Hastings & District Geological Society Journal

Hastings and District Geological Society
affiliated to the Geologists' Association

President
Professor G. David Price, UCL

Founded 1992

Fairlight Cove as seen from the Fairlight Landslip - June 2008

Volume 19 December 2013

Cover picture: Fairlight Cove as seen from the Fairlight Landslip - June 2008 - photo: Ken Brooks

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2013 Officials and Committee

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Hastings & District Geological Society Website - http://hastingsgeology.btck.co.uk/

Geologists' Association Website - http://www.geologistsassociation.org.uk/

Contributions for next year's Journal would be appreciated and should be submitted by the October 2014 meeting.
Please contact Peter Austen on: tel: 01323 899237 or e-mail: p.austen26@btinternet.com

This Journal is issued free to members of the Hastings & District Geological Society (HDGS) and is also freely available on the HDGS website.

HASTINGS & DISTRICT GEOLOGICAL SOCIETY

Minutes of the A.G.M. - 9th December 2012

The meeting was declared open by the Chairman, Ken Brooks at 2.35 p.m. There were twenty-eight members present.
Ken went on to say that this year was the 20th anniversary of the Society and that apart from himself, there were three of the original members present, Gordon Elder, Eve Weston-Lewis and John Boryer.

1) **Apologies:** Were received from:
Stuart Barnes, Ivan Constable, Trevor Devon, Chris Edwards, Norman Farmer, Val Grist, Terry Liddiard, Pat Littleboy, Pauline Mackay-Danton, Annette Maloney, Terry Martin and Nancy Wagner.

2) **Minutes of the last A.G.M.:** These were printed in the *H.D.G.S. Journal* which had been handed out to members. Tony Standen proposed their acceptance, seconded by Geoff Bennett and unanimously approved.

3) **Chairman's report:** Ken said that the overall attendance to meetings during the year was very pleasing. The average attendance had been 32 out of an actual 60 members. The highest number had been 40 for the talk by Paul Barrett about Wealden dinosaurs.

a) 2012 Programme: Ken summarised the year's activities:

Lectures by visiting speakers:

'William Buckland: First Professor of Geology' by *Dr.* Chris Duffin
'New Fossils from a Classic Era' by Tess Ormrod
'Thirty Years of Mineral Collecting' by John Pearce
'Wealden Dinosaurs' by *Dr.* Paul Barrett

Members' Day talks and barbecue:

'Basic Geology 1' by Ken Brooks
'Basic Geology 2: Sedimentary Rocks' by Ken Brooks
Barbecue with Trevor and Fiona Devon

Field Trips:

***Smokejacks*:** Leaders Peter & Joyce Austen
***Pett/Fairlight*:** Leaders Ken Brooks & Peter Austen
***Cooden*:** Leaders Peter & Joyce Austen

Ken also mentioned that Trevor and Fiona Devon had hosted a very enjoyable barbecue in August, where £43 was raised from a raffle organised by Norman Farmer.

b) Ken welcomed Don Yule who would be inviting members to take part in a Christmas Quiz after the meeting. He went on to congratulate Peter and Joyce on the research, compilation and editing of the H.D.G.S. Journal and he also thanked the members who had contributed articles to the Journal.

4) **Treasurer's report for the year ending 31st December 2012:**

Norman had been unable to attend and had asked Ken to relay his statement to the meeting:
"There has been a reduction in expenditure this year, mainly because of a fewer number of speakers and a reduction in the hire of the hall from nine to seven times, which together with

income from sales, raffles, donations and income from leading an external field trip at Pett, has increased the balance by £248.97 to £747.47."

Ken asked members to refer to the Statement of Income and Expenditure sheets, typed up by Diana. Acceptance was proposed by Diana Nichols and seconded by Dale Smith.

5) Election of the Committee:

It was proposed that the Committee should be re-elected *en bloc*. However, Gordon said that he did not wish to stand again and would therefore be offering his resignation. Ken said that Gordon had been a tremendous asset to the Society and that his input had started in 1993, with a wealth of enthusiasm and knowledge, not to mention responsibility for the first ten Society Journals. Ken thanked him very much and said that he would always be welcome. Gordon said that he would like to continue to be a member.

The re-election of the Committee *en bloc* was proposed by John Fowler and seconded by Gordon Elder. All were in favour. It was also proposed that an assistant secretary was needed to help Diana. John Boryer was proposed by Tony Standen and seconded by Sue Hadfield. All were in favour.

Therefore the Committee was said to be as follows:

2012	**2013**
Chairman	
Ken Brooks	Ken Brooks
Treasurer	
Norman Farmer	Norman Farmer
Secretary	
Diana Brooks	Diana Brooks
Assistant Secretary	
	John Boryer
Journal editors	
Peter & Joyce Austen	Peter & Joyce Austen
Librarian & Education Officer	
Gordon Elder	T.B.A.
Website manager	
Trevor Devon	Trevor Devon
Other Officers	
1. Colin Parsons	Colin Parsons
2. Pat Dowling	Pat Dowling
3. John Boryer	

6) 2013 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 gave a brief résumé of the coming year:

- ***'Richard Owen & Fossil Vertebrates'*** by *Dr.* Chris Duffin
- ***'Devonian Fishes'*** by *Dr.* Peter Forey
- ***'In the Shadow of the Dinosaurs'*** by *Dr.* Steve Sweetman
- ***'The Stones of Stonehenge'*** by Geoff Downer
- **Members' Day: '*Basic Geology 3*'** by Ken Brooks

• ***'Aspects of Sussex Geology'*** by John Cooper
• **Presidential Lecture** by *Prof.* David Price

Ken said that two trips had already been organised – the visit to UCL with *Prof.* David Price, and the combined field trip with the Geologists' Association to Fairlight – and that the remaining two field trips were still to be arranged.

He also said that as the New Year's Day walk would coincide with a high tide, it would start from the Country Park. He said that he had made provisional reservations at the Coastguards Tea Room for those wishing to have lunch first, and asked that members let him know if they wanted to attend as he would have to confirm numbers.

7) Any Other Business

• Peter Austen said that access to the Ashdown Brickworks at Turkey Road was now possible, but that for health and safety purposes, visits would have to be organised through the H.D.G.S., who have appropriate insurance cover. Dave Brockhurst (an employee of Ashdown Brickworks) would have to be present on all trips. About eight visits per annum would be possible with a maximum of 12 people per trip. Any scientifically important finds would have to be offered to Bexhill Museum. Peter said that several important research papers were currently in progress.

• Peter went on to say that the Oxford Geological Group had offered to arrange a field trip to the Jurassic site at Blockley Quarry, Gloucestershire, which could be combined with a visit to Oxford Museum of Natural History, possibly involving an overnight stay.

• Peter said that he would appreciate notification of the source of any bone bed finds in the Hastings area.

• Ken thanked 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.

• Finally, John Fowler proposed a vote of thanks to Ken for another successful year.

Ken declared the Meeting closed at 3.15 p.m.

HDGS Barbecue

Sunday, 11th August 2013

Once again HDGS members gathered in Trevor and Fiona Devon's garden for the annual Barbecue on a fine, sunny afternoon.

We were delighted that three of our Society's founder members were there to enjoy the festivities - left to right, Gordon Elder, Eve Weston-Lewis and Chairman Ken Brooks.

Thank you again to Trevor and Fiona for their hospitality.

HASTINGS & DISTRICT GEOLOGICAL SOCIETY

Statement of Income & Expenditure for the Year Ending 31st December 2012

INCOME	£	EXPENDITURE	£
Subscriptions		**G.A. Affiliation fees**	33.00
Single 41 @ £15.00	615.00	**Hire of hall**	112.00
1 @ £5.00 (part year)	5.00	**Society *Journal* production**	196.10
Family 14 @ £20.00	280.00	**Insurance premium**	152.00
	900.00	**Stationery, copying, postage**	55.45
		Lecture fees and expenses	119.98
		Purchase of raffle prizes	38.94
Field Trip receipts	8.00	**Barbecue expenses**	131.71
Raffle receipts	89.00	**Refreshments**	40.00
Barbecue receipts	140.00	**Donations**	20.00
Sale of books and magazines	31.15	**Purchase of books & magazines**	20.00
	1,168.15		919.18
		Surplus being excess of income over expenditure	248.97
	1,168.15		1,168.15

Bank Account and Monies in Hand

Balances as at 31st December 2011	£	Balances as at 31st December 2012	£
NatWest Bank	452.89	NatWest Bank	730.35
Monies in hand	45.61	Monies in hand	17.12
	498.50		747.47
Increase in Balances 2012	248.97		
	747.47		747.47

December 2012

Wealden ornithischian (‘bird-hipped’) dinosaurs

by Peter Austen

Based on a talk given to the Hastings & District Geological Society on 18th November 2012 by Dr Paul Barrett, Head of Vertebrates, Anthropology and Micropalaeontology, Natural History Museum, London

The following article is based on Dr Paul Barrett’s talk in which he gave an overview of English Wealden dinosaurs and current research. Dr Barrett covered all the Wealden dinosaurs, the ornithischian (‘bird-hipped’) dinosaurs and the saurischian (‘lizard-hipped’) dinosaurs, but this article only deals with the most abundant group, the ornithischians. It also includes some additional notes from the recently published Palaeontological Association field guide English Wealden fossils *(Batten 2011*a*), and from other sources (referenced), including a 19th century unpublished manuscript recently donated to Maidstone Museum.*

*Author references for all genera and species included in the text, but not discussed in detail, can be found in Norman (2011*a*) for ornithopod dinosaurs, and Barrett and Maidment (2011) for armoured dinosaurs.*

Introduction

Wealden dinosaurs were first recognized around 200 years ago, with one of the earliest workers being Dr Gideon Algernon Mantell (1790–1852), an obstetrician, geologist and palaeontologist from Lewes, East Sussex. In 1825, in the *Philosophical Transactions of the Royal Society*, Mantell described “*the teeth and bones of a fossil herbivorous reptile*” (Mantell 1825, p. 179) which he named *Iguanodon*. This name was chosen because the fossil teeth were similar in “*form and structure*” to those of the present day *Iguana* (Mantell 1825, p. 182). This was the second dinosaur ever to be described (the first being *Megalosaurus* in 1824 by Canon William Buckland) and was based on teeth and bones found in sandstones in the vicinity of Tilgate Forest, West Sussex (Fig. 1). The first teeth were found by Mantell’s wife, Mary Ann. In *Illustrations of the Geology of Sussex* Mantell wrote “. . . *The first specimens of the teeth* [Iguanodon] *were found by Mrs. Mantell, in the coarse conglomerate of the forest* [Tilgate]*, in the Spring of 1822; . . .*” (Mantell 1827, p.71). Some internet sites dispute this and suggest that the teeth were found by Gideon Mantell himself, but solid evidence to support this proposition appears to be very hard to come by. The remains were actually from the Cuckfield Stone Member, a sandstone within the Grinstead Clay Formation, which lay between the Lower and Upper Tunbridge Wells Sand formations. Mantell realized that these unusual animals were gigantic reptiles, but with only teeth and limb-bones to go on, he could only speculate on the form these animals took. In truth, a lot of the early dinosaurs were named on very fragmentary material, and it was to be a number of years before more complete specimens were known, and more accurate reconstructions could be produced.

Fig. 1. Drawings of the first Iguanodon *teeth to be described. The* Iguanodon *teeth at the top are compared with present-day* Iguana *teeth below. (from Mantell 1825, plate XIV)*

The Weald

Although Wealden deposits can be found in other localities in northern Europe (i.e. France, Belgium, Netherlands, northern Germany), this article deals with dinosaurs found in the classic Wealden areas of the UK (Fig. 2). Wealden deposits are essentially terrestrial, comprising rivers, lakes and lagoons, and in the UK they are bounded below by the lagoonal Purbeck (Limestone) Group (below which is the marine Portlandian), and above by the marine Lower Greensand Group. So in the Wealden we are looking at terrestrial, rather than marine, life, and terrestrial deposits of this age are relatively rare in the world, particularly those of the lower Weald (Hastings Group), making our own Hastings and Bexhill coastline of international importance.

The most productive areas for Wealden dinosaurs are the south-west coast of the Isle of Wight, and the Hastings and Bexhill coastlines. There are also clay pits in both the upper and lower Weald (Weald Clay Group and Hastings Group respectively), but dinosaur remains are not as abundant in these as on the coast. There are also limited Wealden deposits in Dorset around Lulworth Cove, but very little dinosaur material has been recovered from these.

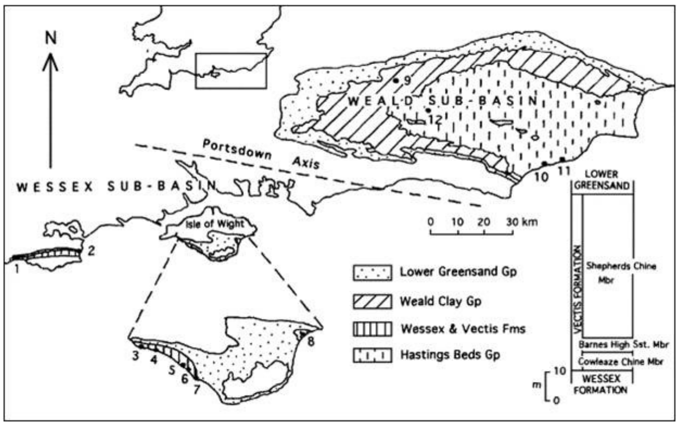


Fig. 2. Map of south-east England, Isle of Wight and Dorset showing Wealden and Lower Greensand exposures.

The Wealden deposits in south-east England (Hastings Group and Weald Clay Group) were separated from the Wealden deposits of the Isle of Wight (Wessex and Vectis formations) by an elevated region known as the Portsdown High (Fig. 2). Both areas had large river systems, lakes, mudplains and lagoons.

To the east of the Portsdown High is the Weald Sub-basin (Fig. 2), comprising the Hastings Group and the Weald Clay Group. The Hastings Group is the older formation (Valanginian; 133–140 million years). It consists of the Ashdown Formation (including the Fairlight Clays facies) at the base, and, in chronological order, is overlain by the Wadhurst Clay Formation, Lower Tunbridge Wells Sand Formation, Grinstead Clay Formation, and the Upper Tunbridge Wells Sand Formation (Fig. 3). The most productive deposits for material collected in the 19th century were the Tunbridge Wells Sand Formation, in particular the Grinstead Clay Formation (which includes the Cuckfield Stone Member). With the closure of many of the old quarries, and more efficient mechanical extraction techniques in those that remain, the most productive deposits are now to be found along the Hastings coastline. The younger Weald Clay Group is divided into the Lower Weald Clay Formation (Hauterivian; 129–133 million years), and the Upper Weald Clay Formation (Barremian; 125–129 million years) (Fig. 3). The Lower Weald Clay Formation is rather barren of dinosaur remains, although some have recently been reported from Langhurstwood Quarry in West Sussex (Styles 2000). A greater number have been found in the Upper Weald Clay Formation.

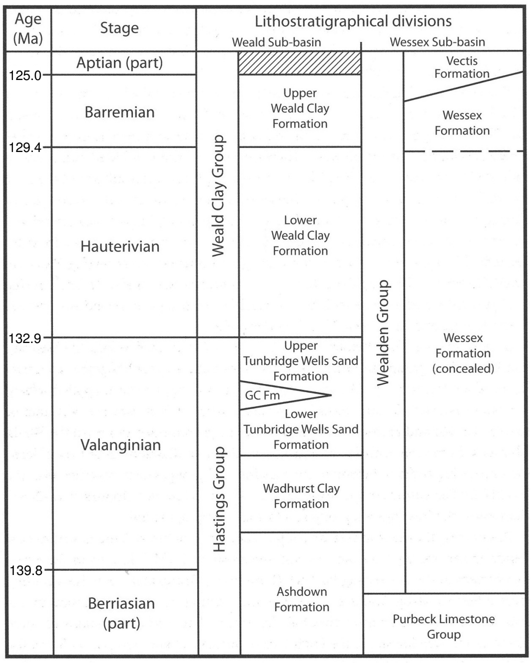


Fig. 3. Stratigraphy of the Weald and Wessex Sub-basins. Only the top part of the Wessex Formation is exposed on the Isle of Wight (Barremian).
(adapted from Batten 2011b, p. 8, text-fig. 2.1)

To the west of the Portsdown High, on the Isle of Wight, is the Wessex Sub-basin (Fig. 2), comprising the Wessex and Vectis formations, equivalent in age to the Upper Weald Clay Formation on the UK mainland (Fig. 3). The Wessex Formation on the Isle of Wight has a rich dinosaur fauna. The Wealden deposits in Dorset are dominated by the alluvial Wessex Formation.

Early workers in the Weald

The earliest workers on Wealden dinosaurs were the Reverend Dr William Buckland (1784–1856) (Fig. 4A), a theologian, geologist and palaeontologist who became Dean of Westminster; Dr Gideon Algernon Mantell (1790–1852) (Fig. 4B), discussed above; and Sir Richard Owen (1804–1892)

(Fig. 4C), superintendent of the natural history department of the British Museum, and driving force behind the establishment, in 1881, of the British Museum (Natural History) in London, now the Natural History Museum. Richard Owen first coined the term *Dinosauria* meaning "terrible lizard" in 1841 in his address to the *British Association for the Advancement of Science* at Plymouth (Owen 1842), and produced much of the work on dinosaurs in the 19th century, including an excellent series of monographs for the *Palaeontographical Society* on Wealden reptiles (Owen 1853–79) which can still be usefully referenced even today. Later workers on Wealden dinosaurs were the Reverend William D. Fox (1813–1881), a clergyman and palaeontologist who worked on the Isle of Wight, and John Whitaker Hulke (1830–1895), a surgeon and geologist, who was a long-time fossil collector from the Wealden cliffs of the Isle of Wight.

