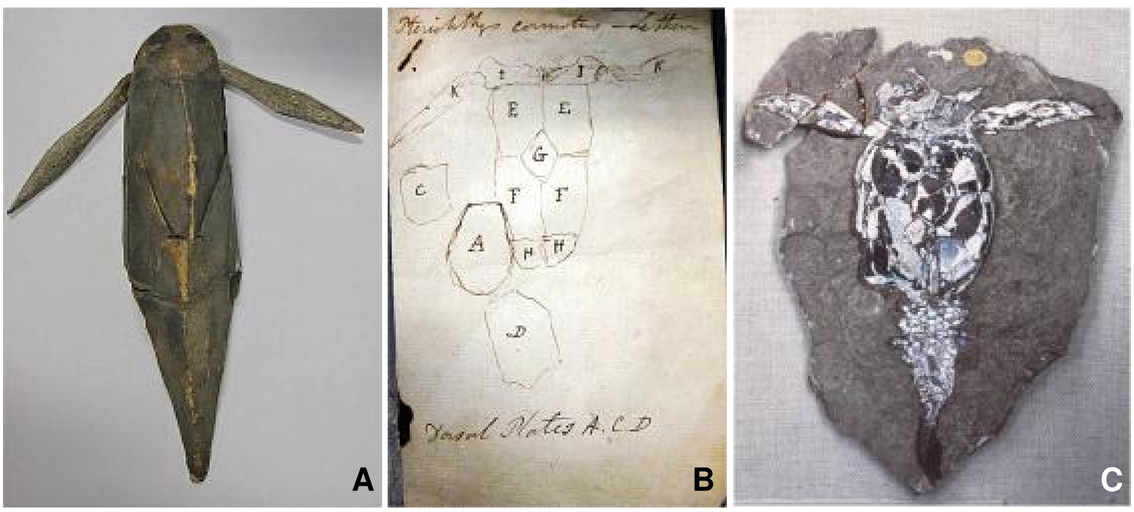


Fig. 12. Pterichthyodes
A, Miller's cardboard reconstruction - around 8-9 inches long.
B, Miller's pencil sketch of the underside.
C, Actual specimen.

Cromarty was very remote and initially Miller worked very much on his own, but as his reputation grew he received visits from the likes of Louis Agassiz who was much impressed by Miller's work and discoveries, and used many of his specimens in his monograph on the fish of the Old Red Sandstone (Agassiz 1844–1845).

Fig. 14. Achanarras Quarry, Caithness, Scotland.

Hugh Miller was a brilliant man, and during his life produced a number of geological books (some published posthumously) including: *The Old Red Sandstone* (1841), *Footprints of the Creator* (1849), *The Testimony of the Rocks* (1857), *Sketch-book of Popular Geology* (1859), and *The Cruise of the Betsey* (1858), which as well as recording some of his geological travels also documented social issues of the time. He was a devout Christian and in 1840 he helped to establish *The Witness,* an evangelical newspaper which he edited from its inception until his death in 1856. Miller did not believe in evolution even though the theory had been well known in scientific and literary circles for a number of years. Robert Chambers had written *Vestiges of the Natural History of Creation* anonymously in 1844 (Anon. 1844) which proposed a theory of evolution, but it wasn't until three years after Miller's death that Charles Darwin published *On the Origin of Species* (Darwin 1859), providing evidence supporting evolution. Miller's beliefs were reflected in the titles of two of his books, *Footprints of the Creator* (1849) and *The Testimony of the Rocks* (1857). Throughout 1856 Hugh Miller suffered a series of severe headaches, and on Christmas Eve 1856 after he'd finished checking printers' proofs for his book *The Testimony of the Rocks* he committed suicide by shooting himself with his revolver. The more sensational interpretations of his suicide claim that he shot himself because of the conflict between his religious beliefs and the contrasting evidence he saw in the rocks, but the less dramatic and perhaps more realistic interpretation is that his worsening headaches and delusions were a sign of an undiagnosed brain condition, and realizing his health was deteriorating, he shot himself for fear of losing his mental abilities, or even unwittingly harming his wife and children.

Middle Devonian fossil fish can still be collected in Scotland today, both on the Orkney and Shetland islands, and also in north-east Scotland, particularly from Caithness and Cromarty. One site, Achanarras Quarry (Fig. 14), just south of Thurso in Caithness is one of the classic Middle Devonian fish localities. It is a Site of Special Scientific Interest (SSSI) and is owned and managed by Scottish Natural Heritage. Fossil collecting is permitted at the site provided visitors follow the 'Code of Good Practice for visitors to Achanarras' which is clearly displayed at the site entrance.

Placoderms (Armoured Fish)

The world map (Fig. 15) shows that the placoderms were common during the Middle to Upper Devonian (Givetian–Frasnian stages) with a worldwide distribution. The black shaded areas on the individual pie charts in figure 15 indicate that the placoderms had more species than any other group of fish, however, by the end of the Devonian they had become extinct. Figure 16 shows the skull of *Dinichthys*, a placoderm from the Upper Devonian, Cleveland Shale of Ohio, USA. This monster grew to 9 m in length - the skull and trunk shown (Fig. 16) is around 2 m long, each

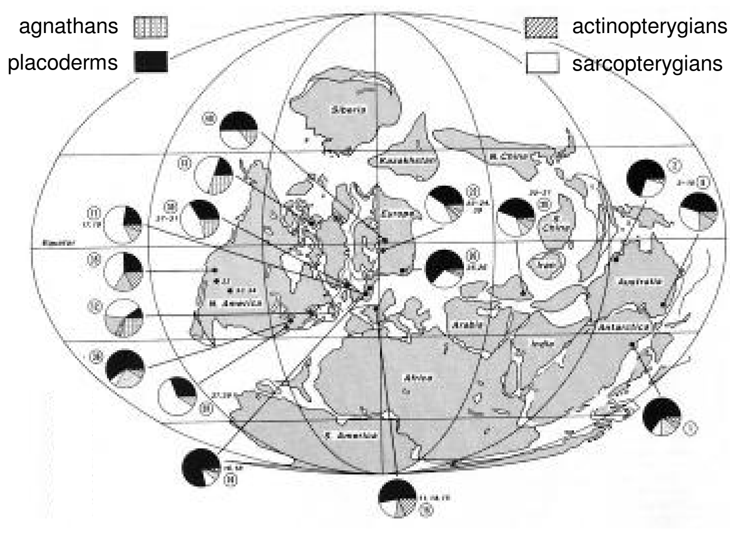


Fig. 15. Middle to Upper Devonian distribution of fossil fish. Note the abundance of the placoderms (shaded black).

section being made up of a number of interlocking armoured plates. The head and trunk were connected with a ball and socket joint, and whereas they could readily move up and down in relation to each other, they had very limited sideways movement. The jaws themselves had large blade-like teeth, but these were made of bone rather than dentine so were not very tough, certainly not as hard-wearing as true teeth, and could not be replaced so gradually wore down as the fish aged.

Fig. 16. Dinichthys, *a placoderm from the Upper Devonian, Cleveland Shale, Ohio, USA. Skull and trunk approx. 2m long.*

Upper Devonian Fish - GoGo Formation, Western Australia

An important locality for Upper Devonian fish is the GoGo Formation in the Kimberley region of Western Australia. This is an Upper Devonian reef community (Fig. 17) where the fossils exhibit exceptional preservation. Limestone concretions weather out of the reef systems and around one in three of these limestone nodules contain fossil fish (Fig. 18). Although the nodules are resistant to weathering, when they are bathed in acetic acid the limestone dissolves leaving an almost perfect three-dimensional skeleton (Fig. 19). More than fifty species of fish have been described from the GoGo Formation and figure 19 shows *Onychodus,* an early bony fish from this formation. Unlike the placoderms, the bony fish had true teeth that could be replaced throughout their lives.

Fig. 17 (above). Outcrop of an Upper Devonian reef at the GoGo Cattle Station in the Kimberley region of Western Australia.

Fig. 18 (top right). Limestone nodule containing the three-dimensional remains of an Upper Devonian fish from the GoGo Formation.

Fig. 19 (right). Reconstructed skull including true teeth of the bony fish Onychodus *from the Upper Devonian GoGo Formation.*

Development of land-dwelling vertebrates

In 1861, two years after Charles Darwin published *On the Origin of Species*, Thomas Huxley published *Preliminary essay upon the systematic arrangement of the fishes of the Devonian epoch* (Huxley 1861) where he argued that some fish had attributes that gave rise to modern fishes. The question being asked was no longer "What is a fish?", but "How did one fish become another?" People were now starting to look for transitional forms. Huxley proposed a group common in the Devonian, the crossopterygii

(Fig. 20), otherwise known as the fleshy-finned fishes, where the limb bones were outside the body of the fish, rather than within the body like most modern-day fish. He believed that from within this group you would find the fish that gave rise to the land vertebrates, the ancestor of the tetrapods.

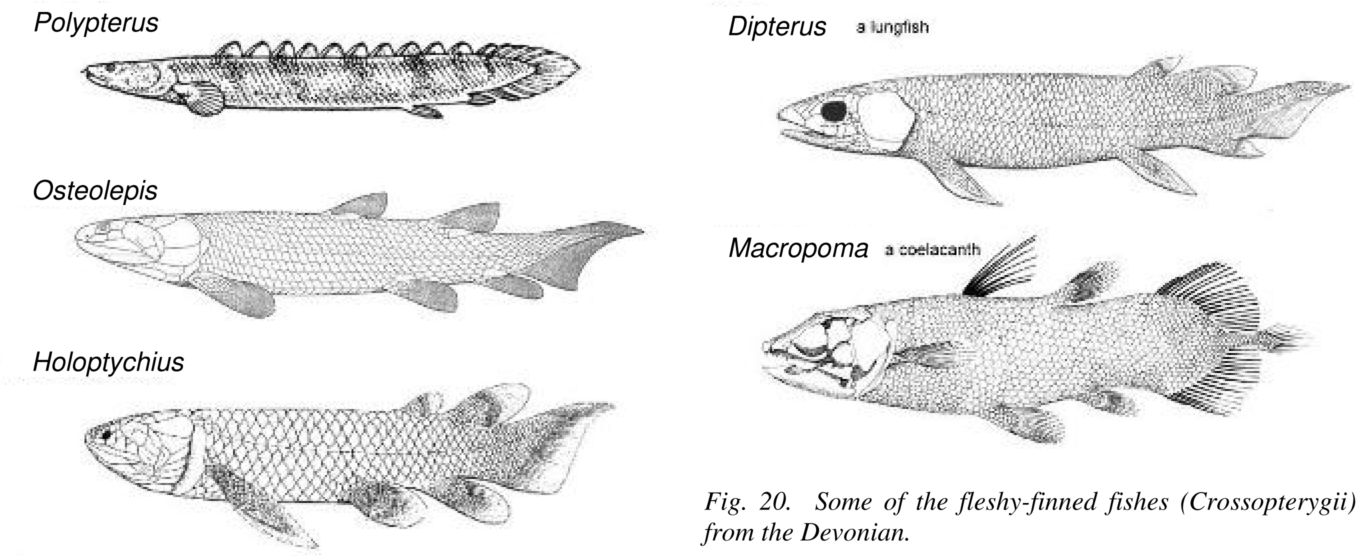


Fig. 20. Some of the fleshy-finned fishes (Crossopterygii) from the Devonian.

Erik Jarvik 1907-1998

One of these links was finally found by Erik Jarvik (Fig. 21) in the sarcopterygian (or lobe-finned) fish *Eusthenopteron*, a Devonian fish preserved in three-dimensional detail from Miguasha, Quebec. Erik Jarvik was a Swedish palaeozoologist in the Department of Palaeozoology of the Swedish Museum of Natural History, and using a technique developed there in the 1920s Jarvik took serial sections of *Eusthenopteron*, building up a detailed model of the fish's internal structure including blood vessels and nerves (Pander had used a similar technique in his work with chick embryos in the early 19th century). Jarvik took a complete specimen of *Eusthenopteron* and ground it down a millimetre at a time, making a drawing of each cross-section. This drawing was then enlarged and a wax slice made of it. This procedure was repeated 1 millimetre at a time until a complete model had been produced. This process could take several years for one model and would, of course, destroy the original fossil, but eventually you would have a detailed model showing all the internal structure including blood vessels and nerves. Figure 22 shows a section taken from the fossil (red line in fig. 22A); the drawing taken from this section showing the bones in black on the outside and the braincase in lighter shading on the inside (Fig. 22B); and the model that could be built up from these wax sections (Fig. 22C), the lines of the sections being obviously visible (the vertical lines representing each vertical slice). Figure 23 shows the actual specimen that was ground down to produce these models and figure 24 shows a reconstruction of the brain case together with cavities and canals inside the neurocranium produced from these wax sections.

Fig. 21. Erik Jarvik.

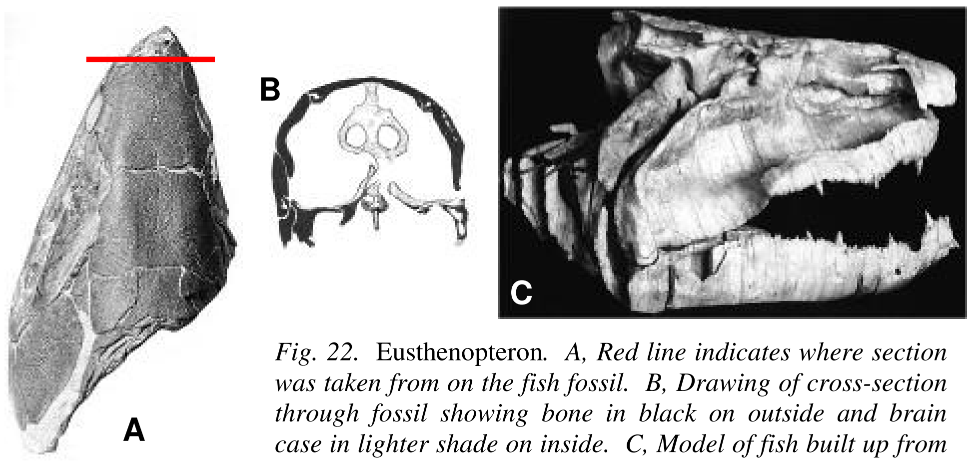


Fig. 22. Eusthenopteron. *A, Red line indicates where section was taken from on the fish fossil. B, Drawing of cross-section through fossil showing bone in black on outside and brain case in lighter shade on inside. C, Model of fish built up from multiple sections.*

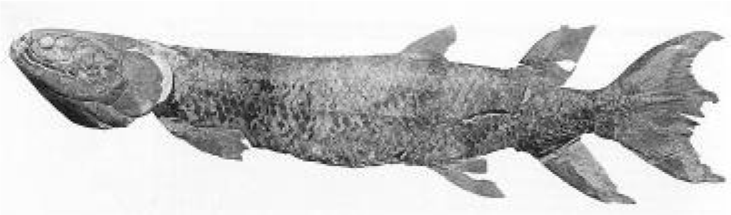


Fig. 23. The famous P-222 specimen of Eusthenopteron foordi *before its skull was destroyed by serial sectioning to produce the wax model shown in figure 24.*

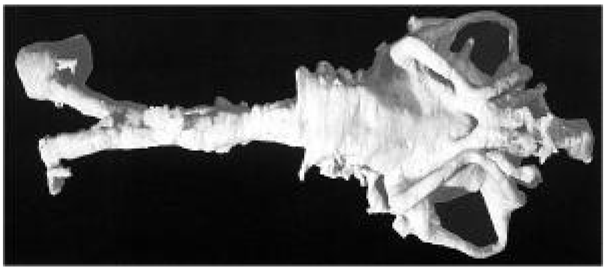


Fig. 24. Jarvik's wax model showing the cavities and canals inside the neurocranium of Eusthenopteron foordi. *The model was created using information gathered by serial sectioning the specimen shown in figure 23.*

Jarvik's work in revealing the anatomy of *Eusthenopteron* seemed to infer it could be a good candidate for the transitional form of fish that moved from water to land - whereas most fishes today have the bones of the pectoral fins inside the body, those of *Eusthenopteron* were outside the body, equivalent today to the ulna, radius and carpels. However, since Jarvik's pioneering work with *Eusthenopteron* other fish have been discovered more closely linked to the transitional form:- *Panderichthys* (Fig. 25B), which had a lower head, eye ridges and a more tetrapod-like pectoral fin; *Tiktaalik* (Fig. 25C), even more like a tetrapod, which now had a pectoral limb and an elbow joint; and *Acanthostega* (Fig. 25D), which had fingers and toes. So although *Eusthenopteron* (Fig. 25A) is no longer regarded as the missing link, it was an important step on the road towards identifying the transitional forms of fish showing much closer links to the tetrapods.

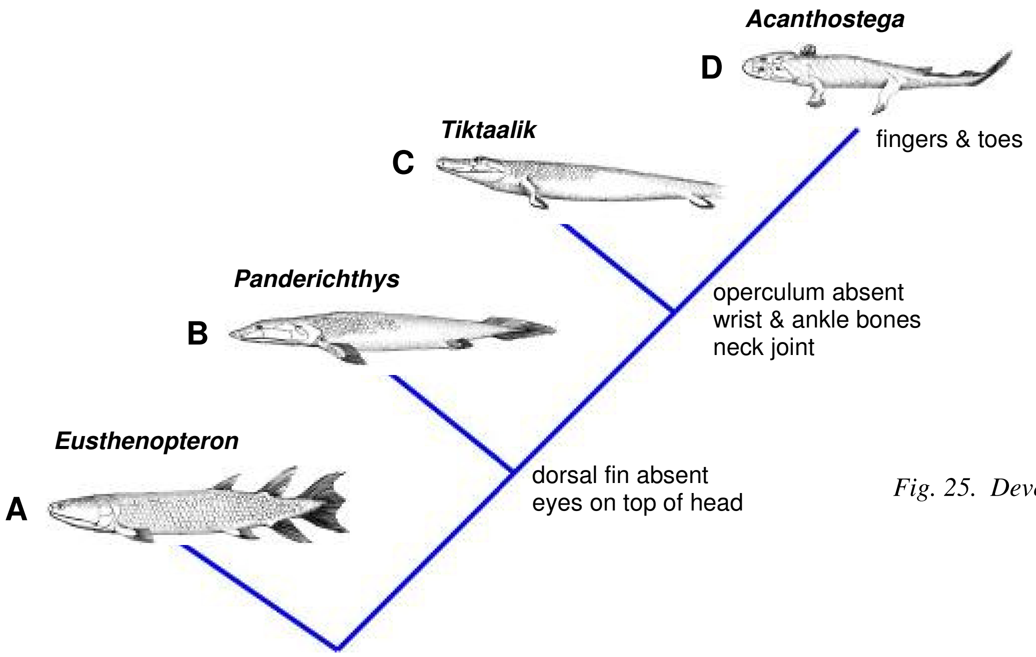


Fig. 25. Devonian tetrapod lineage.

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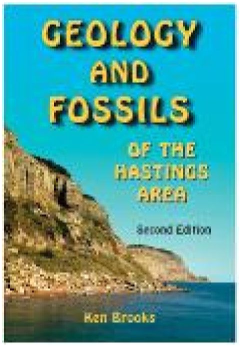
Primitive fish in Lake Orcadie (Middle Devonian, 385 million years ago). *Painting by Christopher Chatfield (1979)*

Book review - Geology and Fossils of the Hastings Area (Second edition)

Reviewed by Chris Darmon in Down to Earth (Issue 89, November 2014)



This is the second edition of Ken's excellent little book that is a must for anyone who is intent on fossil hunting in the area. The book has been extensively revised and updated and now includes a number of additional images in full colour of specimens, many of which were collected by the author.

The book begins with a nice section that introduces the reader to the geological history of the area, followed by a lovely page giving sound advice about carrying out fieldwork, especially in a coastal area with cliffs that are being constantly eroded.

Ken includes notes to two field locations, Rock-a-Nore and Pett to Fairlight Cove, both places he knows intimately. These are angled towards the needs of the fossil collector, as you might expect, but there are also notes about things like faulting.

The majority of the book is given over to what Ken calls 'reconstructions' of the physical environments and, most importantly, the fossils themselves. These 'pen pictures' are really concise and easy to understand and packed full of Ken's own little insights taken from his local knowledge and fieldwork. It was particularly pleasing to see information about the local, and rare, vertebrates, including dinosaurs and even mammals. It's very clear that Ken's collecting has been very fruitful over a number of years, with some exquisite samples photographed.

This is a little gem of a book, in which Ken imparts his immense local knowledge to a wider audience. It is written in an easy style that anyone can understand and appreciate. Get yourself a copy!

GEOLOGISTS' ASSOCIATION FIELD MEETINGS – 2015

The HDGS is affiliated to the Geologists' Association (GA), and as such members are entitled to attend GA lectures, normally held at Burlington House, Piccadilly, London, W1, or attend any of the GA field trips. Below is the 2015 GA field programme, although some of these dates may change. Details of these trips and also GA lectures appear in the *Magazine of the Geologists' Association*, which is available at HDGS meetings. Details can also be found on the GA website http://www.geologistsassociation.org.uk/. All bookings must be made through the Geologists' Association office – details in the *Magazine of the Geologists' Association*.