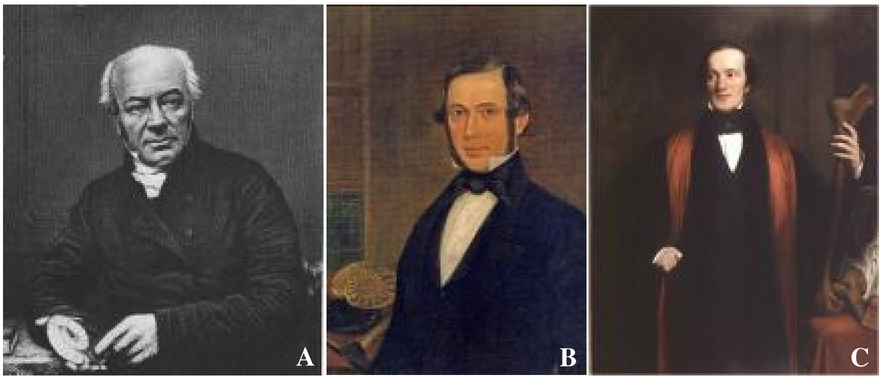


Fig. 4. A, Reverend Dr William Buckland (1784–1856). B, Dr Gideon Algernon Mantell (1790–1852). C, Sir Richard Owen (1804–1892).

Early reconstructions

We now know that the early reconstructions of *Iguanodon* were not correct, but on the basis of the material that was available to workers at the time – a few teeth, the odd hipbone and limb bone – the reconstructions were very reasonable. Figure 5A shows a reconstruction of *Iguanodon* from Mantell's manuscripts, which was not intended for publication. A similar reconstruction (Fig. 5B) has recently come to light in an unpublished journal kept by Mr W. H. Bensted (see section on *Iguanodon* below), the owner of the '*Iguanodon*' Quarry where the Maidstone *Iguanodon* (known as the 'Mantell-piece') was discovered, and it perhaps begs the question as to who penned the reconstruction first, Gideon Mantell or Mr Bensted?

Following the success of The Great Exhibition in Hyde Park in 1851, the building that housed the exhibition (nicknamed 'The Crystal Palace'), was dismantled, moved and re-erected in a park in Sydenham, South London. The grounds of the park, which became known as Crystal Palace, were extensively renovated, and Benjamin Waterhouse Hawkins was commissioned to produce a number of life-size concrete models of dinosaurs for permanent display in the grounds (Fig. 6). The models, which were unveiled in 1854, were constructed with advice from Sir Richard Owen, and can still be seen in the park today. Figure 6 shows two *Iguanodon* (left), and on the right

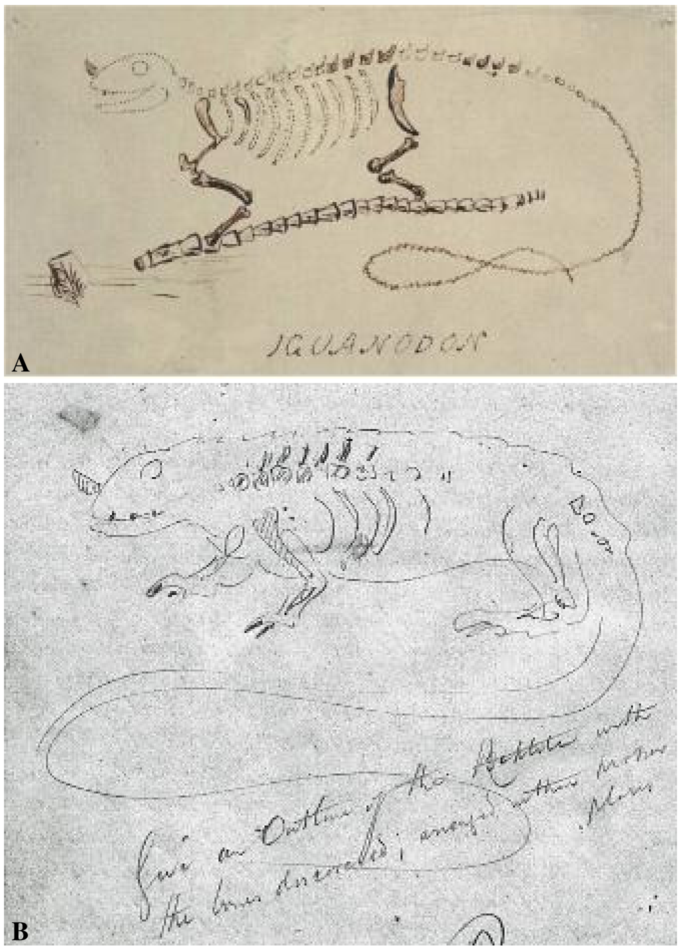


Fig. 5. A, Mantell's pencil sketch of Iguanodon.
B, Bensted's pencil sketch of Iguanodon. *Which came first?*

The pencilled note across Bensted's drawing (B) says: "Give an Outline of the Reptile with the bones discovered; arranged within proper places". Could this be an instruction from a potential publisher of the manuscript? (Anon. 2002)

Hylaeosaurus, which after *Megalosaurus* and *Iguanodon* was the third dinosaur to be named (Mantell 1833). Much discussion took place about these strange new creatures in the *Illustrated London News*, in fact there was a great deal of interest in dinosaurs throughout the latter half of the 19th century. This interest waned during the 20th century, but took off again in the 1970s, the publics' imagination being further fired in the 1990s with the release of the series of *Jurassic Park* films.

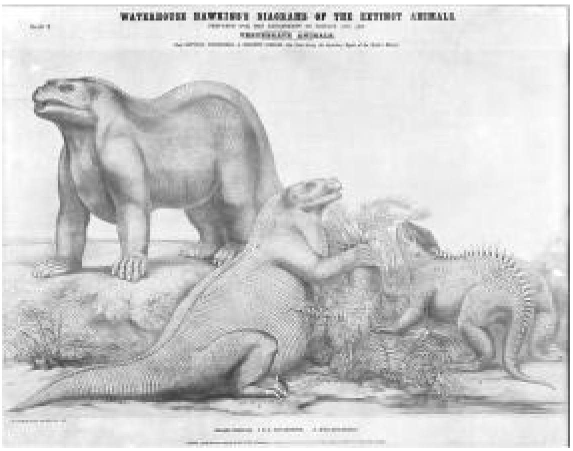


Fig. 6. Reconstruction of Iguanodon *(two at left) and* Hylaeosaurus *(right) by Benjamin Waterhouse Hawkins.*

Ornithopod dinosaurs (mostly bipedal ornithischian ('bird-hipped') dinosaurs)

Iguanodon

Today we have only one species of *Iguanodon* in the Weald, *Iguanodon bernissartensis*, but until fairly recently there were around 10 species recognized in the scientific literature, mostly from southern England. There has been much work recently reassessing and reclassifying *Iguanodon* material housed in museums (Paul 2007, 2008; Norman 2010, 2011*a*, 2011*b*, 2012; Carpenter and Ishida 2010; McDonald *et al*. 2010), not all of it receiving universal agreement. David Norman, of the University of Cambridge, who has studied *Iguanodon* for more than 30 years, gives a clear summary of the current position in Norman (2011*a*).

When *Iguanodon* was first named by Mantell in 1825 it was based on very limited material, perhaps explaining why Mantell was unwilling to give it a specific name, but in 1834 the partial remains of an *Iguanodon* (Fig. 7A) were found in a slab of Kentish Ragstone (Lower Greensand Group) in a quarry near Maidstone – the '*Iguanodon*' Quarry. As mentioned above this fossil became known as the Maidstone *Iguanodon* (or 'Mantell-piece'). It had been exposed by blasting at the quarry and contained the bones and, reportedly, teeth of *Iguanodon atherfieldensis* (=*Mantellisaurus atherfieldensis*), the same type of animal that Mantell had described in 1825. Unfortunately, it appears the teeth were subsequently lost, although impressions are still visible on the slab. This was the first well-preserved ornithischian ('bird-hipped') dinosaur ever found (Jarzembowski 2002). The slab was purchased from

Fig. 7A. The 'Mantell-piece' found in the 'Iguanodon' *Quarry near Maidstone as it is reconstructed today. (from Gardom and Milner 1993, p. 93.)*

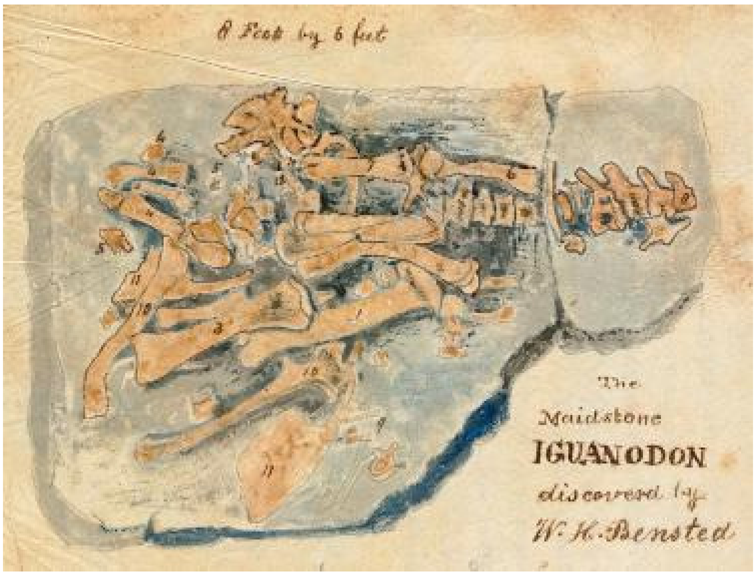


Fig. 7B. The 'Mantell-piece' as reconstructed by the quarry owner, Mr Bensted, soon after its discovery in 1834. Note that the string of vertebrae (top right) has now been repositioned to bottom right as in figure 7A.

*Fig. 8. A painting by Mr Bensted of the '*Iguanodon*' Quarry where the 'Mantell-piece' was found.*

the owner of the quarry, Mr W. H. Bensted, for Gideon Mantell by a group of friends for £25 and is now housed in the Natural History Museum in London.

Mr Bensted, the quarry owner, kept a journal entitled '*Geology of Maidstone and the environs etc. etc.*'. This journal came to light in 2002, when Mrs Jean Bensted donated the unpublished manuscript to Maidstone Museum. The journal gives a first-hand account of the find (see Appendix, p. 11, for transcript) and much else on the local geology at the time (Jarzembowski 2002). It also contained a painting of the '*Iguanodon*' Quarry (Fig. 8), and a painting of the block containing the Maidstone *Iguanodon* as it was originally reconstructed (Fig. 7B). When comparing it with the specimen today (Fig. 7A) we can see that some of the vertebrae were placed in a different position, (the string of vertebrae on the top right of Bensted's painting [Fig. 7B] has been repositioned to the bottom right in the present day specimen [Fig. 7A]), but it's worth noting that the original slab was broken into many pieces by the blasting at the quarry and took a month for Mr Bensted to reconstruct.

Iguanodon bernissartensis

A major advance in our understanding of *Iguanodon* occurred with the major new discovery in 1878 of a large number of fossils in a coal mine at Bernissart, Belgium. Excavated over a three year period this spectacular find included a large number of virtually complete *Iguanodon* skeletons, as well as crocodiles, rare amphibians, insects, thousands of fossil fish, an abundance of coprolites, and a diverse flora. Although around 15 million years younger (Barremian) than Mantell's original *Iguanodon*, the *Iguanodon* skeletons from the Bernissart mine allowed scientists to produce a fairly accurate reconstruction of the animal and the environment in which it lived. Rather than an iguana-like reptile or the heavily-built, horned quadruped of earlier reconstructions, *Iguanodon* now took on an upright posture similar to that seen in a kangaroo. More recent reconstructions have raised its tail off the ground and given it a more balanced, horizontal posture (Fig. 9). The specimens found at Bernissart were sufficiently different from *Iguanodon atherfieldensis* to be given a new name, *Iguanodon bernissartensis*, which is now the exemplar species of *Iguanodon*, all others having been

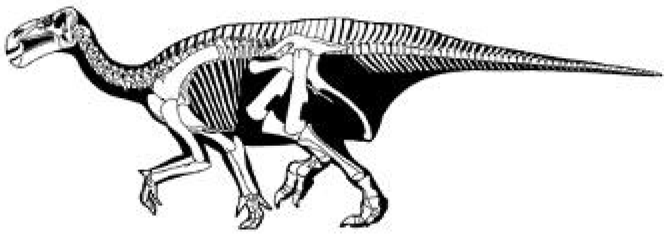


Fig. 9. Reconstruction of Iguanodon bernissartensis.

renamed or included within other species. *Iguanodon bernissartensis* has been found in the Upper Weald Clay Formation at Ockley (Smokejacks Brickworks) on the UK mainland, and in the Wessex Formation on the south-west coast of the Isle of Wight, although it is not that common. Other species that are now regarded as being the same as *Iguanodon bernissartensis* (synonyms) are *Iguanodon seelyi* and *Dollodon seelyi* (Norman 2011*a*).

Mantellisaurus atherfieldensis

Mantellisaurus atherfieldensis was known as *Iguanodon atherfieldensis* until 2007, when Gregory S. Paul, an amateur palaeontologist from Baltimore, USA, considered that there were sufficient differences between *Iguanodon bernissartensis* and *Iguanodon atherfieldensis* to warrant a new genus, *Mantellisaurus atherfieldensis* (Paul 2007, 2008) (Fig. 10). There are actually quite a number of anatomical differences between *I. atherfieldensis* and *I. bernissartensis*, with *I. atherfieldensis* being much more gracile (more lightly built) than *I. bernissartensis*. In a cladistic analysis (comparison of shared characteristics) of the two species, *I. atherfieldensis* falls out on a different branch of the evolutionary tree to *I. bernissartensis*, thus warranting the new genus. In the UK *Mantellisaurus atherfieldensis* is found in the Weald Clay Group on the mainland and in the Wessex Formation on the Isle of Wight. The type skeleton of *Mantellisaurus atherfieldensis* comes from the Isle of Wight. As well as *Iguanodon atherfieldensis* other species that are also now regarded as being the same as *Mantellisaurus atherfieldensis* (synonyms) are *Vectisaurus valdensis*; *Sphenospondylus gracilis*; *Iguanodon gracilis*; *Dollodon bampingi*; and *Proplanicoxa galtoni* (Norman 2011*a*).

Fig. 10. Skeleton of Mantellisaurus atherfieldensis *on display at the Natural History Museum, London.*

Barilium dawsoni

Barilium dawsoni was known previously as *Iguanodon dawsoni*. A study conducted by David Norman concluded that it differed substantially from *Iguanodon bernissartensis* and *Mantellisaurus atherfieldensis* and warranted the creation of a new genus, *Barilium dawsoni* (Norman 2010). *Barilium dawsoni* is more robust (more chunkily built) (Fig. 11A) than either *Iguanodon bernissartensis* or *Mantellisaurus atherfieldensis*, and another significant difference is a depression in the top of the ilium and a lobe at the back of the ilium (Fig. 11B). *Barilium dawsoni* is known from the Wadhurst Clay Formation (Hastings Group). As well as *Iguanodon dawsoni* other species that are also now regarded as being the same as *Barilium dawsoni* (synonyms) are *Torilion dawsoni* and *Sellacoxa pauli* (Norman 2011*a*). Norman (2011*a*, pp. 442–443; 2012, p. 184 [NHMUK 28660]) also considers *Kukufeldia tilgatensis* to be a synonym of *Barilium dawsoni*.

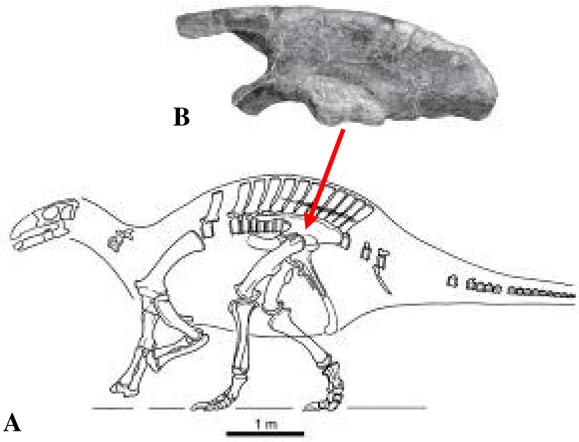
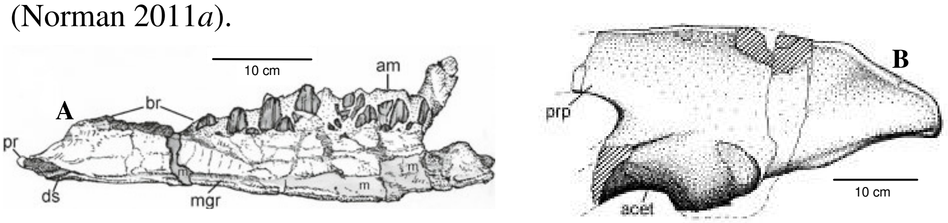


Fig. 11. Barilium dawsoni. *A, reconstruction. B, ilium (from Norman 2011*a*, p. 442 [B], 449 [A].)*

Hypselospinus fittoni

Hypselospinus fittoni was known previously as *Iguanodon fittoni*. A further study conducted by David Norman concluded that *Iguanodon fittoni* differed significantly from other species and once again warranted the creation of a new genus, *Hypselospinus fittoni* (Norman 2010). One of the main differences was that it had very elongate spines on the vertebrae, five or six times as long as the body of the vertebra (Fig. 12C–D) (*Hypselospinus* means high spines), and once again it showed differences in the ilium (Fig. 12B). The jaw of *Hypselospinus fittoni* is shown in figure 12A. The species is also known from the Hastings Group (Wadhurst Clay and Tunbridge Wells Sand formations). As well as *Iguanodon fittoni* other species that are also now regarded as being the same as *Hypselospinus fittoni* (synonyms) are *Iguanodon hollingtoniensis* and *Wadhurstia fittoni* (Norman 2011*a*).