FIELD MEETINGS IN 2015

Sat 21st March	Saltford - Discovering and promoting local geology	Simon Carpenter and Richard Ashley
Sat 16th May to Sun 17th May	The Old Red Sandstone of South Wales (Joint meeting with the South Wales GA Group)	John Davies and Geraint Owen
Sat 6th June	William Smith and Bath	Hugh Torrens
Sat 20th June	Oxfordshire geological highlights	Mike Howgate
June/July (date to be confirmed)	Geology of the Severn Valley Railway	Peter Worsley
Sun 26th July	Fairlight Glen to Rock-a-Nore, Hastings (Joint GA/HDGS trip)	Ken Brooks, Peter Austen and Ed Jarzembowski
Sat 8th August	Geological highlights of Martley, Worcs. (Joint meeting with the Teme Valley Geol.Soc.)	John Nicklin and others
Sun 23rd August	The geology of Reculver Country Park	Geoff Downer
September (date t.b.c.)	Dorset weekend	John Cope
September (date t.b.c.)	The Lower Thames gravels	David Bridgland and Peter Allen
Sat 7th November	GA Festival of Geology (UCL, London)	Geologists' Association

Trips still to be finalised: The chalk of Margate - Haydon Bailey / Building stones walk in London - Ruth Siddall / Building stones of St Albans - Di Smith / Buckinghamshire geology - Jill Eyres.

Cliff recedes at Birling Gap

by Joyce Austen

Following last winter's severe storms and much heavier than usual rainfall, the chalk cliffs at Birling Gap, near Eastbourne were subject to the equivalent of seven years of erosion in just two months at the beginning of 2014. Numerous rock falls in January and February caused the cliff edge to recede more than 5 m in places, and by the beginning of March the unprecedented rate of erosion had left the end cottage at Birling Gap precariously close to the edge of the cliff. Unfortunately, this meant there was no alternative but to demolish the cottage, both for public safety and in order to save the adjoining property from being damaged as the end cottage inevitably crumbled into the sea. The sun lounge and ice cream parlour of the National Trust café also had to be demolished as the cliff edge crept ever closer.

This area is particularly prone to erosion as the geology creates a weakness in the low lying cliff face. Birling Gap is a glaciated dry river bed, carved through the chalk by torrents of water from melting ice 100,000 years ago. The meltwater left deposits of Combe Rock (soft, brown chalk pebbles) in the valley which are weaker than the surrounding chalk and particularly susceptible to saturation and erosion. Combined with the position of Birling Gap itself which receives the full force of the south westerly wave action at the cliff base, this results in an average of 75 cm of cliff loss every year in any event, and the unusually severe 2013/14 winter weather led to an unprecedented increase in this rate of erosion.

There have been a series of unusually large cliff falls all along the chalk coastline from Seaford to Eastbourne after last winter's storms, including falls at Seaford Head, Hope Gap, the Cuckmere estuary and in several places from the Seven Sisters along to Beachy Head.

March 4th - Large cliff fall threatens end cottage. Bottom steps to beach removed after storm damage.

March 31st - Demolition in progress after further falls undermine end cottage.

April 8th - Cottage has been demolished - work beginning to remove the outhouse.

April 29th - Demolition of cottage complete. Bottom steps to beach replaced for Summer season.

Palaeontology in the News

A review of recent research and discoveries

Edited by Peter and Joyce Austen

The following is a summary of recent research and discoveries in or associated with palaeontology. Where possible I have included enough detail (i.e. species name, author, etc.) to allow for a search of the internet for further information. In most cases more information is available, including an abstract of the paper and press releases, and quite often if you go to the author's own website or the museum/university website to which the author is affiliated you may be able to obtain a copy of the original paper. If you do not have a computer at home, all libraries in the UK are now equipped with computers with internet access for use by the general public. Once again special thanks to Christine Wagner for bringing to my attention several of the news items included below.

Was *Archaeopteryx* losing its ability to fly?

In previous issues of this journal we've reported on whether *Archaeopteryx* was a dinosaur[*1] or a bird[*2,*3], on its method of flight[*4] and even its hearing capabilities[*5], but now Michael Habib, a biologist at the University of Southern California, USA, has proposed that *Archaeopteryx* was actually starting to lose its power of flight (Fig. 1). He made the claim at the annual meeting of the Society of Vertebrate Paleontology in Los Angeles, California. With the skeleton of a dinosaur and the feathers of a bird, *Archaeopteryx* has long been hailed as marking the transition from dinosaurs to birds, and it has long been debated whether it was actually able to fly or merely evolving toward that ability. In an attempt to understand its flying abilities, Habib calculated limb ratios and degrees of feather symmetry in *Archaeopteryx*, and compared them with those of living birds. He found that the creature's traits were surprisingly similar to those of modern flightless birds such as rails and grebes that frequently dwell on islands, and we know that *Archaeopteryx* lived in what is now southern Germany during a time when Europe was an archipelago of islands in a shallow, warm, tropical sea, around 150 million years ago. Also, we now know that *Archaeopteryx* appeared around 10 million years after the oldest known bird-like dinosaurs first appeared, so although contentious it is not an unrealistic proposal. It was also pointed out by other delegates at the conference that there are many birds that are better fliers as juveniles than as adults and that a few species even lose flight completely as they mature. Thomas Holtz, a palaeontologist at the University of Maryland in College Park, USA, suggested "Perhaps young *Archaeopteryx* flew, but adults were more ground-based."

Fig. 1. The anatomy of the early bird Archaeopteryx *is similar to that of modern flightless birds that descended from flying ones.*

Image: Stocktrek Images, Inc./Alamy

*1 See '*Archaeopteryx* knocked off its perch?!', HDGS Journal, Dec 2011, Vol. 17, p.43.
*2 See '*Archaeopteryx* back on its perch?', HDGS Journal, Dec 2012, Vol. 18, p.57.
*3 See 'New discovery strengthens *Archaeopteryx*'s position as an early bird.', HDGS Journal, Dec 2013, Vol. 19, p.59–60.
*4 See 'Feather structure in early birds.', HDGS Journal, Dec 2013, Vol. 19, p.53.
*5 See 'Hearing capabilities of *Archaeopteryx*.', HDGS Journal, Dec 2009, Vol. 15, p. 29–30.

Reference

KAPLAN, M. 2013. Theory suggests iconic early bird lost its flight. *Nature News*, doi:10.1038/nature.2013.14142.

Oldest 'big cat' found in the Himalayas

Until now the oldest known fossils of pantherine cats (lions, tigers, jaguars and leopards) were 3.8-million-year-old fragments from Africa, leading some scientists to suggest that they originated there and then spread to other regions. Now, researchers have discovered the bones of three big cats in south-western Tibet, including a partial adult skull with several teeth still in the upper jaw. The find, named *Panthera blytheae*, which was reported by Jack Tseng, a vertebrate palaeontologist at the American Museum of Natural History in New York, USA and colleagues, was from 4.2-million-year-old rocks on the Tibetan Plateau, with further fossils from the same species in nearby strata dated at 5.95 million years (*Proceedings of the Royal Society B: Biological Sciences*, 2014, Vol. 281, No. 1774, doi:10.1098/rspb.2013.2686). Many features of *Panthera blytheae*'s teeth are similar to those of a snow leopard (Fig. 2), and it appears to be about the same size as a clouded leopard which is about 10% smaller than a snow leopard, both of which live in the Himalayas today. The authors suggest that *Panthera blytheae* is a "sister species" to the snow leopard and a close relative of today's tiger. There is already a greater diversity of big cats in eastern and southern Asia today than in Africa, and this find gives support to the idea that the pantherine cats first appeared in Asia, and then spread out to Africa.

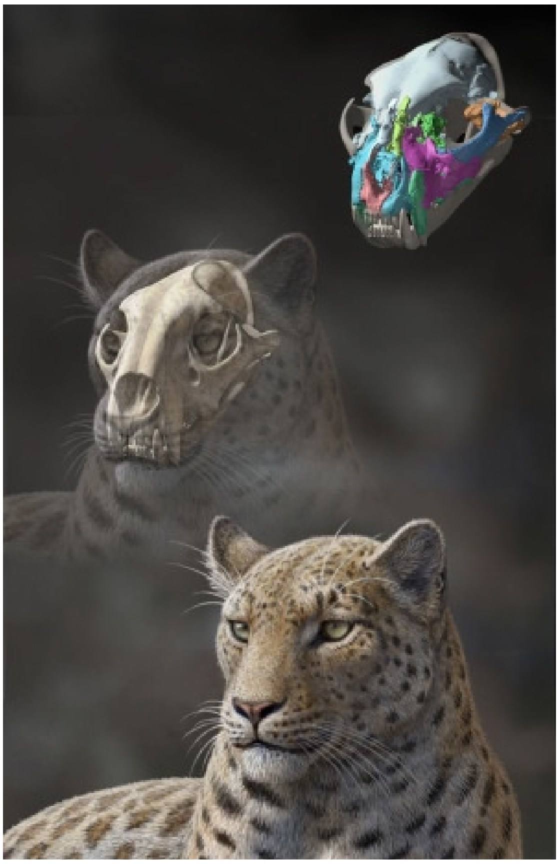


Fig. 2. The 4.2-million-year-old skull of Panthera blytheae *from Tibet (top) resembles that of a modern snow leopard (middle and bottom).*
Image: Mauricio Antón

Reference

PERKINS, S. 2013. Leopard-like creature is the oldest big cat yet found. *Nature News*, doi:10.1038/nature.2013.14161.

Juvenile hadrosaur found by US high-school student

Kevin Terris, a high-school student from Claremont, California, USA, has discovered the first near-complete juvenile specimen of the hadrosaur (duck-billed dinosaur) *Parasaurolophus*. Students from Terris's school often accompany palaeontologists from the Raymond M. Alf Museum of Paleontology on their digs, and it was on one of these trips that Terris found the specimen in a large boulder. The discovery was reported and described by Andrew Farke of the Raymond M. Alf Museum of Paleontology, Claremont, California, and colleagues in the open access journal *PeerJ* (Farke *et al.* 2013). The near-complete specimen was from the late Campanian Kaiparowits Formation (*c.* 75.5 Ma) of southern Utah, USA, and at around 2 m long was a quarter of the length of an adult *Parasaurolophus*. It had none of the annual growth rings typically found in dinosaur bones, implying that it was a juvenile and probably less than a year old. One surprising finding was that although most known hadrosaurs start developing their head crests when they have reached half their adult size, this juvenile *Parasaurolophus* was already developing its curved, tube-like head crest at less than a quarter of its adult size. Many scientists believe that the hollow crest was a trombone-like device for amplifying the animal's calls, others that it used its crest to display to potential mates.

Reference

FARKE, A. A., CHOK, D. J., HERRERO, A., SCOLIERI, B. and WERNING, S. 2013, Ontogeny in the tube-crested dinosaur *Parasaurolophus* (Hadrosauridae) and heterochrony in hadrosaurids. ***PeerJ* 1:e182; DOI 10.7717/ peerj.182**.

Pterosaurs didn't float

The highly pneumatic skeleton of pterosaurs suggests that they would float high up on the surface of open water, but in a study conducted by David Hone, at Queen Mary University of London, and Donald Henderson at the Royal Tyrrell Museum of Palaeontology in Drumheller, Alberta, Canada, they showed that pterosaurs would have risked drowning if they spent too much time on the water (*Palaeogeography, Palaeoclimatology, Palaeoecology*, 2014, Vol. 394, p. 89–98). They tested the floating-pterosaur hypothesis by creating computer models together with body mass estimates of the four pterosaurs *Dimorphodon*, *Rhamphorhynchus*, *Pteranodon* and *Dsungaripterus*, and found that part of their head would have been below the waterline, leaving them vulnerable to drowning. Even though pterosaurs foraged in marine and freshwater environments, it seems likely that they did not regularly rest on the water surface and if immersed would need to take off again rapidly.

Why sharks have cartilage, not bone

Fig. 3. DNA from the elephant shark, Callorhinchus milii*, was used to investigate its bone-forming ability.*
Image: Norbert Wu/Minden Pictures/Getty Images

To date, scientists have sequenced the genomes of eight bony fish and two jawless vertebrates known as lampreys, but until now they have not sequenced the genomes of the cartilaginous fish (sharks, skates, rays and chimaeras). These have a skeleton that is made primarily of cartilage rather than bone, and although scientists knew what genes were involved in bone formation, it wasn't clear whether sharks had lost their bone-forming ability or just never had it in the first place. After all, sharks do make bone in their teeth and fin spines. To resolve this, Byrappa Venkatesh, a comparative-genomics expert at the Agency for Science, Technology and Research in Singapore and colleagues sequenced the genome of the present day elephant shark, *Callorhinchus milii* (Fig. 3), which lives in deep waters off southern Australia and New Zealand (*Nature*, 2014, Vol. 505, No. 7482, p. 174–179). They chose the elephant shark both because of its relatively small genome and also because it is an early jawed vertebrate that has changed little since bony fishes appeared around 420 million years ago – making it the slowest-evolving of all known vertebrates. The sequence revealed that members of the cartilaginous fish are missing a single gene family that regulates the process of turning cartilage into bone, and that a gene duplication event gave rise to the formation of bone in all other vertebrates. In fact, when the team knocked out this gene in a zebrafish, it significantly reduced its ability to form bone. The research also shed new light on the vertebrate immune system.

Reference

BORRELL, B. 2014. Why sharks have no bones. *Nature News*, doi:10.1038/nature.2014.14487.

Were all dinosaurs feathered?

For the past 20 years or so, scientists have known that theropods, the dinosaur group that contained the likes of *Tyrannosaurus* and *Velociraptor* and from which modern birds evolved, were covered in feathery structures from early on in their evolutionary history. By contrast, the ornithischian lineage, which contained the likes of *Triceratops*, *Stegosaurus* and *Ankylosaurus*, and the large sauropods (*Diplodocus* etc.) were considered to be scaly, similar to modern reptiles. That was until 2002 when remains of ornithischians were found with filament-like structures in their skin. This led some to speculate that feather-like structures were an ancestral trait for all dinosaur groups. Now, a study carried out by Paul Barrett of the Natural History Museum in London and David Evans of the Royal Ontario Museum in Toronto, Canada, indicate that although some ornithischians, such as *Psittacosaurus* and *Tianyulong*, had quills or filaments in their skin, the vast majority had scales or armour – scales were also the norm for the sauropods. The results were revealed by Paul Barrett at the Society of Vertebrate Paleontology's annual meeting in Los Angeles, USA.

Mass mortality of whales in the Miocene

In 2010, work to expand the Pan-American Highway in the Atacama Region of Chile uncovered a mass mortality of Late Miocene whales and other aquatic animals in an area called Cerro Ballena (Fig. 4). The site has been studied by Nicholas Pyenson of the Smithsonian Institution in Washington DC, USA and his colleagues, and they discovered the fossils of baleen and other whales, seals, an aquatic sloth and predatory bony fish, which covered four distinct horizons dating from 9 million years to 6.5 million years old (*Proceedings of the Royal Society B: Biological Sciences*, 2014, Vol. 281, No. 1781, doi:10.1098/rspb.2013.3316). The team suggested that the whales and other creatures had been killed by the growth of toxic algae, and the fact that they were in four discreet horizons over a period of 2.5 million years suggests that this was a recurring event in that area.

Fig. 4. Site of the mass mortality of Miocene whales alongside the Pan-American Highway in Atacama, Chile.

Image: Adam Metallo/Smithsonian Inst.

Reference

ANON. 2014. Algae dealt blow to ancient whales. *Nature*, vol. **507**, no. 7490, 11.

Cambrian filter-feeders

Anomalocarids are known as large, fierce, shrimp-like predators that patrolled the Cambrian oceans catching prey with their sharp claws. However, fossils discovered in Greenland in 2009 and 2011 show that this group also included filter-feeders. The fossils from the 520-million-year-old Early Cambrian Sirius Passet fauna of North Greenland were described by Jakob Vinther from the Schools of Earth Sciences and Biological Sciences, University of Bristol, UK and colleagues (*Nature*, 2014, Vol. 496, No. 7493, p.496–499). The study showed that the fossils, named *Tamisiocaris borealis*, used wispy, comb-like frontal appendages around 12 centimetres long to sweep up plankton as small as 0.5 millimetres (Fig. 5). This behaviour has evolved several times in Earth's history in groups as diverse as sharks, rays, teleost fishes and whales, all during periods of abundant marine food supplies, but this is the earliest-known large, swimming filter-feeder.

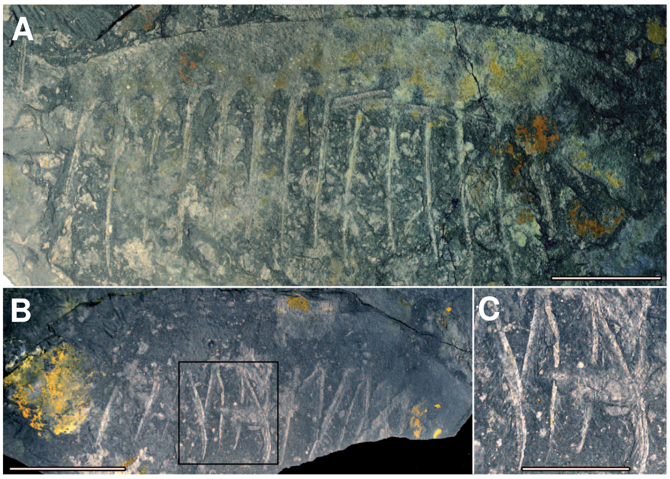


Fig. 5. Frontal appendages of the anomalocarid, Tamisiocaris borealis*, from the Lower Cambrian of Greenland.* ***A****, Isolated and relatively complete appendage.* ***B****, Isolated appendage, preserving auxiliary spines in great detail.* ***C****, Detail of spine (boxed area in* ***B****).*

Image: Vinther et al. *2014, p.496, fig. 1.*

Reference

VINTHER, J., STEIN, M., LONGRICH, N. R. and HARPER, D. A. T. 2014. A suspension-feeding anomalocarid from the Early Cambrian. *Nature*, vol. **496**, no. 7493, 496–499.

Origin of echolocation in whales

The toothed-whales, which include the sperm whales, orcas, beaked whales, dolphins and porpoises, hunt and navigate using echolocation – however, exactly when this complex behaviour evolved is largely unknown. Jonathan Geisler of the Department of Anatomy, New York Institute of Technology

College of Osteopathic Medicine, New York, USA and colleagues have reported the discovery of a 28-million-year-old skull of a toothed whale, named *Cotylocara macei*, from a drainage ditch in Berkeley County, South Carolina, USA (*Nature*, 2014, Vol. 508, No. 7496, p. 383–386). The deposits are from Bed 2 of the Chandler Bridge Formation and are of late Oligocene age. The fossil skull has several features suggestive of echolocation, and the authors believe that a rudimentary form of echolocation evolved in the early Oligocene, shortly after toothed-whales diverged from the ancestors of filter-feeding whales.

Trilobites ventured out of the ocean

Trilobites are often thought of as ocean dwelling creatures, but the discovery of trilobite fossils and trackways in the 540-million-year-old tidal flats of the Cambrian Rome Formation in the southern Appalachian Mountains of Tennessee, USA, by Gabriela Mángano from University of Saskatchewan, Canada and her colleagues, suggests that some trilobites ventured into the intertidal zone (*Geology*, 2014, Vol. 42, No. 2, p.143–146). The rocks where the fossils were found showed signs of mud-cracks from periodic drying, suggesting that they originated in a tidal flat zone rather than the sea floor.

Diminutive tyrannosaur from Arctic Alaska

Scientists have discovered the fossils of a diminutive tyrannosaur in Alaska high above the Arctic Circle. It is the first known tyrannosaur from either pole, and it is also the first example of a 'pint-sized' tyrannosaur so far found. The 70-million-year-old dinosaur, named *Nanuqsaurus hoglundi*, would have measured some 7 metres long against *Tyrannosaurus rex* which measured 12 metres in length (Fig. 6). The find, made by Anthony Fiorillo and Ronald Tykoski, of the Perot Museum of Nature and Science in Dallas, Texas, USA, was from the Kikak-Tegoseak Quarry (Prince Creek Formation), North Slope Borough, Alaska, USA (*PLoS ONE* 9(3): e91287. doi:10.1371/journal.pone.0091287 (2014)). They recovered part of a skull and several jaw fragments and knew it was from a fully grown dinosaur because one jaw section shows a distinctive peg-and-socket pattern that is only found in adult animals. Alaska was located at least as far north as today, although temperatures were warmer overall, but it would have been an extreme environment and *Nanuqsaurus*'s relatively small body size may have been due to the pressures of hunting food in a landscape limited by six months of light and six months of darkness.

Reference

FIORILLO, A. R. and TYKOSKI, R. S. 2014. A diminutive new tyrannosaur from the top of the world. *PLoS ONE* 9 (3): e91287. doi:10.1371/journal.pone.0091287.