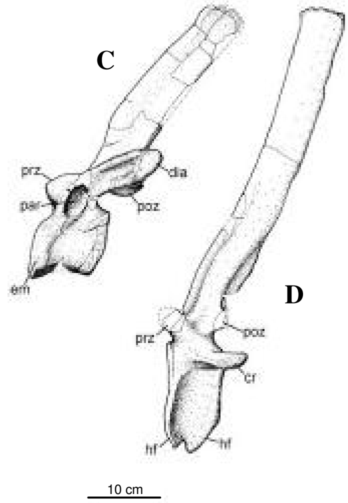


Fig. 12. Hypselospinus fittoni.
*A, jaw with teeth. B, ilium. C, anterior dorsal vertebra. D, anterior caudal vertebra. (from Norman 2011*a*, p. 451 [A], 450 [B], 453 [C, D].)*

To summarize current thinking on the iguanodonts, *Barilium dawsoni* and *Hypselospinus fittoni* are found in the lower part of the Weald, (the Hastings Group); and *Iguanodon bernissartensis* and *Mantellisaurus atherfieldensis* are found in the upper part of the Weald, (the Weald Clay Group on the UK mainland and the Wessex Formation on the Isle of Wight). This means the genus name *Iguanodon* raised by Mantell (1825) based on dinosaur material found in the lower Wealden Hastings Group is now only used for dinosaurs found in the upper Wealden (Weald Clay Group and Wessex Formation).

Kukufeldia tilgatensis

The iguanodont *Kukufeldia tilgatensis* is known only from a single bone, the jaw (Fig. 13). The specimen was collected from one of the quarries at Whiteman's Green, Cuckfield, West Sussex (Grinstead Clay Member of the Tunbridge Wells Sand Formation, Hastings Group). It has previously been assigned to both *Iguanodon mantelli* and *Iguanodon anglicus*, but McDonald *et al.* (2010) considered there to be differences between this specimen and the ones described above, enough to warrant the creation of a new species, *Kukufeldia tilgatensis*. The generic name is derived from Kukufeld, an Old English name for the village of Cuckfield, near which the specimen was found. As mentioned above, Norman (2011*a*, pp. 442–443; 2012, p. 184 [NHMUK 28660]) thinks that this may belong to *Barilium dawsoni*.

Fig. 13. Right jaw of Kukufeldia tilgatensis. *Scale bar is 10 cm. (from McDonald* et al. *2010, p. 5.)*

Hypsilophodon foxii

Hypsilophodon foxii is a small ornithopod found only in one bed in the Wessex Formation of the Isle of Wight – the Hypsilophodon Bed. It was a small fast-running herbivorous dinosaur (Fig. 14), first described by Huxley in 1870, and this one bed has yielded numerous specimens, even to the present day. It appears to have been a mass mortality event, when a herd of young *Hypsilophodon* were overwhelmed, drowned and rapidly buried either in a flash flood, or in a quicksand which had been formed as a result of seismic activity rendering what had been a firm substrate into a liquefied state. Either scenario is consistent with both the preservational and sedimentological evidence (Sweetman 2011).

Fig. 14. Skeleton of Hypsilophodon foxii.

Valdosaurus canaliculatus

Valdosaurus canaliculatus is a dryosaurid and is known from the Wessex Formation of the Isle of Wight, mainly from the Hypsilophodon Bed (Norman 2011*a*), although limited remains have been found more recently in the Lower Weald Clay Formation of Horsham, West Sussex (Styles 2000; Naish and Martill 2001, p. 91). It is known only from bones from the rear of the animal – thigh bones (Fig. 15), shin bones, hip material and some vertebrae – no bones have been found forward of the hips. It has a very distinctive femur, and it could be that some specimens identified as *Iguanodon* and *Hypselospinus* are actually *Valdosaurus canaliculatus*. At present this species is poorly understood and more material is needed to clarify the situation.

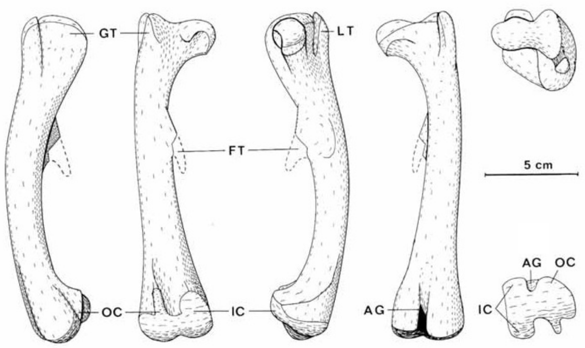


Fig. 15. Left femur of Valdosaurus canaliculatus *(four views of single femur, plus one each from above and below). (from Galton 1975, p. 746, text-fig. 3A–F.)*

Dryosaurus

Remains found by Gideon Mantell from the Hastings Group, near Cuckfield, West Sussex, are thought to be those of *Dryosaurus*. The specimens (Fig. 16) have previously been attributed to *Hylaeosaurus*, and *Valdosaurus canaliculatus*, but they more closely resemble those of the typical dryosaurid, *Dryosaurus*. A new genus and species has yet to be established (Norman 2011*a*). Figure 17 shows a reconstruction of a dryosaurid from the Late Jurassic of the USA.

The remains of dryosaurids are rare in Wealden sediments, and it's likely that the Wealden environment was not their preferred habitat (Norman 2011*a*), and that any dryosaurid remains were probably washed in from further afield by chance.

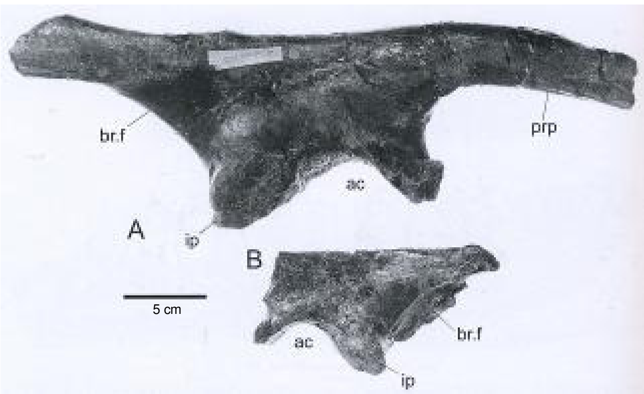


*Fig. 16. Right (A) and left (B) ilia of an unnamed dryosaurid. (from Norman 2011*a*, p. 436.)*

Fig. 17. Reconstruction of a dryosaurid from the Late Jurassic of the USA. Copyright: Masato Hattori

Thyreophorans (armoured ornithischian ('bird-hipped') dinosaurs)

There are two groups of armoured dinosaurs known from the Weald, the ankylosaurs and the stegosaurs. Both groups were heavily-built, slow-moving quadruped herbivores, and one of their main features was the dermal armour extending along the back, tail and limbs. This armour comprised numerous individual bony plates (osteoderms), which came in a wide range of shapes and sizes. Ankylosaur armour is thought to have played a defensive role, although display and temperature control have also been proposed, whereas stegosaur osteoderms are likely to have served as species recognition or display (Barrett and Maidment 2011, p. 391).

Although there are three ankylosaurs recognized from the Weald, *Hylaeosaurus armatus*, *Polacanthus foxii* and *Polacanthus rudgwickensis*, their remains are not abundant. Stegosaurs are even rarer, with only a single species recognized from the Weald, '*Regnosaurus northamptoni*', and that is known only from a single specimen, a section of jaw.

Hylaeosaurus armatus

Hylaeosaurus armatus (Fig. 19) was the third dinosaur, and the first armoured dinosaur, to be described (Mantell 1833), and together with *Megalosaurus* and *Iguanodon* formed the basis for Richard Owen's *Dinosauria* (Owen 1842). It was initially described by Gideon Mantell in 1833, based on a section of articulated skeleton from the front of the creature, just behind the skull. The bones were encased in a block from the Grinstead Clay Formation (Hastings Group) which had been blasted into several pieces during quarrying in the Tilgate Forest, near Cuckfield, West Sussex. The blocks were reassembled by Mantell and encased in a wooden frame (Fig. 18). It was sold to the British Museum (now the Natural History Museum) in 1838 as part of the Mantell Collection, and is currently undergoing preparation (Gray *et al*. 2004), but the matrix is incredibly hard and proving extremely difficult to prepare. Very little is known about the rear of *Hylaeosaurus*.

Fig. 18. The original specimen of Hylaeosaurus armatus *encased in its original block. Scale bar represents 20 cm. (from Barrett and Maidment 2011, p. 394.)*

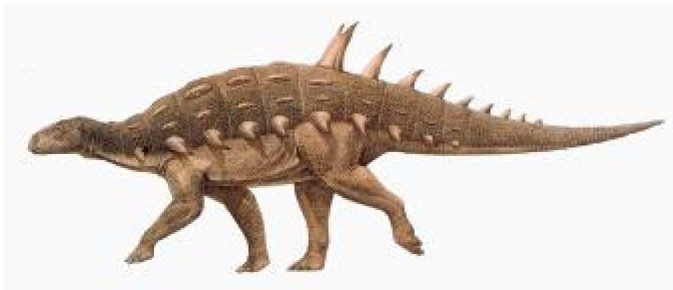


Fig. 19. Reconstruction of Hylaeosaurus.

Further material has been found by David Brockhurst and colleagues at a quarry in Bexhill, East Sussex (Wadhurst Clay Formation, Hastings Group) (Austen *et al*. 2010). The material is housed in Bexhill Museum and is currently being studied by Bill Blows and Kerri Honeysett. Another significant discovery was an ankylosaur braincase and partial skull roof (Fig. 20), probably *Hylaeosaurus*, found by Alan Prowse on the foreshore in Fairlight Cove. Although not *in situ* it is most likely that it came from the Ashdown Formation (Hastings Group). Alan donated the specimen to the Natural History Museum where it is currently being studied by Paul Barrett (Anon. 2005, 2007; Barrett and Maidment 2011).

Fig. 20. Ankylosaur braincase and partial skull roof, probably Hylaeosaurus. *Scale in cm. (from Anon. 2005, 2007, p. 2, figs 3–4.)*

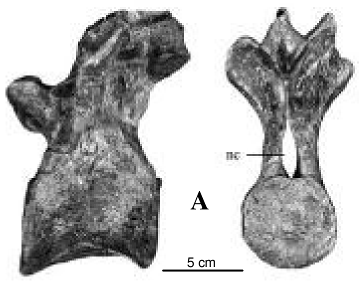
Photo: Jerry Kennington

Polacanthus

Polacanthus foxii was originally described by Richard Owen in 1865 in an article in the *Illustrated London News* (Anon. 1865). It is based on material collected from the upper part of the Wessex Formation on the Isle of Wight (Fig. 21), consisting of a number of bones from the rear of the creature.

Polacanthus rudgwickensis was described by Bill Blows in 1996, based on material found in the Upper Weald Clay Formation (Weald Clay Group, early Barremian) at Rudgwick Brickworks, West Sussex, by Sylvia Standing, an amateur collector. It is around 30% larger than *Polacanthus foxii*, with other anatomical differences, and although Barrett and Maidment (2011) suggest that the differences may represent individual variations, they acknowledge that any reassessment would require better material of both species.

Figure 22 shows a reconstruction of *Polacanthus*, with a section of *Polacanthus* skin (top right) which has a different structure to that of the other armoured dinosaur, *Hylaeosaurus*.



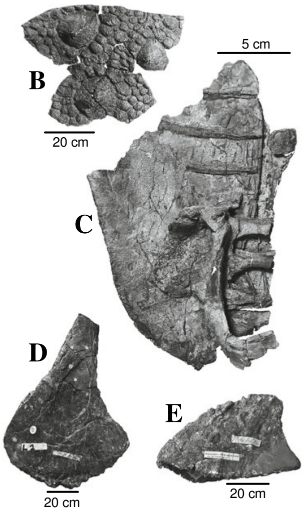


Fig. 21. Polacanthus foxii.
A, *vertebra. B, part of sacral shield. C, right pelvic region. D, dorsal spine. E, caudal spine.*
(B–E from Barrett and Maidment 2011, p. 397.)

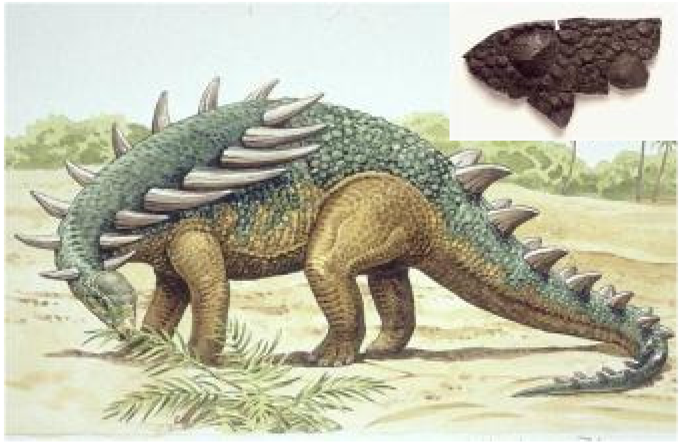


Fig. 22. Reconstruction of Polacanthus*. With a section of* Polacanthus *skin (top right).*

Although *Polacanthus* and *Hylaeosaurus* are similar, there are significant differences (see Barrett and Maidment 2011). It has been suggested that *Hylaeosaurus* is restricted to the lower part of the Weald (Hastings Group), whereas *Polacanthus* is known only from the upper part of the Weald; *Polacanthus foxii* from the Wessex Formation of the Isle of Wight, and *Polacanthus rudgwickensis* from the Upper Weald Clay of the UK mainland. However, recent discoveries of possible *Polacanthus* material by David Brockhurst and colleagues at a quarry in Bexhill, East Sussex (Austen *et al*. 2010), indicate that it may also be present in the lower part of the Weald (Wadhurst Clay Formation, Hastings Group). This material is potentially significant, because if confirmed, it will extend the stratigraphic range of *Polacanthus* down into the Hastings Group (Valanginian). The material is housed in Bexhill Museum and is currently being studied by Bill Blows and Kerri Honeysett (Blows and Honeysett, in press, and in preparation).

Regnosaurus northamptoni

Worldwide, most stegosaurs are Middle / Late Jurassic in age, reaching their peak in the Late Jurassic, and by the time we reach the Early Cretaceous their remains are extremely rare. In the English Wealden there is only one 'confirmed' species of stegosaur, '*Regnosaurus northamptoni*', and this is known only from a single piece of jaw (Fig. 23). It was found in the Grinstead Clay Formation (Hastings Group), near Cuckfield, West Sussex, and was described by Gideon Mantell in 1848 (Mantell 1848). It has had a complicated taxonomic history, being initially identified by Mantell (1838, 1841) as *Iguanodon*, then by Owen in 1842 as *Hylaeosaurus*. Following the discovery of an *Iguanodon* jaw, which was clearly different from this specimen, Mantell renamed it '*Regnosaurus northamptoni*' in 1848 (pp. 198–199). More recently (1990) it was suggested that it was a sauropod, but in 1995, Barrett and Upchurch redescribed it as a "primitive" stegosaur (see Barrett and Maidment (2011) for full history). It still remains problematic, but the anatomy of the jaw is consistent with other stegosaurs from around the world, so that does seem most likely. This would make it one of the last stegosaurs, and Paul Barrett made the point during his talk that more material is needed, and that "**it's a priority to find a stegosaur in the Weald**". Figure 24 shows a stegosaur reconstruction.

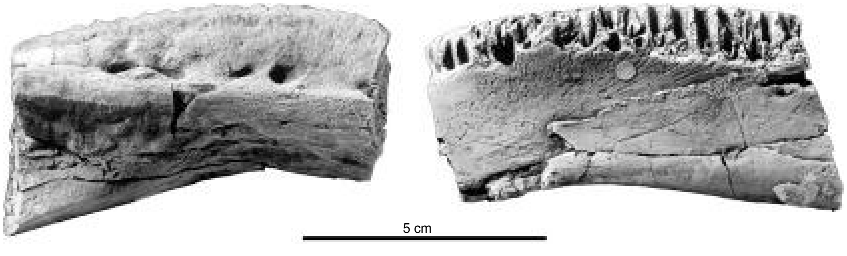


Fig. 23. Partial right lower jaw of '*Regnosaurus northamptoni*'.
(from Barrett and Maidment 2011, p. 401.)

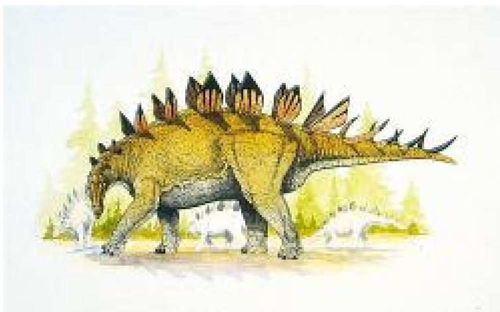


Fig. 24. Reconstruction of a stegosaur.

Appendix (from Anon. 2002)

Extract from a notebook written by Mr. W. H. Bensted (owner of the quarry where the Maidstone *Iguanodon* was found), and donated to Maidstone Museum in 2002 by Mrs Jean Bensted.

The remains of the Iguanodon *were discovered in 1834, by one of the workmen blasting the layer with gunpowder, the bore being placed in the middle of a rise, or mound in the stone, the separation of the mass was so complete, that some parts were thrown by the force of the powder to a considerable distance, and a month had elapsed before I had fitted the fragments together in their relative places. Fortunately there was no intervening piece lost and the mass as shown in the drawing was complete as far as it went. It is however most probable that more of the skeleton had been in the surrounding stone and might have been removed by the men before the blast took place as I took every precaution to search the surrounding stone for some time afterwards, but without success.*

I then constructed a shed to cover the specimen and by the aid of a chisel cleared away much of the stone covering a portion of the bones. As the enormous proportion of the femur became developed, the interest increased to a great degree, and not having any one near me acquainted in the least with such a novelty, and finding the character of the bones to differ so greatly from any drawing I could get access to, I resolved to acquaint Dr Mantell with my discovery and soon received a reply from that Gentleman expressing the highest interest in the discovery. I now purchased his work Geology of the S.E. of England and then began to have a correct idea of the geology of the country around. From the drawings in this excellent work I soon formed an opinion that my specimen was a large portion of the fossil lizard called the Iguanodon *and in a few days I discovered a tooth and the perfect cast of another, this was conclusive, and on the arrival of Dr Mantell, who came for the purpose of inspecting it, he perfectly agreed with my opinion, stating his pleasure and gratification in the discovery, as confirmation of his correctness in comparative anatomy he having appropriated separate bones to their proper position in the skeleton of the* Iguanodon *from a large collection of saurian remains, discovered in the Hastings sand formation. These remains belonged to several monsters of the reptile were classed according to order and species.*

The name Iguanodon *is taken from "Iguana" and, "nodon",* [pencil correction to "odon"] *the latter, from a Greek word signifying monster* [pencil correction to tooth]. *The Iguana is a small lizard now found in the West India Islands, seldom more than five feet in length, but from the peculiarity of its teeth and other affinities, it offered the nearest type to the extinct gigantic lizard of the Weald, and hence the name of* Iguanodon. *Since my discovery there have been found bones of this creature that warrant the conclusion that the individual must have been of the astounding length of ......* [left blank!] *feet.*

From the structure of the teeth there can be no doubt that it was herbivorous, such a monster and such a country, with food for its sustenance it is difficult to form a conception of, but the deductions are made with a strict regard to laws imperative in their attributes, and are confirmed by all the recent investigations by microscopic examination of the structure of the teeth, and the comparative anatomy of such creatures both extinct and living.

Notes

Bibliographic details of Gideon Algernon Mantell, Richard Owen, William Buckland, William D. Fox, and John Whitaker Hulke were obtained from Wikipedia.

Dates for geological stages during the Early Cretaceous were taken from the 2012 International Stratigraphic Chart, produced by the *International Commission on Stratigraphy*.

Stop Press!

During 2012/13, articulated remains of a partial skeleton of *Valdosaurus* were discovered on the south-west coast of the Isle of Wight.

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* *Wealden News* can be found at: http://geoconservationkent.org.uk/ (click on 'Resources' and scroll down page)

The West Coast Fossil Park, Western Cape, South Africa

by Margaret A Dale

Whilst planning a touring holiday, which encompassed part of the west coast of South Africa, I spotted the words "Fossil Park" on the map about 150 km north of Cape Town some distance from a village called Langebaanweg. Intrigued to find out more I searched the internet to determine if it was accessible to the public and, if so, its opening times. I found nothing. Not to be deterred, my husband and I decided once we were in the country the usual tourist literature would give us the required information. Unfortunately, again, there was nothing. So, determined not to be outdone, we drove to the area in the hope we could find it and visit it. Fortunately we managed both.

The fossils in the park (Fig. 1) date back to the late Miocene and early Pliocene eras. These are important periods in our evolution, since it is believed that the last common ancestor of humans and our closest living relative, chimpanzees, lived during this period. Mio-Pliocene hominid fossils are extremely rare and have only ever been found in East Africa and not amongst the West Coast Park deposits to date.

With more than 200 different kinds of animals being identified, the park possibly represents:

- the greatest diversity of 5 to 5.2 million year old animal fossils found anywhere in the world and
- the richest fossil bird site older than 2 million years in the world.

The fossils incorporate those of many animals that are new to science and many that are now extinct. They include sabre-toothed cats, short-necked long horned giraffes (Fig. 2), hunting hyenas, three-toed horses, three species of elephants including four-tusked elephants, giant pigs, African bears (which are the first ever found in sub-Saharan Africa) (Fig. 3) and antelopes (including one species now only found in Asia).

There are also fossils of smaller animals similar to those we know today of fish, frogs, lizards, chameleons, mole rats and mice and over 80 species of birds, many of whom made their first appearance in the fossil record at the park.

In the late Miocene and early Pliocene eras, the area was adjacent to an ocean and consisted of a mixture of lush, riverine forests, wooded savannah and open grasslands. A vast river flowed through it and was the force that swept the animals, whose bones later became fossilised, to rest along its estuary banks in jumbled disarray.

Fig. 1. One of the many partly excavated fossil beds

The fossils may have remained undiscovered if an open-cast phosphate mine had not opened in the 1940s and an alert employee in the 1950s had the foresight to alert scientists to a fossilised ankle bone from an extinct short-necked giraffe and a fossilised tooth of an extinct elephant found amongst the rocks. Unfortunately it can only be assumed that until then many tons of fossils had been crushed along with the phosphate rock.

In 1996, a 14 hectare fossil-rich area was declared a National Monument Site and, subsequently, 700 hectares, the entire mining area, was made a National Heritage Site. It and its contents form a valuable resource for researchers from all over the world.

Currently, over 80m² of fossil beds and a small museum, with a vast collection of excavated fossils, are open for viewing by the public and information about the park is now available on the internet.

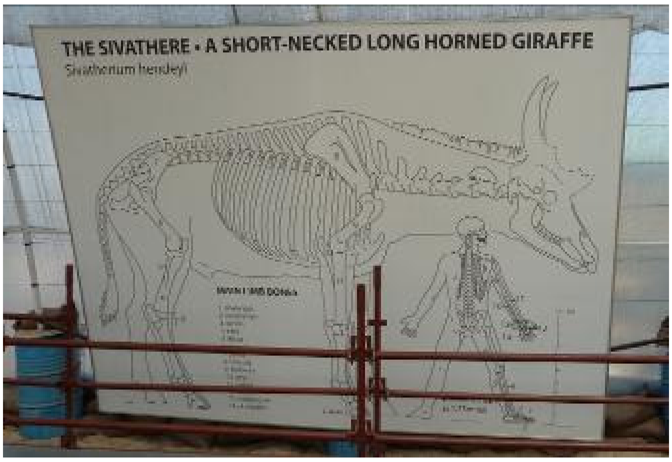


Fig. 2. A representational drawing of a Short-Necked Long Horned Giraffe, with a human to illustrate scale

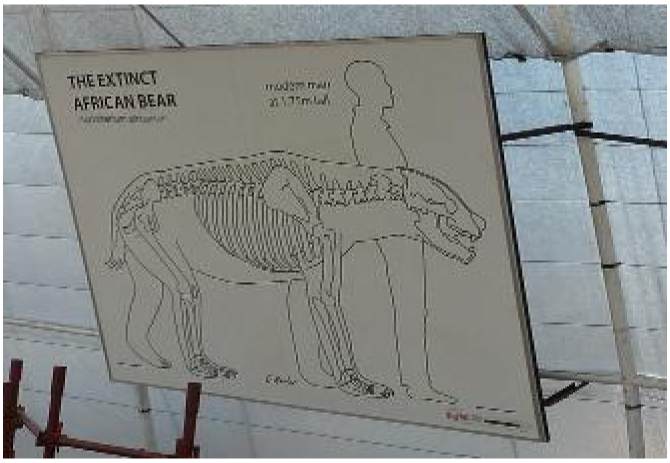


Fig. 3. A representational drawing of the African Bear, with a human to illustrate scale.

The park is very isolated, which means visitor numbers are likely to be low - there were only four people on our tour. It does not have much in the way of visitor facilities as the main focus of the park is scientific discovery and research. However, they have a pleasant café and (if our experience is anything to go by) well informed and interesting guides.

Antelope Canyon

by Jim Priestley

This is an update of an article published in the Spring 2001 Journal following a Members' Day talk given to the Society in January the same year. The talk was illustrated with coloured slides. At that time it was not possible to include colour photographs in the Journal. Now that this facility is available, members might be interested in some of these dramatic photographs.

Introduction

Antelope Canyon is a slot canyon on the Colorado Plateau in northern Arizona in the south west of the USA. A slot canyon is a deep, narrow, vertically-sided gorge. In common with most landscape features, it was formed by a particular combination of geography, climate and geology.

Geography

The canyon was eroded by the waters of Antelope Creek, which starts on a high mesa (table mountain) before meandering northwards in a wide, sandy channel, following the contours of a gently falling plateau (Fig. 1). The creek passes through the canyon just as it begins a deep descent into an arm of Lake Powell (Fig. 2). This was a deep side canyon until the lake was created by the damming of the Colorado River in the 1960s.

Fig. 1. The stream bed as it approaches the canyon.

Fig. 2. The beginning of the slot.

Climate

Most of the Colorado Plateau has a very low rainfall, so that much of it is desert or semi-desert. Antelope Canyon is bone-dry for most of the year, but the high mesa at the creek's source, standing above the general level of the plateau, attracts rain during the brief winter and summer rainy seasons, especially the latter, when violent thunder storms send flash floods running down the creek.

The immediate area around Antelope Canyon is in the rain shadow of much higher land to the west, so it receives next-to-no rain. At the high altitude of the plateau there are frequent cycles of frost and thaw. However, with the arid climate there is little ice to cause weathering.

Geology

The canyon is in the Navajo Sandstone Formation, which was deposited as sand in a desert similar in size to the Sahara. This was in the Upper Triassic and Lower Jurassic Periods, when this part of North America was even drier than today.

As could be expected with desert sand, it is composed of fine, well-rounded, uniform grains of almost pure quartz and displays, in some exposures, classic examples of the large scale stratification typical of dune deposits. The grains are moderately well cemented, mainly with ferric compounds, which give the rock its predominantly pink colour, although there are areas of almost pure white.

It is fairly easily eroded but, as a massive rock with few joints or other weaknesses, it stands vertically very well, so it forms some of the many cliffs, canyons, mesas and monuments which make the Colorado Plateau what one geologist called "a wonderland of rock scenery".

The making of the Canyon

We are all familiar with the way in which V-sectioned valleys have been created in areas of plentiful rainfall.

Figure 3(a) shows the process. The river or stream at the bottom of the valley deepens its course by downward erosion, whilst weathering and erosion, mainly due to rainwater, loosen materials from the valley sides. Water and gravity move the debris down into the river, which carries it away to be deposited elsewhere and eventually become rock again.

Figure 3(b) demonstrates how weathering and erosion of the valley sides does not take place if there is little rainfall or ice.

Formation of a V" shaped valley and a slot canyon

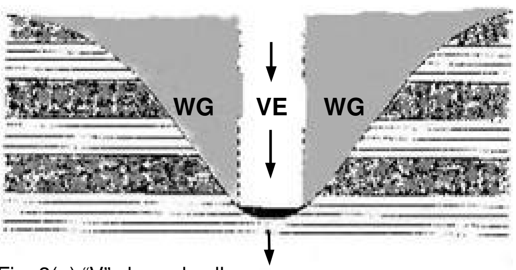


Fig. 3(a) "V" shaped valley

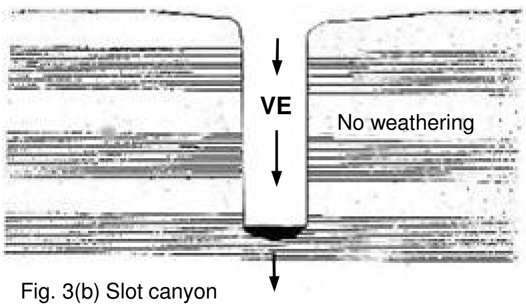
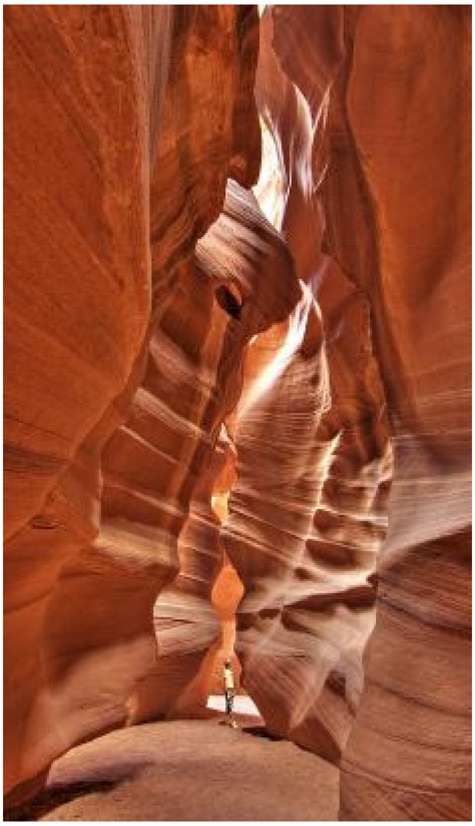


Fig. 3(b) Slot canyon

VE Zone of rock removed by vertical erosion as river cuts along its bed

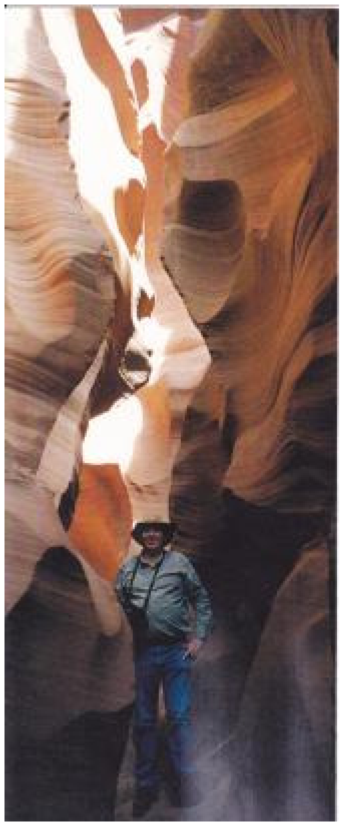
WG Zone of rock released by weathering and carried by gravity into river channel

At Antelope Canyon there is hardly any rainfall or ice at all and the rock stands well, so that the canyon sides remain vertical. The creek, when it runs, flows slowly over the gently-sloping plateau, but its velocity increases as it passes through the canyon due to the steepening fall as it nears the edge of the plateau, so there is considerable downward erosive force. Once confined within the canyon the water can do little to widen it so it rarely exceeds 3 metres (10 feet) in width, and in places is not wide enough to take my shoulders.



The canyon is deep ----

---- and narrow.

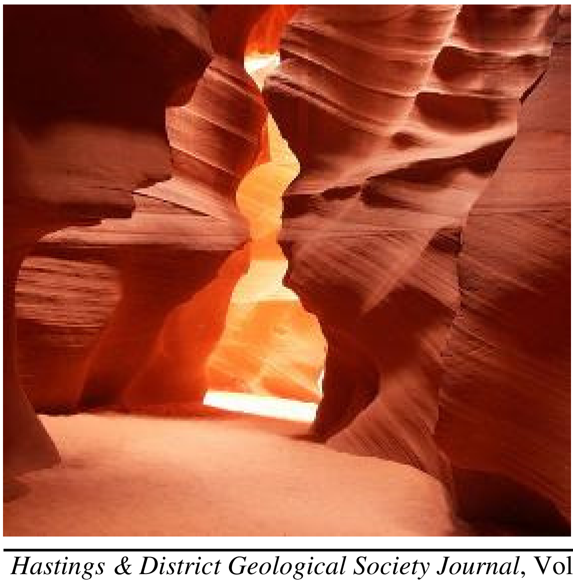


The Canyon

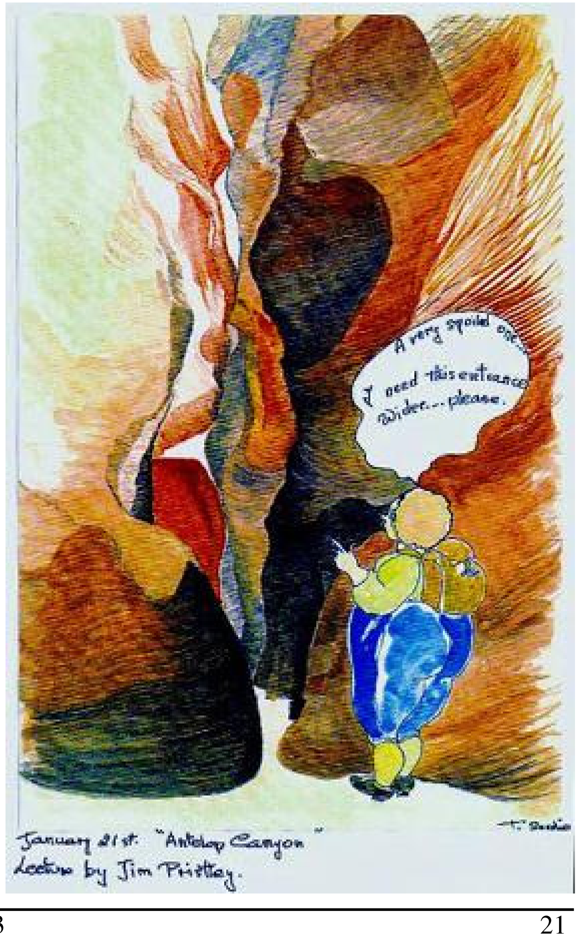
The canyon starts as a narrow, shallow gully at its upstream end and gradually deepens to about 30 metres (100 feet). There are several vertical drops of about 3 to 4 metres (10 to 13 feet) which form waterfalls when the creek is running. The slot ends quite abruptly with another vertical drop of about 6 metres (20 feet) where the canyon widens, shortly before its lower end is partly submerged to form an arm of Lake Powell. The slot itself is about 300 metres (1,000 feet) long.