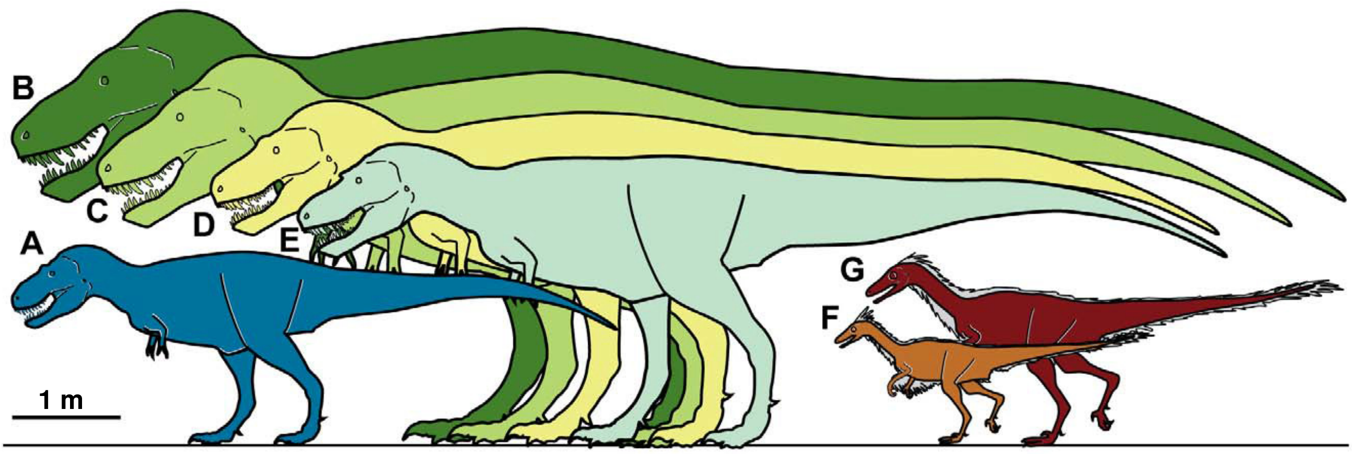


Fig. 6. Relative size of Nanuqsaurus hoglundi. *Silhouettes showing approximate sizes of representative theropods.* ***A***, Nanuqsaurus hoglundi*;* ***B***, Tyrannosaurus rex, *in Field Museum of Natural History, Chicago;* ***C***, Tyrannosaurus rex, *in American Museum of Natural History, New York;* ***D***, Daspletosaurus torosus*;* ***E***, Albertosaurus sarcophagus*;* ***F***, Troodon formosus, *from lower latitudes;* ***G***, Troodon *sp., from Alaska (higher latitudes).*

*Image: Fiorillo and Tykoski 2014 (*PLoS ONE *9(3): e91287. doi:10.1371/journal.pone.0091287), p.11, fig. 8*

End Permian extinction caused by methane-belching microbes?

Fig. 7. Scanning electron micrograph of the archaea Methanosarcina.
Image: Power and Syred/SPL

The extinction event at the end of the Permian period 252 million years ago known as the 'Great Dying', which wiped out some 90% of all species on Earth, has often been attributed to Siberian volcanoes which are known to have been hugely active at the time. However, a study conducted by Daniel H. Rothman of the Lorenz Center & Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA and colleagues, suggests that methane-belching microbes may have been behind the 'Great Dying' (*Proceedings of the National Academy of Sciences*, 2014, Vol. 111, No. 15, p.5462–5467). It has long been known that microbes can have enormous effects on the planet's geology and life through the chemicals they consume and release, a classic example being the creation of the oxygen-rich environments that made the evolution of complex animals possible, known as the 'Great Oxygenation Event' around 2.4 billion years ago. Rothman and his colleagues looked at the events leading up to the 'Great Dying'. Geological evidence shows that the event was accompanied by lethally high global warming and ocean acidification, and that prior to the extinctions large quantities of organic matter had accumulated in the ocean sediments, essentially "a pile of food sitting there" waiting to be eaten, but with nothing in a position to eat it. At that time the oceans were also home to single-celled microbes known as archaea, some of which, known as *Methanosarcina* (Fig. 7), consumed carbon compounds and released methane, but they could not process acetate, one of the key compounds that made up the sediment reserves. The authors suggest that around the time of the mass extinction, approximately 250 million years ago, these single-celled microbes captured two acetate-processing genes from a bacterium by a process known as gene transfer. This evolutionary event allowed *Methanosarcina* to feed on the organic sediment leading to a prodigious microbial bloom and the consequent dumping of methane, a powerful greenhouse gas, into the atmosphere, thus causing the mass extinction.

Reference

WALD, C. 2014. Archaeageddon: how gas-belching microbes could have caused mass extinction. *Nature News*, doi:10.1038/nature.2014.14958.

Starfish visual systems

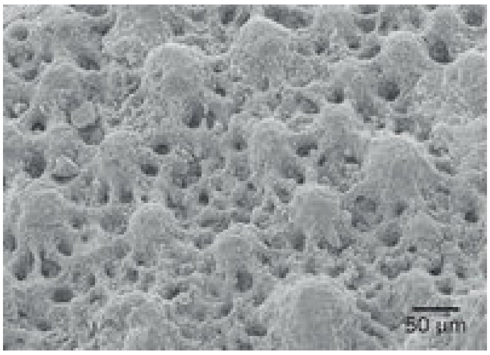


Fig. 8. Crystal calcite microlenses in a 75-million-year-old echinoderm – structures match those found in modern echinoderms.
Image: Przemysław Gorzelak/Polish Academy of Sciences

A study conducted by Przemysław Gorzelak at the Polish Academy of Sciences in Warsaw and colleagues, has found that starfish and echinoderms may have had complex visual systems for around the past 80 million years (*Nature Communications* 5, Article 3576, doi:10.1038/ncomms4576). Some existing echinoderms, such as brittle-stars, are covered in crystal calcite microlenses that are sensitive to light. Gorzelak and his team analysed 75-million-year-old brittle-star and starfish fossils from the Late Cretaceous (Campanian, *c.*79 Ma) of Poland by using a scanning electron microscope, and found that both kinds of fossil contained structures that matched modern echinoderms' microlenses in size and shape (Fig. 8). The authors suggest that after an explosion in the diversity of fish and crustacean predators around 80 million years ago, echinoderms may have developed visual systems to avoid such predators.

Reference

ANON. 2014. Ancient starfish spotted predators. *Nature*, vol. **508**, no. 7494, 10.

Long-snouted tyrannosaur from China

Fig. 9. Reconstruction of Qianzhousaurus sinensis*, nicknamed 'Pinocchio rex'.*

Image: Chuang Zhao

Most tyrannosaurs had short, brutish faces like that of *Tyrannosaurus rex*. Now palaeontologists in China have unearthed the remains of a slender, long-snouted tyrannosaur, and because of its long impressive nose, nicknamed it 'Pinocchio rex'. The 66-million-year-old fossil, real name *Qianzhousaurus sinensis* (Fig. 9), was unearthed at a construction site in the city of Ganzhou in southern China, and published by Junchang Lü of the Chinese Academy of Geological Sciences in Beijing, China and colleagues (*Nature Communications* **5**, Article 3788, doi:10.1038/ncomms4788). The fossil, which constitutes most of a single animal, represents an entirely new class of dinosaurs. It was 9 metres from nose to tail, with its snout making up about 70% of the length of its skull. It would have been the top predator of its time, and a more agile creature than *T. rex*, and its long snout would have given it different feeding strategies from the muscular *T. rex*. It is similar in proportions to two other species that had previously been found in Mongolia, but these were juveniles so scientists were unsure whether they lost their long snout as they grew to adulthood. No long-snouted tyrannosaurs have been found in the Americas, suggesting that the Asian dinosaurs had subtle but important differences from their cousins in North America.

Reference

WITZE, A. 2014. Long-snouted tyrannosaur unearthed. *Nature News*, doi:10.1038/nature.2014.15159.

Bird pollination in the Eocene

Fig. 10. Eocene bird from Messel with pollen grains in its stomach (boxed).

Birds are important pollinators, but the evolutionary history of bird pollination is poorly known. Now a 47-million-year-old fossil bird with pollen grains in its belly is the first direct evidence of nectar-feeding in birds. The study of a fossil bird, *Pumiliornis tessellatus* from the middle Eocene of Messel in Germany, was conducted by Gerald Mayr and Volker Wilde at the Senckenberg Research Institute in Frankfurt, Germany (*Biology Letters*, Vol. 10, No. 5, doi:10.1098/rsbl.2014.0223). The bird is similar to cuckoos or parrots, and its thin, long beak resembles those of other nectar-slurping birds, such as hummingbirds. The researchers subjected the bird to electron microscopy revealing pollen grains in its stomach (boxed) (Fig. 10). *Pumiliornis tessellatus* is not closely related to present-day nectar-feeding birds, suggesting that interactions between birds and flowers predate the present-day species.

Reference

ANON. 2014. Nectar feast in fossil belly. *Nature*, vol. **510**, no. 7503, 10.

KT asteroid hit at the wrong time

A study conducted by Stephen Brusatte, a palaeontologist at the University of Edinburgh, UK and colleagues, suggests that the extinction of the dinosaurs 65 million years ago when a large comet or asteroid hit the earth was exacerbated by a decline in the diversity of plant-eating dinosaur species in the period leading up to the impact (*Biological Reviews*, 2014, doi.org/10.1111/brv.12128). To explore this question, the study pulled information from a database on global dinosaur diversity, including hundreds of fossils found in the past decade. They found that in North America, in the last 8 to 10 million years before the asteroid impact, two major groups of herbivores did decline, with some multiple species shrinking to just one. This was also the period of massive volcanic eruptions in India forming the Deccan flood basalts (Deccan Traps) which would have brought about cooler climates and changes in the types of vegetation available for the herbivorous dinosaurs to eat. Plenty of dinosaur groups had recovered from such declines in population before, but the scarcity of plant-eaters would have left them more vulnerable to starvation and population collapse after the impact, with consequences that rippled all the way up the food chain. Stephen Brusatte said "The asteroid hit at a particularly bad time. If it had hit a few million years earlier or later, dinosaurs probably would have been much better equipped to survive." It is, however, good news for us – the demise of the dinosaurs meant that the mammals could diversify to fill all the ecological niches left by their extinction, ultimately leading to you reading this article now!

Early brain structure in Cambrian arthropods

Three exceptionally well-preserved fossils found in China have thrown new light on the brain structure of early arthropods and highlighted previously unexpected relationships with present-day arthropods. The fossils found in the Cambrian Heilinpu Formation, Yunnan Province, China, and published by Peiyun Cong of Yunnan Key Laboratory for Palaeobiology, Yunnan University, Kunming, China and colleagues, show the brain structure of a Cambrian anomalocarid, named *Lyrarapax unguispinus* (Fig. 11) (*Nature*, 2014, Vol. 513, No. 7519, 538–542). The anomalocarids were bizarre spade-shaped predators, which lived in the seas during the Cambrian period (541–485 million years ago), and had eyes that protruded on stalks and a pair of giant appendages on the sides of their mouths, unlike anything alive today (Fig. 12). What surprised the researchers was that the layout of the brain was an uncanny match to the wiring of the brain of the present-day velvet worm (onychophoran). The brain structures of arthropods come in three main types, two of which are already known to be very ancient, and the new fossils suggest that the third type (that found in velvet worms and their like) has also changed little over more than half a billion years of evolution, despite drastic changes to their body plans. The discoveries also suggest that the anomalocarid's frontal appendages are analogous to the mouthparts of present-day related arthropods.