Access to the Canyon

The Canyon is in a Navajo Tribal Reserve and the road to it is gated. Entry is restricted to tours led by authorised guides. Tours can be booked in the nearby town of Page and cost from $30 to $80 according to the length of the tour.



Inside petrified sand dunes.



Cartoon by Teresa Serdio.

Booth Museum yields big ankylosaur surprise

by Andy Ottaway

All dinosaur enthusiasts dream of finding the fossilised remains of one of these stupendous creatures. It's far from a common occurrence, so finding one in the centre of Brighton is something I could never have imagined!

Sussex holds an historic place in the discovery of Dinosaurs. In the 19th Century, Lewes doctor Gideon Mantell famously described two of the first three dinosaurs known to science that were found in the county. These were *Iguanodon* in 1825 and the armoured dinosaur *Hylaeosaurus* in 1833.

More recently, Sussex has continued to produce important dinosaur fossils from its Early Cretaceous Wealden deposits. For the past ten years or so, I've been lucky enough to be part of a team that has excavated partial skeletons of an iguanodont and the armoured dinosaur *Polacanthus* from a site near Bexhill. These are now on display at Bexhill Museum, while another iguanodont skeleton has just been found at the same site.

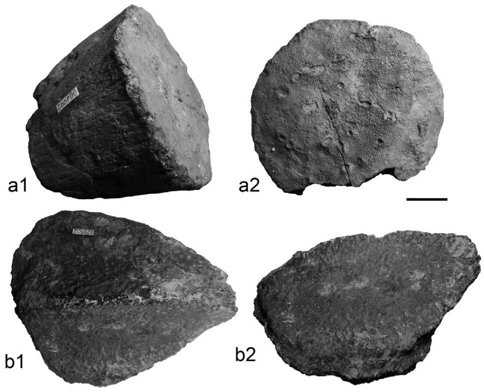


Fig. 1. Presacral vertebra (a) and osteoderm (b) from Booth ankylosaur.
Scale bar for a = 25 mm and b = 20 mm.
(from Blows in press)

The discovery of *Polacanthus* is of particular interest to this story because ankylosaur material is so rare and mostly fragmentary here in the UK. While many spectacularly large ankylosaurs have been found in the United States, Asia and even Australia, here in the United Kingdom we have had to make do with a handful of modestly sized species lacking tail clubs, known as nodosaurs. Both *Hylaeosaurus* and *Polacanthus* are nodosaurs from the Wealden of Sussex that reached 4 metres in length. Their remains have been unearthed near Horsham, as well as in Cuckfield and the Bexhill area.

So what has all this to do with Brighton? Let me explain. The story begins in 2011 when I visited Bexhill Museum to try and identify various small vertebrate fossils I had found at the dinosaur site in the Wadhurst Clay at Bexhill. These were small fragments of bone, scales and teeth from fish, turtles, crocodiles and possibly even pterosaur. Left with a few specimens I could not identify I decided I would take a look at the Wealden material housed at the Booth Museum in Brighton and Curator Lee Ismail was kind enough to permit me to do so.

The Booth Museum was founded in 1874 and is best known for its extensive stuffed bird displays. However, behind the scenes lies a veritable treasure trove of specimens never seen by the casual visitor. Amongst these are historically important fossils, including dinosaur material that was collected by eminent Victorian geologists of their day.

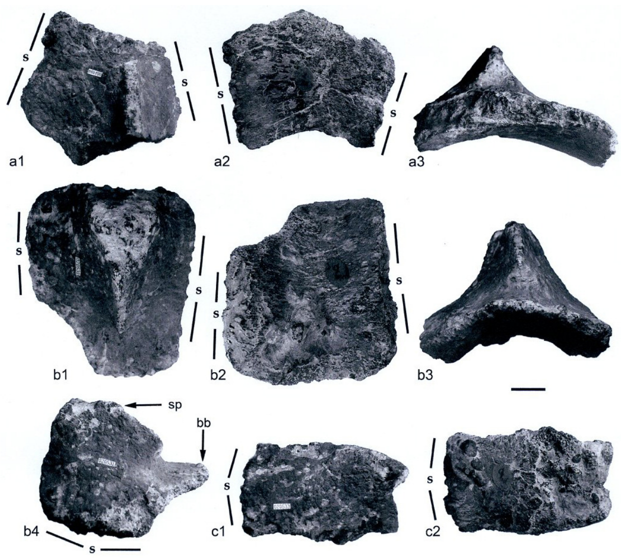


Fig. 2. Cervical half-ring pieces from Booth ankylosaur.
Scale bar for a1, a2, b4, c1, c2 = 20 mm, for a3, b1-b3 = 15 mm.
(from Blows in press)

I spent several happy visits to the Booth poking through one fascinating drawer after another of Wealden fossils. I then came across a row labelled 'Cambridge Greensand', which are deposits roughly 30 million years younger than the 140 million year old fossils I had collected from Bexhill. I decided to take a look and I'm really glad I did!

I was surprised to find the first drawer I opened was full of marine reptile material, mostly plesiosaur vertebrae, limb and paddle bones. This I recognised having spent several years as a volunteer curator at the Natural History Museum (NHM) in London working on the marine reptile and dinosaur collections there.

However, amid the plesiosaur material I noticed an oval shaped bone a few inches in length, with a centrally raised keel on one side. I had seen similar ones before at the NHM and I was certain it was an osteoderm from an armoured dinosaur, one of the many bony scutes embedded in the skin of these Mesozoic reptilian tanks.

Along with the scute were a number of other fragments, including a smaller osteoderm and a couple of pieces of curved bone with raised spikes. These too looked like bony armour to me and certainly not part of any plesiosaur. On closer inspection I noticed some had rather old labels attached to them on which was written the word 'deinosaurian'.

I was very excited to think I may have stumbled across dinosaur fossils presented to the Booth as long ago as the 1870s that had never been properly identified. I photographed the specimens and sent them to William Blows of City University, London to seek his opinion. Bill has been on several digs with me at the Bexhill quarry and as luck would have it, he is an expert on armoured dinosaurs. However, it was not until several months later in April 2012 that Bill was able to travel down to the Booth Museum from his Dartford home to take a look at the material for himself. It was then he confirmed to my delight that all six specimens were indeed from an ankylosaur!

Bill identified the fossils as being two dermal scutes, a presacral vertebra (Fig. 1) and three pieces of cervical armour called 'half-rings' (Fig. 2) that protected the neck of ankylosaurs from the unwelcome attention of carnivorous dinosaurs. There were two or three of these bony half-rings over the back of the neck, separated by skin heavily impregnated with bony ossicles that provided protection while maintaining flexibility (see example in fig. 3). This armour varies between species so it can provide a useful aid to identification.

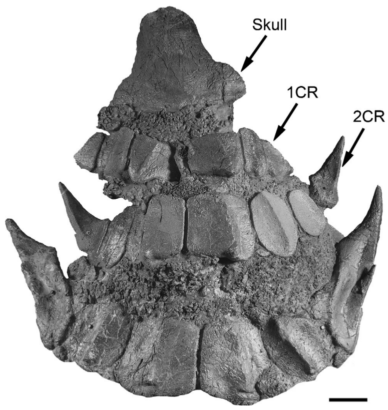


Fig. 3. Edmontonia rugosidens *from the Upper Cretaceous of Alberta, Canada, showing cervical armour. Scale bar = 20 mm.*

(from Blows in press)

Earlier this year I was thrilled to hear that Bill was publishing a scientific paper on the Booth ankylosaur material. Interestingly, he discovered that the cervical rings showed unfused margins which reveal this was an immature animal. Furthermore, their relatively large size strongly suggests they belong to a nodosaurid dinosaur, but one far larger than previously known. This beastie could have been 7 or 8 metres in length, twice that of *Polacanthus* or *Hylaeosaurus*, and plodded around Britain in the mid-Cretaceous some 100 million years ago.

Of course, a major reason to grow very large and spiky is to avoid being eaten by something rather ill-tempered that is much bigger than yourself. If a British ankylosaur could reach twice the size of any previously known species found here, I'd like to think it may indicate the presence of a huge carnivorous monster, hitherto unknown, that also awaits discovery. It's nice to think that everything we knew about Britain's dinosaurs may just have got that much bigger.

More information can be found on the Royal Pavilion & Brighton Museums website:
http://rpmcollections.wordpress.com/2012/04/19/rare-discoveries-at-the-booth-museum/

Reference

BLOWS, W. T. in press. Notice of nodosaur (Dinosauria, Ankylosauria) remains from the mid-Cretaceous of Cambridge, England, with comments on cervical half-ring armour. *Proceedings of the Geologists' Association,* 7 pp. Available on line 27 Jul 2013.

Acanthopholis*, an ankylosaur from the Cambridge Greensand (reconstruction by Neave Parker in a series of late 1950s Natural History Museum postcards)*

Report on the visit by a group of HDGS members to University College London

Sunday, 19th May 2013

Reporter: Jim Simpson

1. Introduction

Visits to the Earth and Planetary Sciences Department of UCL, of which this is, I understand, the fifth, have arisen from the good offices of Professor G. David Price, our Society President.

The aim of this report is to serve as a record of a most enjoyable and instructive day for those fortunate enough to attend, and to provide for those of our membership who could not attend, an attempt to convey something of the geological marvels presented in the three particularly exciting fields covered:

(i) The use of micropalaeontology to place a rock sample in its correct geological period.

(ii) Rock fracture mechanics, particularly at very high temperature and pressure, also research at low temperatures with the additional interest of the behaviour of ice, and friction between ice and materials.

(iii) A review of photographic and radar evidence of the surfaces of planets visited on space missions.

It is also hoped that this note might provide a starting point for anyone wishing to study any aspect further.

The tours of the labs were conducted with inexhaustible enthusiasm by Professor G. David Price in the Rock and Ice Physics Laboratory (RIPL), Dr. Marcelle BouDagher-Fadel in the Rock Room, and PhD student Amy Edgington in the Centre for Planetary Sciences (CPS), for whose efforts on their behalf, the Hastings visitors were most appreciative.

2. The history of UCL

Prior to separating into two groups for the tours, the visitors enjoyed a talk from Professor Price on the history of UCL. A précis of Professor Price's talk appears in the Appendix 1 (UCL: a brief history).

In light of the difficulties UCL experienced in its early years vis-à-vis other long-established universities and seeking some feel of the status of the science of geology at the time, it is significant to note that inauguration of UCL (1826) pre-dated by 6 years that of King's College London, where Sir Charles Lyell taught.

3. The tours of the work of the Department

(i) The Rock Room

The Rock Room (Figs 1–2), originally established in 1904, served as the base for the visit, and comprised work tables each with microscopes which allowed plenty of opportunities for the visitors to view slides of the microfossils in this part of the tour.

On the walls were geological maps and prints apparently of early geological expeditions, which served to keep in mind the learning brought to us through the work of the geologists of years gone by.

The collection of geological specimens displayed in cabinets around the walls (see fig. 12 in Appendix 1) follow the geological

Fig. 1. Dr. Marcelle BouDagher-Fadel (centre) and HDGS members in the Rock Room.

Fig. 2. HDGS members examining microfossils in the Rock Room.

Fig. 3. Specimen displays an internal structure similar to cross-bedding.

epochs. An exhibit which your reporter found of particular interest was No.36, *Cross-bedding in lava flow from the Borrowdale Volcanic Group which belongs to the Ordovician period*. This slice of rock taken along the direction of flow was surprisingly similar in appearance to deposits of water-borne sand (sand waves) or wind-blown sand (sand dunes) (Fig. 3).

(ii) The use of microfossils in rock samples to determine the age of the rock

Foraminifera are single-celled aquatic micro-organisms, and can be used to date rocks throughout a large period of the geological column. These single-celled creatures varied in size, even the largest shown to us at 25 mm diameter was a single cell, the remainder of its structure having been built outwards concentrically from the cell. A distinguishing feature of these foraminifera is that they comprise three layers.

Slides of the rock samples showing the microfossils were made available for observation under the microscopes provided.

Two books by Dr. BouDagher-Fadel were available on the table for consultation:

Evolution and Geological Significance of Larger Benthic Foraminifera (Developments in Palaeontology and Stratigraphy) – Vol. 21, 548 pp. (2008)

Biostratigraphic and Geological Significance of Planktonic Foraminifera (Developments in Palaeontology and Stratigraphy) – Vol. 22, 301 pp. (2012)

These volumes contain a vast amount of data both from direct research on samples and, to judge from the references, from sources and sites throughout the world, all presented in tabular form according to position in the geological column. The result would seem to provide a very powerful tool giving the ability to place any rock sample on the geological column according to the microfossils found within it.

(iii) The mechanics of the Earth's crust and mantle. (This part of the tour included an additional section on ice and low temperature effects.)

(a) The crust

The first laboratory visited on this section under the guidance of Professor Price involved work on rock strength determination by means of the triaxial test. The behaviour, at failure, of the cylindrical rock sample which was in the machine at the time was to fracture at an acute angle to the vertical.

(b) The mantle

In the second laboratory visited, the apparatus was designed to recreate the higher temperatures and particularly pressures (up to 250 thousand atmospheres at 60 km depth inside the Earth) met in the mantle. Central to this research is the Diamond Anvil Cell (see fig. 8 in Appendix 1). The Cell creates quasi-hydrostatic conditions by loading through all the faces of its octahedron shape. This is achieved by the insertion of small prisms at the corners inside the load cell. Experiments are carried out at temperatures of up to 200°C.

It is understood that the results of these experiments can be used in providing data for mathematical models of Earth's processes, e.g. plate tectonics and earthquakes.

(c) Use of X-ray diffraction

Your reporter's following explanation is imperfect but it is hoped only to demonstrate how diffraction value (the angle by which the ray is deflected on entering and leaving the crystal) can give information both on the nature of the material and its state.

X-ray diffraction is used in identifying elements in the sample. This is based on the work of Loewy, who found that crystals of different substances diffract the X-rays differently. A model of an atomic structure was demonstrated by Professor Price (see fig. 10 in Appendix 1). The layer thickness between layers of atoms determines the diffraction. Diffraction peaks at a D value of the crystal. If the temperature of the sample changes the D-line shifts giving an "equation of state", e.g. 4000°C at the core mantle interface, and 5000°C at the centre of the Earth.

(d) Testing rocks at extremely low temperatures and the physics of ice

Testing as above for high temperatures can also be carried out in cold temperatures down to –100°C.

This lab was kept at noticeably cold conditions, which may explain your reporter's failure to adequately convey information of geological significance relating to the experiments carried out there, except to surmise that glaciation and the disruptive power of ice on freezing would be possible topics. Recollection of the school physics experiment of the thin steel wire with weights attached to the ends slowly cutting through the block of ice with refreezing taking place immediately above, brought to mind the effect of pressure alone in causing ice to melt.

Memorably, we saw a section of a racing sledge and learned that research had been carried out on improving the performance of Olympic sledge runner design (see note under Winter Olympic Sports in Rock & Ice Physics Laboratory section in Appendix 1).

(iv) Centre for Planetary Sciences (Fig. 4)

Photographs of planets visited by various NASA spacecraft are distributed to research agencies around the world, partly to share in their storage and partly to allow others to conduct research on them. UCL is part of this scheme and we saw rolls of prints from Apollo 16.

UCL receives prints of photos taken by the Voyager probes and Mars Rover Curiosity. UCL also has Russian photos of the surface of Venus.

Fig. 4. Amy Edgington (right) and HDGS members in the Centre for Planetary Sciences.

There were two photos of Mars (Fig. 5), which display what appear to be a series of large symmetrical dunes in a rift-like valley. These caught our interest since they were likely to be wind driven. Had they indeed been dunes they would have been expected to be desert dune shaped, i.e. asymmetrical with the steeper face down stream. This serves as an example of how the general reader can derive some interest from the photos which have come, and will come in the future, from space exploration.

Fig. 5. Examples from the Centre for Planetary Sciences of how photographs from the planets (in this case, Mars) provide the opportunity to study similarities in geomorphology with that of the Earth.

4. Concluding thoughts on the visit

Re: Plate tectonics and volcanic activity:–

The realisation that the laboratory testing such as seen on the visit to UCL can provide data to give the professional geologist an understanding of the forces at work *in situ*, and can enhance the enjoyment of the amateur of such television programmes as "*Rise of the Continents*".

The internal structure similar to cross-bedding found in sedimentary rocks seen in the section of lava flow in the Rock Room was a revelation to the reporter.

Re: Benthic and planktonic foraminifera in the rock record as an indicator of their age and evolution:–

I am sure that your reporter was not the only person on the visit for whom this opportunity to enter for a few minutes the world of research revealed under the microscope and in the two books by Dr. BouDagher-Fadel was fascinating. Firstly, on account of the vast amount of data from many locations around the world and the insight presented by the analysis found in the books. Secondly, there is also a connection here with the talk given to HDGS earlier this year by Dr. Steve Sweetman entitled "*In the Shadow of the Dinosaurs*", wherein research in the field of microfossils being carried out in our region (specifically, the Isle of Wight) was presented.

Were anyone to be interested in Dr. BouDagher-Fadel's remarkable research, her most recent volume on the planktonic foraminifera (Volume 22) is freely available on her website at http://www.ucl.ac.uk/EarthSci/people/fadel/home-mkf.htm and her volume on the larger benthic foraminifera (Volume 21) can be obtained through inter-library loan.

Overall, a thoroughly enjoyable and informative day.

Appendix 1

(edited extracts from the UCL website)

UCL: a brief history

Cuncti adsint meritaeque expectent praemia palmae
Let all come who by merit most deserve reward (UCL motto)

University College London (UCL) was founded on 11 February 1826, under the name *London University*, as a secular alternative to the strictly religious universities of Oxford and Cambridge. It was founded from the beginning as a university, not a college or institute. However its founders encountered strong opposition from, among others, the Church of England, which prevented them from securing the Royal Charter that was necessary for the award of degrees. It was not until 1836, when the latter-day University of London was established, that the college was legally recognised and granted the power to award degrees of the University of London.

The present modern and still growing Department of Earth Sciences at University College can take a justifiable pride in its unique historic past and its long contribution to the Science of Geology. Its research spans a diverse range of activities including: crustal processes, Earth and planetary evolution, mineral physics, palaeobiology and palaeoclimatology, polar observation and modelling, natural hazards, environmental geochemistry and sedimentology.

Centre for Planetary Sciences

The Centre for Planetary Sciences (CPS) is one of the United Kingdom's leading centres for planetary science. It houses expertise in understanding planets from their deep interiors, through their surfaces and atmospheres, to their space environment. This expertise is complemented by world leaders in astronomy, terrestrial and solar science, life and chemical sciences.

CPS members play key roles in planetary space missions such as Mars Express, Cassini Huygens and Rosetta. The Centre is also one of three UK universities to play a leading role in the European Union-funded Europlanet project that brings together Europe's major planetary science centres.

CPS members lead and make major contributions to solar system and exoplanet space missions, as well as hands-on studies of rocks and meteorites, ground-based observations of planets, geophysical models of planetary interiors and both theoretical and experimental studies on planetary materials.

The CPS is primarily a "virtual" research centre, and comprises researchers within the several groups at UCL and Birkbeck.

The CPS also houses the United Kingdom's only NASA Regional Planetary Image Facility (RPIF). Its collection includes thousands of images and other data from almost all of the NASA planetary missions since the 1960s, covering all the planetary bodies in the solar system which have been surveyed to date by spacecraft.

The Facility is one of only seven outside the USA. Its task is to provide information and data not only to professional researchers in the UK, but also the general public, students, media, school-children and their teachers about planetary missions and their latest findings. Much of the data and many of the publications are rare and cannot be found anywhere else.

Rock & Ice Physics Laboratory

Experimental and theoretical rock physics, ice mechanics and petrology applied to planetary dynamics, geohazards, sub-surface reservoirs and ice sheets

The Rock & Ice Physics Laboratory (RIPL) at UCL is a major research facility which forms part of the Earth Sciences Department. RIPL has over 15 members and consists of 11 laboratories, housing over £4 million of research equipment, supported by over £2 million of current peer-reviewed funding. The Rock & Ice Physics Laboratory has a unique breadth of experience and ability to design and build its own experimental apparatus.

Fig. 6. Rock & Ice Physics Laboratory

We study the physical behaviour of ice and rocks that make up the surface and interior of the Earth, and other solid bodies in the solar system, so as to constrain the dynamic, tectonic and environmental processes of planetary evolution. Our research is nationally unique and multidisciplinary, being based on experiment and theory.

Winter Olympic Sports (2009)

Some of the Rock & Ice Physics Laboratory members will undertake research into ice friction with the aim of improving the UK's performance in future World and Olympic Winter Games. The work is funded (£80k) by UK Sport.

It is hoped that the project will develop new insights into high-and-low speed friction in a range of sports. The project will involve the design and manufacture of a new high-speed tribometer to determine experimentally the roles of ice friction, lubrication and abrasion; theoretical assessments; experimental testing, and field based testing.

The team will also use the apparatus to develop new design principles in a range of other Winter Olympic sports, including snowboard and boarder cross events, speed skating and bobsleigh.

Amy Williams won Britain's first solo Winter Olympics gold medal for 30 years in 2010 with victory in the women's skeleton.

Haskel Multi-Anvil

The Haskel High Pressure Laboratory at UCL conducts basic research into effects of high pressure and high temperature on igneous rock/mineral/magma systems using a solid media high pressure apparatus. Areas of research include understanding the origins of mantle derived melts and minerals (silicate and non silicate, but especially carbonate systems), and results are incorporated into undergraduate teaching courses.

Research Equipment includes: 2 x 1000 ton presses for interchangeable Walker-style multi-anvil and piston cylinder cells, with resistive heating systems and *in-situ* measurements of conductivity under mantle conditions.

Fig. 7. Haskel High Pressure Laboratory.

Diamond Anvil Cell

The Diamond Anvil Cell Laboratory is mainly devoted to high-pressure experimentation.

The laboratory is currently undergoing a major redevelopment. It contains single-crystal diffractometers that can be used with diamond-anvil cells for the investigation of materials at pressures up to 100 kbar.

We expect that the new facilities that we are installing will allow us both to work to higher pressures and to make measurements at simultaneous high P and T.

Fig. 8. Diamond Anvil Cell

Fracture Mechanics

The mechanical properties of volcanic rocks at high temperatures and low pressures are key properties in the understanding of a range of volcanological problems, in particular lava flow dynamics. The measurement of these properties on extrusive volcanic samples under the appropriate pressure and temperature conditions has a direct application in the assessment of volcanic hazards.

Research Equipment includes: High-temperature (700ºC) fracture mechanics apparatus using water/brine or gas as a pore fluid medium (up to 70 MPa) utilizing short rod specimens. This apparatus is used to simulate conditions in a volcanic ediface and lava flows.

A development of the above fracture mechanics apparatus has been to modify its design to a triaxial deformation cell to obtain mechanical strength data on rock samples at temperatures up to 1000ºC and pressures up to 30 MPa. Significantly, the cell uses large cylindrical rock specimens, 25 mm diameter by 75 mm long, never previously employed in such a high-temperature apparatus. The large specimen size is necessary to test volcanic rocks with their large crystals and vesicles.

Its operating temperature and pressure range encompasses the conditions of an advancing flow from the vent to the front, as well as the conditions of the volcanic rocks hosting magma at equivalent depths of up to 2 km.

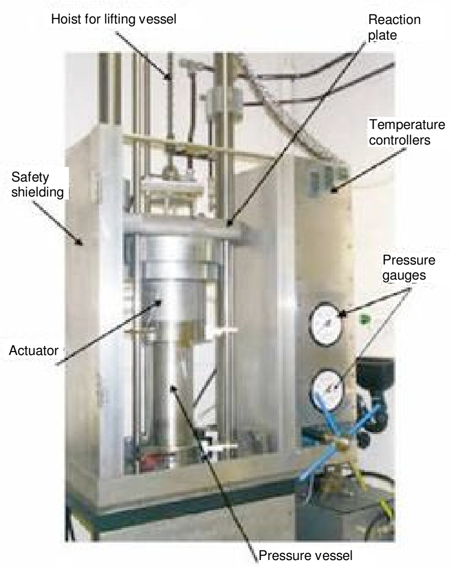


Fig. 9. Fracture mechanics apparatus. Image: UCL

X-Ray Diffraction Laboratory

The X-Ray Diffraction Laboratory contains instruments for both powder diffraction and general single-crystal experiments.

Research Equipment includes: A new PANalytical, X'pert PRO MPD, high resolution powder diffractometer. In addition to the new powder diffractometer there are facilities in this laboratory for investigating both single crystals and powders by photographic methods.

Fig. 10. Professor Price demonstrating atomic structure.

Fig. 11. High resolution powder diffractometer.

The Micropalaeontology Laboratories

The UCL Micropalaeontology facility specialises in calcareous fossils such as benthic and planktic foraminifera, siliceous fossils such as radiolarians and diatoms, and microfossil (conodonts and radiolarians) processing and extraction. This includes sample preparation facilities (a wet lab and fume hood for sample washing and acid digestion); a variety of microscopy and microphotography capabilities; reference collections of microfossil species and an extensive micropalaeontological reference library. We make use of the UCL Palaeoceanography research facilities.

The Rock Room

The Geology Collection contains a wealth of rocks, minerals and fossils collected from all over the world during the last 150 year history of the department. Primarily a teaching and research resource, some of the 40,000 specimens are on display to the public. One of the highlights is the Johnston-Lavis volcanological collection of minerals, rocks, photographs and gouaches collected from 1880–1912.

The collection also contains the NASA archive of thousands of images housed in the new Planetary Science suite, and the internationally important micropalaeontological collections.

The Rock Room is open to all visitors, not just UCL staff and students but also members of the general public, and will be staffed during the hours 13:00 - 15:00 every Friday. Groups of more than ten should make a prior appointment and introductory talks are available by arrangement.

The Planetary Centre can be visited by appointment.

Fig. 12. The Rock Room.
Image: UCL

Appendix 2

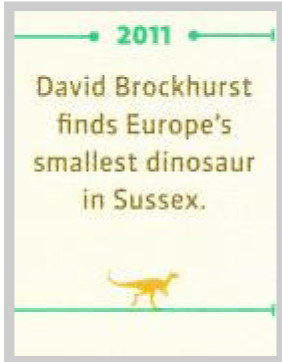
A copy of a paper by Stuart Robinson, a Royal Society University Research Fellow & Honorary Lecturer in the Department of Earth Sciences at UCL, was presented to HDGS members. The paper, by Stuart Robinson and his colleagues, is of particular relevance to our members as it concerns research conducted at Fairlight into early Cretaceous palaeoclimates. An abstract of the paper is given below:

ROBINSON, S. A., SCOTCHMAN, J. I., WHITE, T. S. and ATKINSON, T. C. 2010. Constraints on palaeo-environments in the Lower Cretaceous Wealden of southern England, from the geochemistry of sphaerosiderites. *Journal of the Geological Society, London*, **167**, 303–311.

Abstract
Sphaerosiderites are millimetre-scale concretions of $FeCO_3$ that form predominantly in waterlogged environments and are of use in palaeoenvironmental and palaeohydrological studies. We present petrographic, elemental and stable-isotopic ($\delta^{13}C$, $\delta^{18}O$) data from sphaerosiderites collected from the Lower Cretaceous Wealden sediments of southern England. The sphaerosiderites are composed of very pure $FeCO_3$, with only small amounts of Ca, Mg and Mn present, suggesting that they are well preserved and were precipitated from fresh groundwater. $\delta^{13}C$ values display a relatively large range from about −5 to −30‰ (VPDB). In contrast, $\delta^{18}O$ values are relatively invariant ($1\sigma = 0.83$‰), with an average of −3.01‰ (VPDB). The relationship between carbon and oxygen suggests that the sphaerosiderites faithfully record palaeo-groundwater $\delta^{18}O$. Likely $\delta^{18}O$ values for groundwater were calculated using a published, experimentally derived siderite–water fractionation equation and plausible assumed values for palaeotemperature. The average estimate was −4.9‰ (SMOW). The Wealden sphaerosiderite oxygen-isotope values are comparable with other early Cretaceous data from similar palaeolatitudes but lower than estimated Holocene values for equivalent latitudes. This observation may indicate greater rainfall at 30°N during the Cretaceous relative to the Holocene and also suggests relative stability of palaeoclimatic conditions during the early Cretaceous at this palaeolatitude.

David Brockhurst – Royal Mail's Stamp of Approval!

On the 10th October 2013 the Royal Mail issued a set of 'dinosaur' stamps illustrated by John Sibbick, one of the UK's and, indeed, the world's finest palaeo artists. Included in the set are several of our local 'dinosaurs' – *Iguanodon*, *Polacanthus*, *Baryonyx, Ornithocheirus* and *Megalosaurus*. The set was also available in a special souvenir presentation pack, and although I'm not a stamp collector, I couldn't resist sending for one. The pack consisted of ten different 1st class stamps and an illustrated leaflet written by Angela Milner (NHM) which gave concise information on all the fossil reptiles depicted on the stamps, along with a timeline of significant moments in the history of palaeontology from 1809 to date. It listed some of the great names in palaeontology and their discoveries, including William Smith who found the first *Iguanodon* bone in 1809 (not actually described until 1825); Mary Anning and her discovery of the first *Ichthyosaur* and *Plesiosaur* in 1811 and 1823 respectively; the discovery of the first *Iguanodon* tooth by Mary Mantell in 1822, and the description of *Iguanodon* by her husband Gideon Mantell in 1825; William Buckland naming the first 'dinosaur' *Megalosaurus* in 1824; Richard Owen coining the name 'Dinosauria' (terrible lizard) in 1841; William Walker's discovery of *Baryonyx* in 1983; and finally, in 2011, our very own "**David Brockhurst finds Europe's smallest dinosaur in Sussex**" !!



Of course this is not the first time that Dave has received recognition for his work or, in fact, been associated with the name of Mary Anning, as in 2011 Dave received the Mary Anning Award from the Palaeontological Association (Austen 2012), an accolade which is awarded "*to all those who are not professionally employed within palaeontology but who have made an outstanding contribution to the subject*". Dave was given the award in recognition of the discoveries he has made at the quarry in Bexhill where he has worked for almost 30 years, during which time he has assembled an important collection of fossil vertebrate material, most of which he has donated to the local Bexhill Museum (Fig. 1). This has included the partial remains of a *Polacanthus*, together with the first *Polacanthus* teeth to be found on mainland UK, (recently published by Bill Blows and HDGS member Kerri Honeysett (in press)), and the partial remains of an '*Iguanodon*', (also being studied for publication by Blows and Honeysett), as well as many other important finds (Austen *et al*. 2010).

Dave has also identified several important horizons in the quarry that have yielded a number of new species of microvertebrates including frogs, salamanders and lizards. Many of these have been included in the new Palaeontological Association Field Guide to Fossils *English Wealden fossils* (Sweetman and Evans 2011*a*, *b*) and others have been the subject of separately published papers (Naish and Sweetman 2011; Sweetman 2013). One of the more important finds that Dave has made in these beds, and the one for which he receives recognition in the Royal Mail stamp pack, is that of the cervical vertebra of a new small Wealden theropod (Fig. 2), regarded as Europe's smallest adult dinosaur (Fig. 3) and published in 2011 by Darren Naish and Steve Sweetman (2011).

Fig. 1. Some of Dave's discoveries on display in Bexhill Museum.

Fig. 2. Cervical vertebra of new Wealden theropod.

Photo: Steve Sweetman

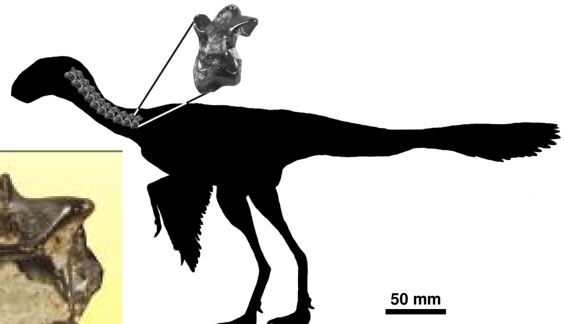


Fig. 3. Cervical vertebra shown in approx. life position in a generalised maniraptoran silhouette.

(from Naish and Sweetman 2011)

A crucial feature of Dave's collecting is his meticulous recording of the beds from which the specimens are recovered, adding significantly to the scientific value of the material. This attention to detail and Dave's generosity in donating specimens were instrumental in his receiving the Mary Anning Award which, along with recognition of his significant contribution to palaeontology in the Royal Mail's dinosaur timeline, is truly well deserved.