Fig. 11. The Cambrian anomalocarid, Lyrarapax unguispinus*, from China with its neural structures highlighted in blue – they are surprisingly similar to those of the present-day velvet worm.*

Image: Peiyun Cong

Reference

CALLAWAY, E. 2014. Ancient fossils sport modern brains. *Nature News*, doi:10.1038/nature.2014.15565.

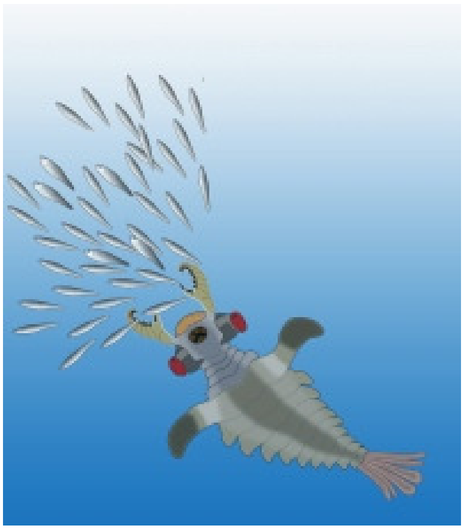


Fig. 12. Reconstruction of Lyrarapax *chasing prey.*

Image: Nicholas Strausfeld/University of Arizona

Large sauropod discovered in Argentina

The remains of a supermassive dinosaur have been recovered from Upper Cretaceous sediments in southern Patagonia, Argentina. The dinosaur, named *Dreadnoughtus schrani* (Fig. 13), has been described by Kenneth Lacovara, a vertebrate palaeontologist at Drexel University in Philadelphia, Pennsylvania, USA and colleagues (*Scientific Reports*, 2014, doi.org/10.1038/srep06196). The bones of two different sized individuals laid down in sediments on a floodplain between 66 and 84 million years ago are the most complete titanosaurs ever found with around 45% of the post-cranial bones being recovered, allowing scientists to accurately reconstruct 70% of the creature's neck, body and tail. Scientists believe it will help them better understand this species' close kin, which are known from a much smaller proportion of bones. It is estimated that the creature stretched about 26 metres from snout to tail (Fig. 14), and would have weighed about 59.3 metric tonnes when it died, although analyses of the larger specimen's fossils suggest that the creature was not yet fully mature and was still growing when it died.

Fig. 13. Reconstruction of the large sauropod, Dreadnoughtus schrani*, from Argentina.*
Image: Jennifer Hall, Carnegie Museum of Natural History

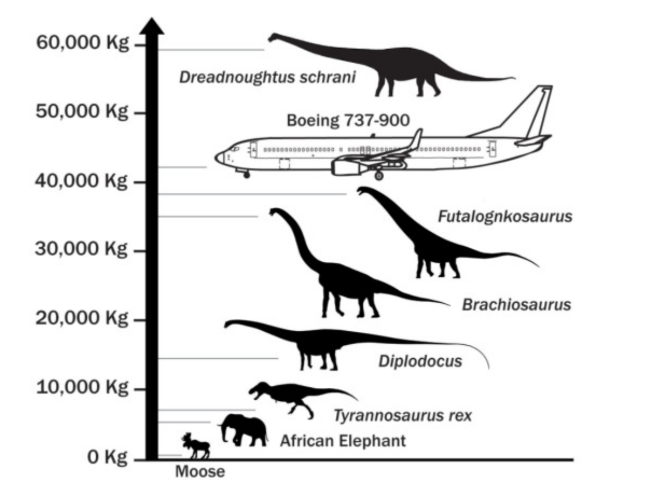


Fig. 14. Size and weight comparisons for Dreadnoughtus schrani.
Image: Lacovara et al. *2014*

Reference

LACOVARA, K. J., LAMANNA, M. C., IBIRICU, L. M., POOLE, J. C., SCHROETER, E. R., ULLMANN, P. V., VOEGELE, K. K., BOLES, Z. M., CARTER, A. M., FOWLER, E. K., EGERTON, V. M., MOYER, A. E., COUGHENOUR, C. L., SCHEIN, J. P., HARRIS, J. D., MARTÍNEZ, R. D. and NOVAS, F. E. 2014. A gigantic, exceptionally complete titanosaurian sauropod dinosaur from Southern Patagonia, Argentina. *Scientific Reports*, 9 pp., doi.org/10.1038/srep06196.

PERKINS, S. 2014. Earth-shaking dinosaur discovered. *Nature News*, doi:10.1038/nature.2014.15842.

When did placental mammals arise?

Scientists have long debated as to when the placental mammals first arose, before or after the demise of the dinosaurs. The placental mammals (animals that give birth to live offspring) include the whales, mice and humans. Early in 2013 Maureen O'Leary, an evolutionary biologist at Stony Brook University in New York, USA and her team published a paper claiming that the earliest placental mammals appeared only after the asteroid impact that killed the dinosaurs and marked the end of the Cretaceous period (O'Leary *et al*. 2013) (see 'Earliest ancestor of placental mammals', *HDGS Journal*, Dec 2013, Vol. 19, p.57). After this the placental mammals quickly diversified to fill the habitats left by the demise of the dinosaurs. Her team had analyzed thousands of traits in dozens of living and fossil mammals and then combined those with genetic data to build a giant tree of life, showing how different placental mammals related to one another. However, to establish when the different creatures evolved her team only looked at the fossil record, and as fossils of placentals are only found after the end of the Cretaceous period concluded that the earliest placental mammals appeared only after the asteroid impact that killed the dinosaurs (O'Leary *et al*. 2013). This finding was strongly disputed by Phil Donoghue, a palaeobiologist at the University of Bristol, UK, who along with evolutionary geneticists Mario dos Reis and Ziheng Yang of University College London, published a study claiming that O'Leary's team were wrong in assuming that lineages of species date back no further than their oldest fossils (dos Reis *et al*. 2014). These fossils should instead mark the minimum age for a lineage, as it is likely that animals existed before that, but were not preserved as fossils or their remains have yet to be discovered. Using genome data from dozens of mammals, Donoghue's team calculated new dates for the placental-mammal family tree, concluding that placental mammals first emerged between 108 million and 72 million years ago – well before the disappearance of the non-avian dinosaurs (dos Reis *et al*. 2014). It seems that this disagreement will only be resolved by the discovery of new fossils.

References

DOS REIS, M., DONOGHUE, P. C. J. and YANG ZIHENG. 2014. Neither phylogenomic nor palaeontological data support a Palaeogene origin of placental mammals. *Biology Letters*, **10** (1), 4 pp., doi.org/10.1098/rsbl.2013.1003.

O'LEARY, M. *et al*. (23 authors) 2013. The Placental Mammal Ancestor and the Post–K-Pg Radiation of Placentals. *Science*, vol. **339**, no. 6120, p. 662–667.

Dinosaurs neither warm-blooded nor cold-blooded

There has been much debate as to whether dinosaurs were 'cold-blooded' ectotherms, which use the environment to adjust their internal temperature, or 'warm-blooded' endotherms, which regulate their body temperature from within. A study conducted by John Grady, a biologist at the University of New Mexico in Albuquerque, USA and colleagues, found that dinosaurs were mesotherms, neither sluggish like lizards, nor high-energy like mammals, but something in between (Fig. 15) (*Science*, 2014, Vol. 344, No. 6189, 1268–1272). Grady and his colleagues compiled a database of growth rates in 381 animal species, ranging from slow-growing crocodiles to fast-growing horses, and including 21 dinosaurs. Dinosaurs ended up mid-way along the scale between ectotherms and endotherms, which meant they would have been able to move around the landscape more quickly than a crocodile, but would require less food than a similar-sized mammal. Grady, the lead author, said "The fact that dinosaurs were pretty much dominant for 130 million years speaks to the fact that they had some special things going for them."

Fig. 15. Most dinosaurs were neither warm-blooded nor cold-blooded, but somewhere between, giving them an ecological advantage.
Image: DEA Picture Library/Getty

Reference

WITZE, A. 2014. Dinosaurs neither warm-blooded nor cold-blooded. *Nature News*, doi:10.1038/nature.2014.15399.

The chicken in *T. rex*

A study published in the *Journal of Zoology* has suggested that *Tyrannosaurus rex* would have eaten like a chicken. Anatomical comparisons of the neck muscles of birds with fossil evidence suggest *T. rex*'s neck muscles would have been structured in a similar way, meaning it would have shared some of their movements. The authors, led by Eric Snively from the University of Wisconsin-La Crosse, Wisconsin, USA, studied the movements during feeding of birds ranging from chickens to owls and eagles (*Journal of Zoology*, 2014, Vol. 292, No. 4, p.290–303). The birds tended to raise their heads and fix their vision on the prey – mealworms, in the case of chickens – before lowering their heads to feed. In the case of prey birds, feeding often also involved securing the prey with a foot, grasping with the beak and thrusting the head upwards to pull the flesh away. David Hone, a lecturer at Queen Mary University of London, who edited the paper, said: "If you look at how an owl or a hawk eats, they put their foot on their prey and lever it up with their neck like a JCB digger." Although muscle tissue is not preserved in fossils, marks on the bones of *T. rex* show that ligaments in their neck were attached in similar locations to modern birds, suggesting that *T. rex* had most of the same muscles and would have performed the same feeding movements with ease. Scientists also believe that the *T. rex*'s powerful neck and jaw muscles may partly explain the dinosaur's feeble forelimbs, as a *T. rex* could not have fed itself by reaching up to its mouth with those tiny limbs.

Parasitic mite and ant in Baltic amber

A 0.7-millimetre-long mite has been found attached to its ant host in a piece of amber (Fig. 16). The amber from the Baltic region dates between 49 and 44 million years, and is only the second known example of a fossilized mite attached to its host. The pairing was published by Jason Dunlop, an arachnologist at the Leibniz Institute for Evolution and Biodiversity Science in Berlin and colleagues (*Biology Letters*, 2014, Vol. 10, No. 9, doi:10.1098/rsbl.2014.0531). Dunlop said "The amber mite looks very similar to modern mites, so we presume it had a similar mode of life and was parasitizing the ant rather than attacking it directly." The mite has been identified as belonging to the genus *Myrmozercon*, which includes numerous species still alive today, and it appears to be firmly attached to the ant's head – a behaviour also seen in modern parasitic mites of the genus *Varroa*, which have been suggested as possible culprits in the sudden collapse of honeybee colonies. Dunlop also said "People who work on this group think that the mites suck the body fluids of the ants from time to time . . . . The ant also carries the mite around, so that when baby mites hatch they can also crawl onto ants and be transported into the ant nest."