Peter Austen

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* *Wealden News* can be found at: http://geoconservationkent.org.uk/ (click on 'Resources' and scroll down page)

GEOLOGISTS' ASSOCIATION FIELD MEETINGS – 2014

The Hastings & District Geological Society 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 2014 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 2014

Sat 1st Mar. to Sun 2nd Mar. (t.b.c.)	Dorset - Inferior Oolite weekend	Bob Chandler
Fri 28th March	Quarries in the Somerton area, Somerset	Simon Carpenter
Sat 12th April	Hertfordshire/Cambridgeshire Chalk	Haydon Bailey
Sat 14th June to Sun 15th June	Geological Gems of the South Downs	Rory Mortimer
Sat 28th June to Sun 29th June	Devon Weekend	Richard Scrivener
Sun 20th July	Covehurst Bay, Hastings (Joint GA/HDGS trip)	Ken Brooks/Peter Austen
Fri 19th Sep. to Mon 22nd Sep.	Isle of Man	Dave Quirk/Dave Burnett
September/October (date t.b.c.)	Dorset: Weymouth and Portland	John Cope
Sat 1st November	GA Festival of Geology	Geologists' Association

Trips still to be finalised: Barton - Pete Reading / Bucks geology - Jill Eyres / Building stones of Tottenham Court Road - Ruth Siddall / Building stones of St Albans - Di Smith.

HDGS/GA field meeting: Cliff End to Fairlight

Saturday, 20th July 2013

by Peter Austen, Ken Brooks and Ed Jarzembowski

This was a joint field meeting of the Hastings & District Geological Society and the Geologists' Association led by Ken Brooks, Peter Austen and Ed Jarzembowski. About 30 members and guests assembled at 12 noon in the Smuggler's pub car park on a cool, cloudy day, despite the heatwave of the previous few days. After an introduction to the fossils and geology of the area (Fig. 1), the party walked along the promenade to the beach where the extensive remains of a Neolithic submerged forest are visible on the foreshore at low tide.

Fig. 1. Ken Brooks with snout of crocodile Goniopholis *found on beach at Cliff End. Photo: EJ*

The cliffs here form part of the Hastings Group (Valanginian, Lower Cretaceous, *c*. 138 Mya), and together with the cliffs west to Rock-a-Nore, are regarded as the best section of the lower part of the Wealden Super-group 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'), through to the lower part of the Wadhurst Clay Formation. These units reflect deposition in fresh-brackish water conditions and were formed when great quantities of sand, silt and mud were deposited by water flowing into this lowland area from the London massif to the north and, to a lesser extent, from the Armorican massif to the south and Cornubia to the west. The section has been long renowned for its diverse assemblage of early Cretaceous plant and animal fossils (Brooks 2001, Batten 2011; Batten and Austen 2011).

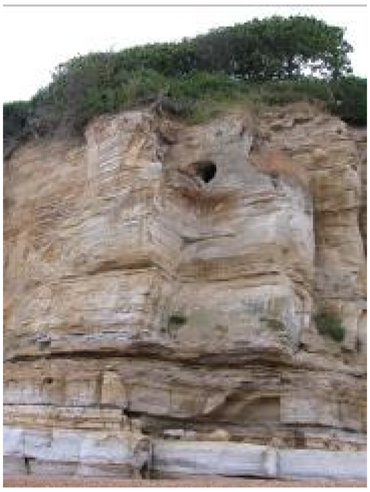

Fig. 2. Cave near top of cliff at Cliff End, exposed by erosion and thought to have been used by stone-age hunters. Photo: EJ

During the Alpine Orogeny, lateral extension and compression of the rocks in this area produced several normal and reverse faults. Near the start of the section, we saw the Cliff End faults, the largest of these being a classic example of a normal fault. Ken also pointed out a cave high in the cliffs (Fig. 2) where four flint blades and a Mesolithic flint axe had been found in the early 20th century (Palmer 1972) – this cave had formed in the late Pleistocene, and was later occupied by Mesolithic hunters. From here we walked along the beach observing the Cliff End Sandstone, a massive unit near the base of the Wadhurst Clay Formation. The beds rise gently and after about 200 m a shelf formed from the top of the Ashdown Formation was revealed at beach level. This consolidated but weakly cemented, fine sandstone contains an extensive bed of *in situ* quillworts extending for about 0.5 km, representing a large, shallow lake. As well as observing a number of *Isoetites* quillworts, a much larger quillwort, possibly the rare *Nathorstiana* (Austen and Batten 2011), was also seen (Fig.3).

*Fig. 3. Quillwort (*Nathorstiana*?) in life position near the top of the Ashdown Formation. Scale bar: 10 cm. Photo: EJ*

This area is also the most productive locality of the Cliff End Bone Bed, a coarse-grained, poorly sorted conglomeratic rock, containing fish teeth and scales, reptilian bone fragments and teeth, pterosaur teeth, and very rarely, primitive mammal teeth. This bed crops out near the top of the cliff, *c*. 3 m above the top of the Cliff End Sandstone, but periodic rock falls ensure there is an ample supply available for study on the beach and foreshore. Pieces of bone bed had been found along the beach up to this point, having been carried east by longshore drift.

As we progressed along the beach towards Cliff End Point, river channel sections, point bars and cross-bedding were observed in the cliff face with good examples of cross-bedding also found in blocks on the beach. Also seen were fallen blocks of siltstone displaying dinosaur footprints and dinoturbation (sediment disturbed by herds of dinosaurs traversing the Wealden floodplain). Gutter casts were also observed under some of the blocks (Fig. 4). Close to Cliff End Point a large, fallen slab from the Ashdown Formation was found displaying cross-sections of over 20 quillworts (*Isoetites*) on its surface (Fig. 5), providing further evidence for the extent of the quillwort bed.

Fig. 4. Gutter casts in fallen block from Wadhurst Clay. Scale bar: 10 cm. Photo: PA

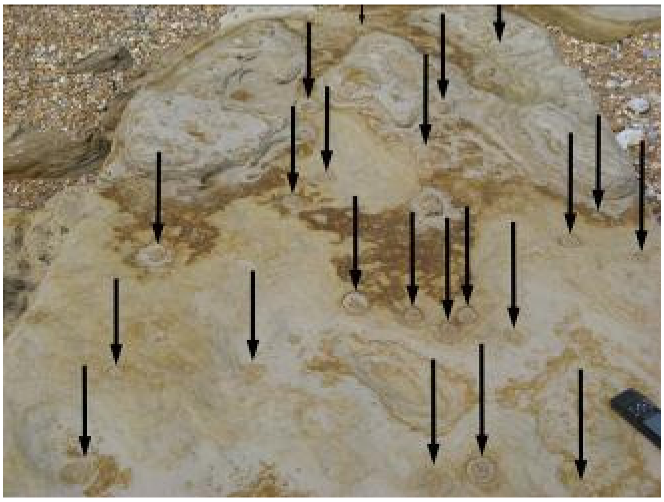

*Fig. 5. Cross-sections of over 20 quillworts (*Isoetites *- arrowed) in fallen block of Ashdown Sandstone nr Cliff End Point. Photo: PA*

Rounding Cliff End Point, we saw Haddock's Reversed Fault where the sandstones of the older Ashdown Formation were uplifted against the Cliff End Sandstone. Also at this point, a large number of *in situ* stems/roots could be seen in blocks of fallen sandstone; these have been usually interpreted as the horsetail *Equisetites*, although, in the absence of any clear diagnostic features, could equally well be Wealden clubmosses.

The group then walked across Fairlight Cove in front of the Norwegian larvikite sea defences constructed in 1990 to protect the houses near the cliff top at Fairlight from falling into the sea; the remains of some houses that had suffered such a fate could be seen on the cliff edge. At the west end of Fairlight Cove, we observed the Fairlight Cove Reversed Fault where the 'Fairlight Clays' of the lower Ashdown Formation have been thrust upwards against the sandstones of the upper Ashdown Formation. Unfortunately, the fault is now obscured by slumped clay and scree, but this marks the start of the 'Fairlight Clays' section and a unique Lower Cretaceous flora, occurring in extensive foreshore deposits. Plant remains, including part of a fern frond and a possible seed, were found by splitting blocks on the foreshore. A lignitic (coalified) piece of fossil wood was also found which appeared to be 'coal jet', a softer form of jet. Continuing around in front of the more recent Fairlight Landslip berm (completed in 2008 using Carboniferous Limestone from the Bordeaux region, France), the group arrived at an extensive plant-rich outcrop of 'Fairlight Clays' on the foreshore, and following a brief examination retraced its steps as the tide turned.

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A version of this report has been submitted to the Magazine of the Geologists' Association *for inclusion in the December 2013 issue. There will be a further joint HDGS/GA field trip to the central coastal section around Covehurst Bay in July 2014.*

Dinosaur found at Bexhill

by Peter and Joyce Austen

Many members will be aware that the partial skeleton of a juvenile iguanodont has been discovered in a quarry in Bexhill. The find, made by Joyce Austen in August this year, was in a newly scraped area near the base of the pit, within the Wadhurst Clay. Dave Brockhurst (HDGS) has been co-ordinating the excavation, assisted by Society members, and the recovered bones are being prepared and reconstructed by Dave before being donated to Bexhill Museum, where a number are already on display.

Bones previously found in the quarry have come from higher in the pit and have generally been well preserved and black/dark brown in colour. However, the bones from this new discovery are much greyer and somewhat fractured; this difference in preservation resulting from 'gleying' (repeated water-logging caused by fluctuating water tables during Wealden times), a process which has not affected those bones higher in the succession. The bones are also very jumbled, which suggests the carcass had been lying on the surface, exposed to predation and decomposition for some time before the bones were washed together and finally buried.

Excavation of any remaining material will continue in the Spring once the weather and conditions in the quarry improve. In the meantime we are grateful to the quarry Manager for allowing continued access to the site.

Iguanodont display at Bexhill Museum

Caudal vertebra

Caudal vertebral process

Iguanodont bones

All scales in cm.

Photographs by Dave Brockhurst.

Section of iguanodont jaw

Iguanodont tooth

Caudal vertebra

Dorsal vertebra

Scapulae

Cervical rib

Iguanodont bones
All scales in cm.

Ulna

Humerus

Femur

Phalange

Metatarsal

Phalange

Photographs by Dave Brockhurst.

Miss Marian Frost and her 'Geological Literature of Sussex'

by Anthony Brook

Experience has taught me over the years that material relevant to the History of Geology turns up in the unlikeliest of places, in books, periodicals, etc. that bear little relationship to the subject. Bearing that experiential axiom in mind, I pose the question: why does the book *The Early History of Worthing*, written by a librarian, have a completely unrelated Appendix on 'The Geological Literature of Sussex'? That a slender volume of specific local interest should have such an anomalous appendix remains a mystery, but redounds to our intellectual benefit. The perpetrator of this peculiarity was a lady called Miss Marian Frost.

William Frost, dentist and chemist, brought his family from Bromley, Kent, to Worthing, Sussex, in 1879, and established his business and home in North Street, on the contemporary northern outskirts of the growing town. His fifth child, and third daughter, Marian, was the last to be born in Bromley, in 1876, and therefore came to Worthing as a 3-year old: one further son was born after the move to Worthing (Fig. 1). As his business prospered and his family grew up, William Frost moved to larger, purpose-built premises in Railway Approach in 1887 (Fig. 2). A small display advert in Kershaw's *Directory of Worthing* (p.106) informs customers that "These new and greatly-enlarged Premises, built expressly for the accommodation of William Frost's rapidly-increasing business, are now open for the Supply of Drugs and Chemicals, of guaranteed purity".

The House of William Frost (1881–1901)

(Census Enumerator's Schedule)

1881	1891	1901
1 North Street	*9 Railway Approach*	*9 Railway Approach*
William Frost Age 38 Dentist b. St. Pancras, London	William Frost Age 48 Dentist / Chemist b. St. Pancras, London	William Frost Age 58 Dentist / Chemist b. St. Pancras, London
Mary Frost Age 37 b. St. Pancras, London	Mary Frost Age 47 b. St. Pancras, London	Mary Hannah Frost Age 57 b. St. Pancras, London
William Frost Jnr. Age 15 Scholar b. Bromley	William Frost Jnr. Age 25 Medical Student b. Bromley	
John Frost Age 12 Scholar b. Bromley	John Frost Age 21 Medical Student b. Bromley	
Mary Frost Age 9 Scholar b. Bromley	Mary Frost Age 20 Medical Student b. Bromley	
Alice Frost Age 7 Scholar b. Bromley	Alice Frost Age 19 b. Bromley	
Marian Frost Age 4 Scholar b. Bromley	Marian Frost Age 14 Scholar b. Bromley	Marian Frost Age 24 Public Librarian b. Bromley
Henry Frost Age 1 b. Worthing, Sussex	Henry James Frost Age 12 b. Worthing, Sussex	Henry James Frost Age 21 Carpenter b. Worthing, Sussex
Servants	Servants	Servants
		Eliza Emily Greenfield Age 16 b. Worthing, Sussex

Fig. 1. Census for the Frost family for 1881, 1891 and 1901.

At the time of the decennial Census in 1891, his three eldest children were all 'medical students', including his eldest daughter, Mary. Ten years later they had all left home, and only Marian and Henry were still living in the family home (Fig. 1). Although The Bridge Pharmacy, as it became known, remained in the family, William Frost retired in 1906 to a newly-built, substantial house on the corner of Shakespeare Road and St Matthews Road, facing Victoria Park and Recreation Ground. His unmarried youngest daughter, Marian, continued living there, after the successive deaths of her parents, until her own death in late December 1935.

Fig. 2. The Bridge Pharmacy.

The young Marian Frost must have had a very striking personality, because she was only 20 years old when she was appointed Assistant to Mr R. W. Charles when Worthing Public Library first opened its doors, in the old West Worthing Commissioners' offices in Rowlands Road in December 1896. The next year it moved into the town centre and took over Richmond House, on the corner of Richmond Road and Chapel Road, until it was demolished to make way for the splendid, new, architect-designed Public Library and Museum (Fig. 3).

Marian Frost had been upgraded to Librarian in 1901, and the following year she began to pursue, and finally persuaded the Scots-born, American industrial philanthropist Andrew Carnegie, to donate £6,200 towards the cost of a brand-new building for the Public Library, under the Public Libraries Act of 1892. Carnegie insisted upon three conditions: the Borough Council should provide the site free of all charges, and levy the free-library rate, to raise funds for repair and maintenance; and also that 90% of the construction workforce should come from the unemployed, as the Council would receive a Government grant for so doing. The outstanding building cost was met by an anonymous benefactor, later publicly identified after his death, as Alderman Alfred Cortis, Worthing's first Mayor in 1890. The handsome 'Wrenaissance'-style building in Chapel Road, to house Worthing Public Library, Art Gallery and Museum, was ceremonially opened by the local M.P. in December 1908. Unusually, it had an all-female staff of seven young ladies in severe, Edwardian, uniform-style dresses (Fig. 4).

Fig. 3. Newly built Worthing Public Library in 1908.

Marian Frost became Head Librarian of a Public Library in 1919, the first lady to do so, and, during the same year, was persuaded to take on additional responsibilities as Curator of Worthing Museum. In both roles she did an excellent job, steadily building up the extensive and invaluable Collections of local and County archival material.

Marian Frost was elected a Fellow of the Library Association, and was the first woman to receive the Diploma of The Museums' Association. She served on its Council for many years, and was Hon. Local Secretary for the Annual Conference held in Worthing in 1929. Five years later she was one of six British delegates to the Conference of the American Association of Museums, held in Toronto, Canada.

Her primary interest outside work was archaeology. She was a founder member of the Worthing Archaeological Society in 1922, and served as Hon. Secretary until forced to retire due to failing health in 1934. She was made a Life Member, and elected President in 1935. She was also a strong supporter of the Sussex Archaeological Society, acting as Local Hon. Secretary for Worthing from 1921 until health problems in 1934 led to her resignation.

Marian Frost appeared in the press a few times during her lifetime. The first reference to her would seem to be at one remove: in *Sussex Notes and Queries* vol.1 (1926-27) p.65, there is a reference to "Old Dovecotes, at Coombes Place, Lewes, figured in *Country Life* 7 September 1912, by Miss M. Frost". Two articles about her and her work, in 1915 and 1921 respectively, are historically interesting, as they illustrate the striking innovations in women in the workplace at this time: 'Woman and her Work; the Woman Librarian' in *The Worthing Gazette* 8 September 1915; and 'Women who have made Good' in *Lady's Pictorial* 26 February 1921. In the mid-1930s *The Worthing Herald* published a series of caricatures of well-known local personalities; Marian Frost was so honoured on 13 January 1934 (Fig. 5). It captured the forceful spirit of a lady whom contemporary commentators described as "a remarkable and formidable woman". *The Worthing Herald* of 25 January 2007 proclaimed her entry into the 'Worthing Hall of Fame'.

Fig. 4. Worthing Library staff in 1909; Marian Frost centre.

Remaining a spinster all her life, she passed away, unexpectedly, aged only 59, on 27 December 1935, greatly mourned by many in the town, to which she had given such magnificent service. Obituaries and tributes to her were published at three geographic scales: Local, in *The Worthing Gazette* (8 Jan 1936) and *The Worthing Herald* (4 and 11 Jan 1936); County, in the *Sussex Daily News*

(30 Dec 1935) and the *West Sussex Gazette* (2 Jan 1936); and National, by Frank Rutter in *The Times* (4 Jan 1936) and *The Museums Journal* vol.35 (Feb 1936) pp.422-424. They all praised her charismatic character and lifetime achievements.