Fig. 16. Parasitic mite attached to an ant, both entombed in Baltic amber.
Image: Jason Dunlop/Museum für Naturkunde, Berlin

Reference

CASTELVECCHI, D. 2014. Mite and ant locked together in amber. *Nature News*, doi:10.1038/nature.2014.15886.

Giant penguin stood taller than a man

Scientists have unearthed fossils in Antarctica which reveal the continent was once home to the biggest species of penguin ever discovered. *Palaeeudyptes klekowskii*, nicknamed the 'colossus penguin', would have stood 2 m from beak tip to toes and roamed Antarctica around 40 million years ago. Carolina Acosta Hospitaleche and Marcelo Reguero, of the La Plata Museum in Argentina, excavated the bones from fossil deposits on Seymour Island (*Geobios*, 2014, Vol. 47, No. 3, p.77–85). It is the most complete penguin skeleton ever recovered from the Antarctic.

Row, row, row your boat . . . . .

A joint study led by Prof. Qiyue Zhang, Chengdu Center of China Geological Survey, and Michael Benton of the University of Bristol, has shown that nothosaurs (marine reptiles, similar to the later plesiosaurs), predators of Triassic seas 245 million years ago, propelled themselves through the water by rowing (*Nature Communications* 5, Article 3973, doi:10.1038/ncomms4973). Tracks found in Middle Triassic seabed sediments in Yunnan, southwestern China indicate that the creatures, which ranged in size from less than 1 m to 3 m, travelled over the seafloor by moving their limbs in unison. Prof. Qiyue Zhang said: "We interpret the tracks as foraging trails. The nothosaur was a predator, and this was a smart way to feed. As its paddles scooped out the soft mud, they probably disturbed fishes and shrimps, which it snapped up with needle sharp teeth."

Swimming *Spinosaurus* from Morocco

The world's first known swimming dinosaur has been found in Morocco. The dinosaur, named *Spinosaurus aegyptiacus* was published by Nizar Ibrahim from the University of Chicago in Illinois, USA and colleagues (*Science*, 2014, Vol. 345, No. 6204, p. 1613–1616). The 15-metre-long beast was from the 97-million-year-old Upper Cretaceous Kem Kem beds of eastern Morocco, and had a crocodile-like face, feet well suited to paddling and a sail-like structure rising from its spine. It also had unusually dense bones, possibly to help weigh it down as it hunted its underwater prey. Prior to the find, geochemists had used oxygen isotopes in fossil bones to conclude that spinosaurs and their relatives spent much of their time in the water just as crocodiles or hippopotamuses do today, but until now, not enough spinosaur bones were available to reconstruct the skeleton and test this idea. A partial skeleton was found in Egypt a century ago by the German palaeontologist Ernst Stromer, but his fossils were destroyed during an allied bombing raid on Munich in 1944. From the newly discovered material, along with Stromer's notes and photographs of his lost specimens and with related dinosaur fossils, the palaeontologists pieced together the most detailed *Spinosaurus* picture yet (Figs 17, 18).

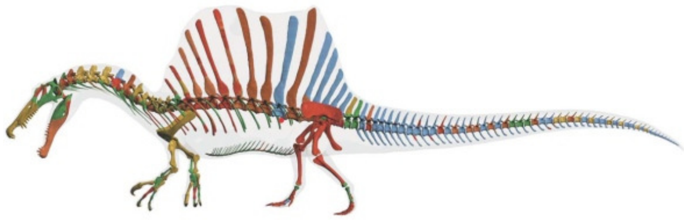


Fig. 17. Digital reconstruction of Spinosaurus aegyptiacus*, using bones from different sources (hence different colours), including Ernst Stromer's specimens in orange.*
Image: Model by Tyler Keillor, Lauren Conroy, and Erin Fitzgerald/Ibrahim et al. *2014*

Reference

IBRAHIM, N., SERENO, P. C., DAL SASSO, C., MAGANUCO, S., FABBRI, M., MARTILL, D. M., ZOUHRI, S., MYHRVOLD, N. and IURINO, D. A. 2014. Semiaquatic adaptations in a giant predatory dinosaur. *Science*, vol. 345 no. 6204, 1613–1616.

MUELLER, T. 2014. King Cretaceous (*Spinosaurus*). *National Geographic*, **226** (4), 100–121.

WITZE, A. 2014. Swimming dinosaur found in Morocco. *Nature News*, doi:10.1038/nature.2014.15901.

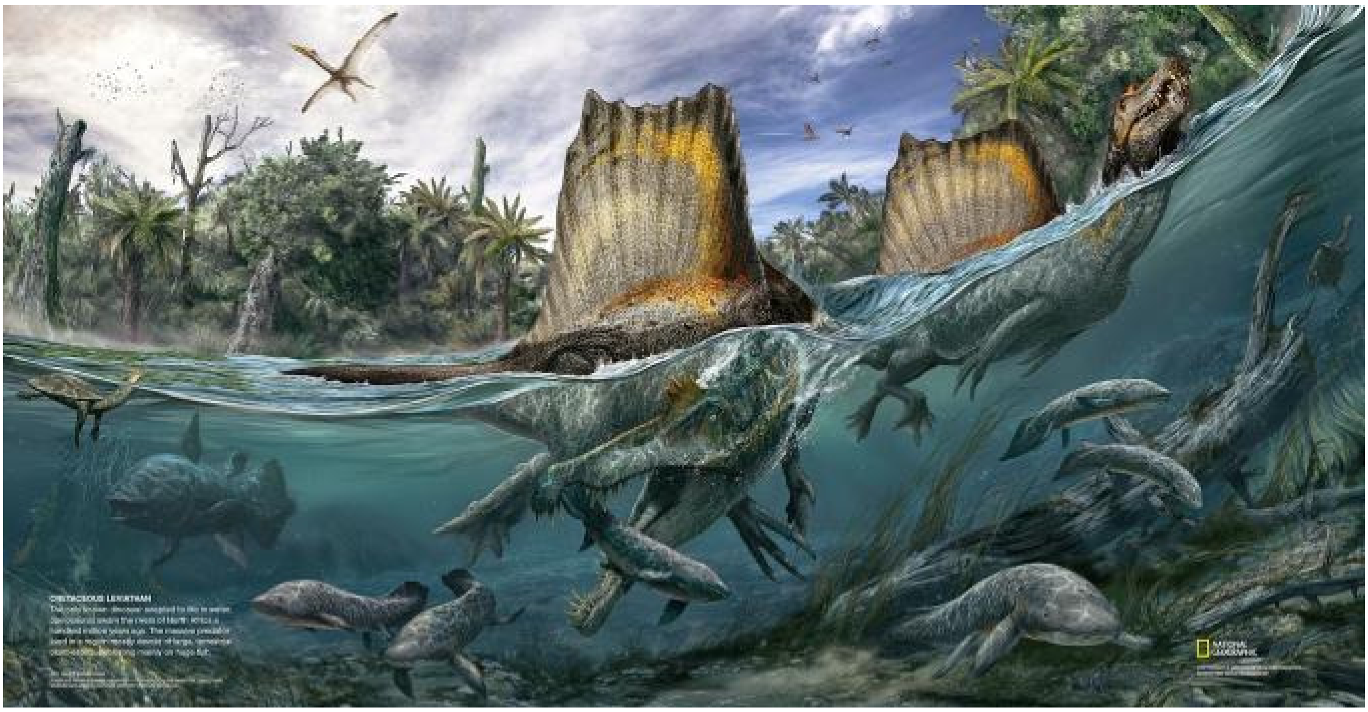


Fig. 18. Cretaceous Leviathan – The only known dinosaur adapted to life in water, Spinosaurus *swam the rivers of North Africa a hundred million years ago. The massive predator lived in a region mostly devoid of large, terrestrial plant-eaters, subsisting mainly on huge fish.*
Image – Art: Davide Bonadonna. Sources: Nizar Ibrahim, University of Chicago; Cristiano Dal Sasso and Simone Maganuco, Natural History Museum of Milan | ngm.nationalgeographic.com (Mueller 2014, p.108–110)
(Image from: novataxa.blogspot.com/2014/09/spinosaurus.html)

OBITUARY

Nancy Margaret Wagner

8th May 1907 - 6th January 2014

Nancy Margaret Wagner (formerly Brindley) was born on 8th May 1907 in Japonica Cottage, Spring Lane, Burghclere, Hants. Her father was Charles Brindley, who worked at Highclere Castle, and her mother was Margaret Harriet Brindley (formerly Hart). Her grandfather, Thomas Hart, was a tenant at Ashold Farm in Spring Lane. So, until she left Burghclere, she had fresh milk, cream, butter and soft cheese from the farm daily.

Nancy Wagner with her card from the Queen on her 106th birthday, 8th May 2013.

She attended Burghclere School until the age of 14. She helped at her grandfather's dairy farm, and always got up early to collect the cows for milking. Her other early morning chore was to get water from the spring, as there was no piped water at that time in Burghclere. She sang in the church choirs at both Burghclere and Old Burghclere church every Sunday, and also attended Chapel as her grandmother was a strict Methodist. She loved to collect and press wild flowers. She also used to find "strange shells" in the local chalk pits. No-one in her family or at school knew that these were fossils. After leaving school she worked initially at Highclere Castle, and then at the Watercress beds, and also helped to tend the horses at various local stables.

At age 16 she obtained a job at a bakers shop in Newbury, where she was responsible for working out the bills for the baker's roundsmen to collect the customers' money on Saturdays. Unfortunately, her collection of shells was lost after she left Burghclere. Eventually she came to live in London, with her sister Gladys. She obtained a job in Harrods, in the accounts department. At Harrods she met Chriss Wagner, who was on the maintenance staff. They married in 1934 at Burghclere Church and then went back to live in Fulham. They were bombed out of their home during the Second World War. When the 'V1' and 'V2' rockets were landing on London, Nancy and baby Christine came to live in Burghclere until the end of the war. From then until 1970 Nancy and Chriss had a happy marriage, gradually improving their home and working on their allotment. In 1970 Chriss had a stroke and died in 1972. Nancy then moved home in 1973 to Merton Park, where she had a bigger garden and grew lots of vegetables.

When she developed heart problems in the late 1970s she could no longer fly to holidays abroad. Instead, she stayed at her daughter's home in Lydd, Kent. There she joined various groups concerned with natural history, geology, local history, footpaths, the local museum, the lifeboat and the scouts. She loved the countryside and wanted to be out and about on the Romney Marsh every weekend. To celebrate her 100th birthday, all the family gathered at the Parish Room in Burghclere. She had a fall at home in Merton Park when she was 103, and broke her hip. After that she needed help from carers, as she was unable to walk unaided. She moved to Lydd permanently in 2011 as better care was available there and she could see the countryside she loved. She died, aged 106 years and 8 months, in January 2014.

OBITUARY

Martin Bluhm

3rd July 1933 - 25th September 2014

Martin was born in Chorleywood, Hertfordshire, and attended a co-educational prep school in Buckinghamshire, followed by Dauntsey's School in Wiltshire. He trained as a teacher and taught arts and crafts (pottery), then worked at the Chiltern Open-Air Museum and Shortenhills Environment Education Centre for a number of years. He moved to Bexhill about twenty years ago.

Martin was a remarkable man. He was interested in so many different subjects and pursued all his hobbies with great enthusiasm, fully realising that life had much to offer him, particularly since his retirement 16 years ago. Among the various societies he joined was the Hastings and District Geological Society in January 2012. Martin attended meetings regularly and he was always very keen to learn about and discuss different aspects of geology.

He was well known in the family for his idiosyncrasies and his tendency to expect everything to follow a certain protocol and order which should never be tampered with. This inevitably led to a lot of anecdotes that were associated with him in an affectionate way.

Born in the 1930s, he forever remained a person of that era in his taste in cars, houses, theatre, literature, art and even the recipes he cooked! He had a passion for Art Deco which was well fed by living so close to the De La Warr Pavilion. Visiting him at his home was almost like going back in time.

This inspired his family to take him to The Burgh Island Hotel in Devon for his 80th birthday last year. This was a real treat for him as the hotel is decorated in the 1930s style where you almost expect to find Noel Coward or Agatha Christie at the cocktail bar.

Martin loved his old 1927 Austin, which everyone called "Uncle", and made many journeys abroad in this, the last of which was to France in May 2014.

He also loved playing the piano, which he inherited from his mother. She was an accomplished pianist who studied at the Royal Academy of Music, and he was largely self-taught and very talented.

Martin had many friends, some of whom he had known since prep school. He made regular trips to London, staying at his club, The Oriental Club in Stafford Place, which perfectly suited his life as a gentleman. He enjoyed meeting his family and friends there for lunch, often followed by cocktail evenings and trips to the theatre or a concert. He also arranged summer parties at his house where the entertainment included croquet on the lawn and refreshments, such as his large bowls of punch!

Martin kept his active mind and continued with his interests to the very end, and this was a comfort to both himself and his family.

He was the last member of his generation on the English branch of the Bluhm family and he will be sadly missed by his family and friends.

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HASTINGS & DISTRICT GEOLOGICAL SOCIETY

Minutes of the A.G.M. - 8th December 2013

The meeting was declared open by the Chairman, Ken Brooks at 2.46 p.m. There were thirty-five members present.

Ken went on to say that this year was the 21st anniversary of the Society and that apart from himself, there were two of the original members present, John Boryer and Eve Weston-Lewis.

1) **Apologies:** Were received from:
Pat Dowling, Pat Littleboy, Pauline Mackay-Danton, John Shirlaw, Diana Simpson, Maureen Sullivan, Christine Wagner, Nancy Wagner and Barbara Young.

2) **Minutes of the last A.G.M.:** These had been printed in the *H.D.G.S. Journal* and handed out to members. Their acceptance was proposed by Douglas Macmillan, seconded by Tony Standen, and unanimously approved.

3) **Chairman's report:** Ken welcomed two new members to the A.G.M., Valerie Threadgill and Siân Evans, and also a guest, Charlie Reeves. He said that the overall attendance to meetings during the year had been up again on the previous year's excellent figures, and that the average turn out had been between 35 and 38 members.

a) 2013 Programme: Ken summarised the year's activities:

Lectures by visiting speakers:

'Devonian Fishes' by *Dr.* Peter Forey

'In the Shadow of the Dinosaurs' by *Dr.* Steve Sweetman

'The Stones of Stonehenge' by Geoff Downer

'Why Are There No Ammonites in Hastings?' by Ken Brooks

'Richard Owen & Fossil Vertebrates' by *Dr.* Chris Duffin

Ken mentioned that Chris Duffin's talk had originally been scheduled for January, but that as Chris had been unable to get to Hastings from London, because of the snow, the talk had been postponed until October. He said that *Prof.* David Price had also been unable to come this year because of food poisoning, and that his talk "*High Pressure Mineral Physics and the Structure of the Earth*" would now have to be postponed until next year.

Field Trips:

***University College London*:** Hosted by *Prof.* David Price

***Beachy Head*:** Leader Ken Brooks

***Pett/Fairlight*:** Leaders Ken Brooks, Peter Austen & *Prof.* Ed Jarzembowski

Ken said that all three trips had been extremely successful. The tour of the Earth and Planetary Sciences Department of UCL (always fascinating) had been led this year by *Prof.* David Price, *Dr.* Marcelle BouDagher-Fadel and one of the students, Amy Edgington. He mentioned that Jim Simpson had written up an article on the visit for the current *H.D.G.S. Journal*. The weather for the Beachy Head field trip had been wet at first, but then turned to sunshine for most of the day. The Pett/Fairlight trip had been combined with members of the Geologists' Association and had been so successful that a second trip had been planned for 2014.

Barbecue:

Ken said that Trevor and Fiona Devon had, once again, hosted a very enjoyable barbecue in August, and that this year £44 profit had been made from the raffle.

b) Fund raising: Raffles and the sale of books and magazines had boosted the H.D.G.S. funds enormously during the year.

c) *H.D.G.S. Journal*: Ken said that, once again, Peter & Joyce Austen had produced another magnificent *Journal*, and thanked them both for all the hours they'd put into producing it. He also thanked all the members who had contributed with articles.

d) Other thanks: Ken thanked everyone who had helped in various ways during the year to keep the meetings running smoothly, i.e. setting up and putting away tables and chairs, making tea and coffee and doing the washing up, etc.

4) Treasurer's report for the year ending 31st December 2013:

Statements of income and expenditure had been given out to members. Norman went through each item and ended by saying that the increase in balances during the year had been £170.01. Acceptance of the statement was proposed by Trevor Devon, seconded by Dale Smith, and unanimously accepted.

5) Election of the Committee:

As all members were willing to remain in office, it was proposed that the re-election of the Committee should be *en bloc*. This was proposed by Diana Nichols and seconded by Geoff Bennett. All were in favour. Ken said that as there was now a vacancy for the post of librarian (Gordon Elder having resigned from the Committee), Douglas Macmillan had said that he would be willing to take this on. He was proposed by Chris Woodcock, seconded by Tony Standen, and all were in favour.

Therefore the Committee was said to be as follows:

2013	**2014**
Chairman	
Ken Brooks	Ken Brooks
Treasurer	
Norman Farmer	Norman Farmer
Secretary	
Diana Brooks	Diana Brooks
Assistant Secretary	
John Boryer	John Boryer
Journal editors	
Peter & Joyce Austen	Peter & Joyce Austen
Librarian	
None	Douglas Macmillan
Website manager	
Trevor Devon	Trevor Devon
Other Officers	
Colin Parsons	Colin Parsons
Pat Dowling	Pat Dowling

6) **2014 Programme:** Copies were handed out to all members present. Those unable to attend would be receiving their copies with the next letter to members. Ken thanked Diana for her work in preparing the Programme and listed the talks for the coming year:

• ***'Fossil Folklore'*** by Ken Brooks
• ***'Sir Arthur Woodward & the NHM Fossil Fish Collection'*** by Mike Smith
• ***'Diamonds'*** by *Dr*. Chris Duffin
• ***'Micro Minerals'*** by *Dr*. Trevor Devon
• ***'Dinosaurs of Bexhill'*** by Julian Porter
• ***'Flint'*** by Diana Smith
• **Presidential Lecture** by *Prof.* David Price

Ken gave a brief résumé of each lecture and said that there was one more talk to be arranged for May.

He said that two field trips had been arranged. The first would be a behind-the-scenes visit to the Natural History Museum in London, organised by *Dr*. Martin Munt (Collections Manager of the Invertebrates and Plants Division), looking at the collections not available to the public. After this there would be a chance for members to have any specimens that they had brought with them, identified. The second would be another joint trip with the Geologists' Association to Fairlight, but this time approaching the beach area from the western end, going down through Fairlight Glen.

He also said that as the New Year's Day walk would coincide with a low tide, there would be a walk along the beach after lunch at The Smuggler Inn (which was now under new management). He asked that members let him know if they wanted to attend as he would have to confirm numbers with the pub.

7) **Any Other Business**

• Trevor Devon said that he had been over to Eastbourne to collect about a hundred books which had been donated to the Society by Patricia Taylor. They had belonged to her sister and were mainly to do with geology and vulcanology. When her sister died, she wanted them to go somewhere where they would be put to good use rather than sit in a charity shop, so she contacted the H.D.G.S. Ken said that some of the books were being put into the library, and the rest would be for sale to members.

• Ivan Constable asked whether next year's Smokejacks' dates had been arranged, and Peter Austen said that the trips would be in April and September, but that the actual days weren't finalised as yet.

• Ken thanked those who had brought items along for display: Peter & Joyce Austen for their Writhlington collection, Trevor Devon for a collection of small minerals, Siân Evans for possible rhino bones from Norfolk, and Dale Smith for some interesting local fossils. At this point, Trevor gave a few details about his mineral collection, which he had recently shown to the Bromley & Beckenham Philatelic Society. He said that there were over two hundred minerals in this collection and that he had displayed them alphabetically.

• Ken then thanked everyone who had brought food and drink for the party, and the Committee and members for their help at meetings. He also thanked Diana, Joyce and others for the teas, and Peter and Joyce again for their work on the Journal.

• Ken invited members who had not paid their subscriptions to rectify this!

• Finally, John Boryer proposed a vote of thanks to committee members "on the top table" for all their work during the year.

The meeting was declared closed at 3.23 p.m.

HASTINGS & DISTRICT GEOLOGICAL SOCIETY

Statement of Income & Expenditure for the Year Ending 31st December 2013

INCOME	£
Subscriptions	
Single: 45 @ £15.00	675.00
1 @ £7.50 (part year)	7.50
Family: 20 @ £20.00	400.00
	1,082.50
UCL visit receipts	270.00
Donations	50.00
Raffle receipts	91.00
Barbecue receipts	170.00
Sale of books and magazines	19.16
	1,682.66
	1,682.66

EXPENDITURE	£
G.A. Affiliation fees	33.00
Hire of hall	126.00
Society *Journal* production	249.68
Insurance premium	152.00
Stationery, copying, postage	151.42
UCL visit expenses	296.00
Lecture fees and expenses	256.36
Purchase of raffle prizes	43.41
Barbecue expenses	154.78
Refreshments	50.00
	1,512.65
Surplus being excess of income over expenditure	170.01
	1,682.66

Bank Account and Monies in Hand

Balances as at 31st December 2012	£
NatWest Bank	730.35
Monies in hand	17.12
	747.47
Increase in Balances 2013	170.01
	917.48

Balances as at 31st December 2013	£
NatWest Bank	874.89
Monies in hand	42.59
	917.48
	917.48

December 2013