Marian Frost published little in her lifetime, and the little she did publish was related to her pastime pursuit of archaeology. Her major effort in this field caused a certain amount of rancour and dispute in 1924. She acted as Secretary of the Editorial Committee of C.H. Goodman (Chairman) and the Eliot Curwens, father and son, appointed by the Worthing Archaeological Society, to prepare a Report on the 'Blackpatch Flint-mine Excavation, 1922', and was, therefore, listed as co-author of the lengthy paper that appeared in the *Sussex Archaeological Collections* vol.65 (1924) pp.69-111. That aroused the ire and indignation of John Pull, Director of the Excavations, who had been neatly sidelined because of his age, inexperience and working-class background. In a Letter to the Editor in the *Worthing Herald Magazine* 4 October 1924, John Pull, on behalf of his team of amateur excavators, vented his annoyance at both the Worthing Archaeological Society and the Sussex Archaeological Society for ignoring his official Report and publishing their own measurements and interpretations. He wrote: "We yield to no one in our admiration for the Editorial Committee in producing this undoubted work of art, especially considering the artistic manner with which it ignored all necessary, and no doubt, troublesome data", and more in the same vein. John Pull resigned from the Worthing Archaeological Society, and did not rejoin until after the War. This was a controversy that Marian Frost, and others, could well have avoided, with the exercise of greater tact, but then it nicely reflects social attitudes of the interwar period.

WHO'S WHO IN WORTHING

MISS MARIAN FROST,
appointed Worthing Librarian and Curator in 1896 and the first woman to receive the Diploma of the Museums' Association. She is author of "Early History of Worthing," published 1929.

Fig. 5. Caricature of Miss Marian Frost appearing in The Worthing Herald *on 13 January 1934.*

In 1929 Marian Frost brought forth her one and only book, a slim volume of less than 100 pages, on *The Early History of Worthing*, with the subtitle 'being an account of the chief events from Pre-historic times to a century ago'. It was privately printed, in a short print-run, by Combridges, of Church Road, Hove, and is, therefore, quite rare. Although the publication date is clearly 1929, there are three pieces of internal evidence that suggest that the text was completed by 1915: the last, very brief Chapter is 'Worthing in 1815'; the phrase in the subtitle 'to a century ago' only really makes sense if written in 1915; and the last entry in the geological bibliography is for January 1915. The reason for the 14-year hiatus before publication will have to remain one of those mysteries of history. Although it seems contradictory to end an 'Early History' as late as 1815, she could, at least, have updated the bibliographical listing to the time of publication. Maybe she simply lost interest, got distracted by other matters, mislaid the manuscript, or just could not find a publisher: we shall never know.

This slim volume has eight preliminary pages detailing Contents, Preface and Illustrations, followed by 13 Chapters (pp.1-71), Appendix (pp.73-90) and finally, an Index (pp.91-99). There are five blank pages. The Appendix, on the unexpected and unrelated topic of 'The Geological Literature of Sussex', occupying 17% of the whole book, has considerable value as a historic document, to geologists in general and Sussex geologists in particular, but is probably little known because of the obscurity of its publication. It is, therefore, reprinted in its entirety herewith, as a service to both Sussex and Geology.

She begins her survey by asserting that "an examination of the literature shows that Sussex has contributed its quota to geological science" (p.73), and, shortly thereafter, declares that "the County of Sussex seems to be second only to Yorkshire in the production of Geological Classics" (p.74), two statements with which Sussex geologists can only most heartily concur. She emphasises the coastal changes on early printed maps of Sussex, and continues: "Another interesting series of county maps, having a distinct geological value, but not originally so intended, were the 'soil maps' issued in the Reports published by the Board of Agriculture over a century ago" (p.74). What she had in mind in particular was Arthur Young's 'Sketch Map of the Soil of Sussex', published in 1808 and 1813. The first purely geological map of Sussex was published by William Smith in 1819, as part of his County map series. Thereafter, and throughout the 19th century, commercial publishers and the Geological Survey published Geological Atlases of Britain, with Sussex coloured geologically. Such maps in series form an instructive sequence in the development of geological knowledge about the County.

The core of her inventory lists "the most important works of geological interest, arranged under authors, in order of date of publication" (p.77), starting, unsurprisingly, with Gideon Mantell (pp.77-79), who, like the following, is denoted by capital letters: Thomas Webster (pp.79-80); Roderick Murchison (p.80); Peter John Martin (pp.80-81); William Henry Fitton (p.81); William Perceval Hunter (pp.81-82); Frederick Dixon (pp.82-83); and Clement Reid (p.86). She remarks that Fitton's *Geological Sketch of the vicinity of Hastings* (1833) "forms a distinct landmark in the history of Sussex Geology" (p.81); and comments, acidly, that the "knowledge [that Dixon's fine archaeological collection now resides at Alnwick Castle] is most disagreeable, as, like Mantell's famous [fossil] collection, it is to be regretted that it did not remain in the County where the collection was made" (p.83). She also notices that the three most important, Sussex-born geologists (Mantell, Martin and Dixon) were all members of the medical profession, devoting all their leisure time to the pursuit of the highly-fashionable science of Geology, and amassing invaluable collections of Cretaceous and Palaeocene fossils and a direct understanding of Sussex strata.

She starts her catalogue of Sussex geology with Mantell's paper in the *Transactions of the Linnean Society* in 1814, and ends it with Brydone's paper on 'The Marsupites chalk of Brighton' in the *Geological Magazine* of January 1915, thus covering a century or so of geological investigations in the county. She acknowledges that "this list is not complete, but I think I have given enough to show that the geology of Sussex is of no mean importance" (p.89), a final flourish of universal agreement.

Although this panorama of the Geological Literature of Sussex is wide-ranging, from maps to papers to memoirs, and includes some obscure sources, such as Science Gossip and Knowledge and Scientific News, it has major faults and defects as a viable and functional bibliography, seriously lacking specific details of the publications listed. For instance, most of the periodical references lack either the volume number and/or the page numbers, providing only a general indication of where the article is to be found. Statements such as "The Geological Society also published many of [Peter John] Martin's papers in 1834, 1842, 1856" (p.81) are indicative, but of little real use and value.

Apart from being incomplete, in places it is also inaccurate. Take the case of Dr Frederick Dixon. The first Worthing Dispensary was established, by Dr Dixon and others, in Ann Street, next to the Theatre Royal, in 1829, moving to new, purpose-built premises in Chapel Road in 1845. Although there would seem to be 40 Plates in Dixon's posthumous masterwork, usually known by its shortened title of *The Geology of Sussex*, according to the title page, there are, in fact, 44. More importantly, the geological map of Sussex, by William Topley, accompanied the 2nd edition of this volume, revised and augmented by Professor T. Rupert Jones, and published in 1878. This was three years after Topley's magnificent Memoir on *The Geology of the Weald*, which accurately listed 564 publications up to 1875, many of them having to do with Sussex.

It is, therefore, highly advisable to treat this memorandum with the utmost care and caution. Nevertheless, considered as a broad cursory survey of the field by a librarian rather than by a geologist or a bibliographer, incidental to the main thrust of her work or interests, and reflective of its day and age, it is a reasonable place from which to begin investigating the geology of Sussex during the period of exciting geological discoveries. It is the most valuable part of an otherwise rather unexceptional book.

One final issue, of great current relevance. With reference to William Smith's beautifully coloured Geological Map of Sussex, published in 1819, Marian Frost proudly proclaims that "we [presumably, Worthing Library] have recently acquired a copy of his map for our Sussex Collection" (p.76); and reproduces it, in monochrome, at the end of the Appendix (p.90). That may have been the case at the time, but neither Worthing Library nor the West Sussex Records Office in Chichester currently have a copy of this cartographic icon. Indeed, David Kingsley, in his authoritative *Printed Maps of Sussex 1575-1900*, Sussex Records Society, Vol.72 (1982) p.122, lists only two simulacrums of this innovative perspective of the county, one in private hands and the other in a bound-set of County Geological Maps in the archives of The Geological Society, which, as it turns out, is most fortuitous. The November 2013 issue of *Geoscientist* (p.8) reported that all these county maps have recently been photographed in high resolution by the Society and are now available as high-quality prints. That means that we can now all acquire a copy of William Smith's Sussex map, if we so wish, in good time to celebrate the bicentenary of his masterful geological cartography of England and Wales, published in 1815. Every Sussex geologist should have one, as should every Public Library in the County!

Published sources on the life and legacy of Marian Frost, apart from those noted in the text, are scarce and sparse:
1. Robert Elleray. *Worthing: A Pictorial History*, Phillimore, 1977, Nos 71 & 72.
2. Robert Elleray. *Aspects of Change*, Phillimore, 1985, Nos 107 & 108.
3. Rob Blann. *Worthing in Old Picture Postcards*, European Library, 1993, No.8.
4. Robert Elleray. *Millennium Encyclopaedia of Worthing History*, Optimus, 1998, pp.8, 93-94.
5. Sally White. *Worthing Past*, Phillimore, 2000, pp.80-82.
6. Freddie Feest. 'Bygones' in *The Worthing Herald*, 28 June 2001.
7. Sally White. *Worthing through Time*, Amberley Publishing, 2009, p.33.

Figures 2-5 are reproduced from the County Photographic Archive, with the permission of West Sussex County Council Library Service (www.westsussexpast.org.uk).

Appendix on 'The Geological Literature of Sussex'

from 'The Early History of Worthing' by Marian Frost

APPENDIX

The Geological Literature of Sussex

AN examination of the literature shows that Sussex has contributed its quota to geological science. Primarily the excavations for the well known Sussex iron revealed the geological possibilities of the County.

Later the agricultural wealth of the weald resulted in soil maps, etc., being produced. Then the well known discoveries made in the Iguanodon quarries by Dixon, Mantell and others enabled our palaeontological treasures to be known to the scientific world.

The subsequent investigations in the Hastings beds, and in the chalk, culminating in the memoir of Dr. A. W. Rowe, and more recently the remarkable finds at Piltdown (proving to be the oldest remains of man-like forms in the whole universe), have given our county a publicity which is flattering, but quite appalling to the Bibliographer. The research connected with the Piltdown Skull is resulting in a literature of its own for I find that over three score items on the subject have been published already.

Details of the Chief Geological features of our County are to be found in W. Jerome Harrison's *Geology of the Counties* 1882, (*Sussex pp.* 263-268), Messrs. Topley and Whitaker's *Geology of the Weald*, (*Geol. Survey Memoir*, 1875) which contains a list of 564 memoirs and papers, H. B. Woodward's *Geology of England and Wales* (1st ed. 1876, 2nd. ed. 1887), in Clement Reid's article on *Geology in the Victoria County History of Sussex*, Vol. 1, 1905, and in the excellent little maps published in

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APPENDIX

the geological atlases first by Reynolds, and later by Stanford.

In addition there are various important memoirs by Mantell, and others, written in the early days of geological research ; the *Quarterly Journal of the Geological Society*, the *Proceedings of the Geological Association* and the *Geological Magazine*, all of which contain a great number of papers.

These deal with subjects varying from the fertility of Soils, Coast changes, the structure of Saurian teeth, building stones, palaeontology of the chalk, mining, pre-historic man, and natural gas, all being included in the general science of geology. The County of Sussex seems to be second only to Yorkshire in the production of Geological Classics.

As the science of geology deals with the changes in the earth's surface which have taken place from the very earliest times to the present day, we find that old maps give information relating to the former outline of the County, and as these show that great changes have taken place during the past few centuries the information is of geological value, though the old cartographers had no knowledge that the work they were doing would be of value to the future " Knights of the Hammer."

Palmer and Covert's map of the Sussex Coast made in 1587, Saxton's map of 1579, and Speed's map of 1610 (referred to in Miss Gerard's excellent paper on " *Sussex Maps*,"*) are among the best known, and on examination show remarkable differences in our Coast-line as compared with that shown on our beach of to-day.

Another interesting series of county maps, having a distinct geological value, but not originally so intended, were the " soil maps " issued in the Reports published by the Board of Agriculture over a century ago.

*Ethel Gerard. Notes on some early printed maps of Sussex with special reference to those in the Worthing Public Library. 1915.

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Through the courtesy of the representatives of the Board of Agriculture I recently had access to these maps at their offices at Whitehall. They were the first which actually showed coloured representations of Sussex soils, and as the different soils are due to the different geological beds beneath, the maps are naturally to a great extent, geological.

A "*General View of the Agriculture of the County of Sussex*" by the Rev. Arthur Young (97 pp.) was published in 1793. It was quarto in size, with wide margins and issued in that form in order that it might be amended and improved before the final report was published.

This occurred in 1808, the volume being octavo with 486 pages, proving that the report had been severely dealt with during the intervening 15 years.

With this work was issued a "*Sketch Map of the Soil of Sussex*" (12½ by 5in.), which was coloured to show sand, waste, clay, rich and stiff loam, marsh, chalk and rich loam. It was engraved by Neele of the Strand; another edition was published in 1813. The first purely geological map of Sussex was published by William Smith the "Father of English Geology," in 1819, four years after his famous large Geological Map of England and Wales.

Smith began publishing a series of County maps in 1819, but the work was never completed, and the parts issued are very scarce.

These maps contained much more detail than appeared in his large general map of 1815. They were issued four at a time and the first instalment contained the first purely geological map of our county.

It was entitled "*A new Map of Sussex*, divided into Hundreds, exhibiting its Roads, Rivers, Parks, etc., by John Cary, Engraver, 1819." and at the top, "*Geological Map of Sussex by W. Smith, mineral surveyor.*"

This map is coloured, and there are tablets explaining the different colours.

2, 3 and 4 ...	Brick, Earth and Sand.
5 ...	... Chalk.
6 and 7. ...	Green Sand and Golt (*sic*) Brick Earth.
8 and 10. ...	Sand beneath the Golt (*sic*) Brick Earth.
11 ...	... Oaktree Clay.
13 ...	... Sand and Sandstone.

It measured 22in. by 19¾in. Scale 1in. = 5 miles.

Smith gives many interesting details of the various beds, we have recently acquired a copy of his map for our Sussex Collection. He also published in 1819 a "*Section of Strata in Sussex dipping southward,*" this is also very scarce.

In 1860 Reynolds published his "*Geological Atlas of Great Britain*" which included a well drawn map of Sussex, coloured geologically, based on the maps by Emslie, which were prepared for Reynold's "*Travelling atlas of England,*" in 1848.

A "new edition" with slightly different colouring appeared in 1864 and a "Second" edition (should be third) in 1889.

The same plates were used by Stanford who published a geological map of Great Britain in 1904, another edition in 1907, and a third in 1914. These were published under the direction of the late H. B. Woodward who brought them up to date, and added useful information as to the palaeontological contents of the different beds exposed around our coast.

The Official Geological Survey maps published in 1864 and revised in 1893 respectively, are of course the most authoritative.

An interesting lesson in the evolution or development of the geology of our county can be gathered from a perusal of the southern portion of our great geological maps.

There is, first, Smith's map of England and Wales of 1815, then Greenough's well known maps (1st. ed. 1820, (dated 1819), 2nd. ed. 1839, 3rd. ed. 1865).

Walker's maps (1835, 1838, 1842, etc.) and with these the maps of the geological survey form an instructive sequence.

I propose to give a list of the most important works of geological interest and have arranged them under authors in order of the date of publication.

MANTELL.

Gideon Algernon Mantell was born at Lewes in 1790 and died in 1852. He was a prolific writer. In Agassiz and Strickland's Bibliographia Zoologiae there are no fewer than 67 books and memoirs under his name—However, I propose only to deal with those of Sussex interest.

Mantell was the first to demonstrate the fresh-water origin of the Wealden strata and by his researches among them he discovered four out of the five genera of Dinosaurs which were known up to 1852.

Lower says that "Dr. Mantell was the first writer who by his works and his lectures made geology a popular science."

In 1814 Mantell read before the Linnean Society a paper entitled: "A description of a fossil *Alcyonium* from the chalk strata near Lewes." This was printed in the Society's *Transactions* Vol. II, and was the first of a long series of publications.

In the Provincial magazine, 1818 appears "A sketch of the geological structure of the South-Eastern part of Sussex."

In 1822 he published his first book, "*The fossils of the South Downs, or illustrations of the geology of Sussex,*" the engravings executed by Mrs. Mantell from drawings by the author. London: 1822. pp. XVI.—328. Map. 42 plates.

In the *Transactions of the Geological Society*—Vol. 1, pt. 2, 1824, appears :—

"Descriptions of some fossil vegetables of the Tilgate Forest in Sussex."

In the *Philosophical Transactions* 1825 :—

Notice on the Iguanodon a newly-discovered fossil reptile from the sandstone of Tilgate Forest, Sussex. (Read before the Royal Society Feb. 1825.)

In the Transactions of the Geological Society 2nd series, Vol. 2 pt. 1. 1826 :—

On the iron sand formation of Sussex.*

All the above were by Mantell. In 1827 he published "*Illustrations of the Geology of Sussex,*" containing a general view of the geological relations of the South-Eastern part of England with figures and descriptions of the fossils of Tilgate Forest. London: 1827 quarto illus. 22 plates. pp. 92.

In the *Transactions of the Geological Society*, 2nd series, Vol. 3, pt. 1, 1829 :—

"A tabular arrangement of the organic remains of the County of Sussex." This paper was read in January, 1828.

In 1833 he published "*The Geology of the South-East of England.*" London: 1833. Royal octavo pp. xxx.—416 5 plates illus. maps.

In the same year he published "*A descriptive catalogue of the objects of Geology, Natural History and Antiquity, chiefly discovered in Sussex,*" in the Museum attached to the Sussex Scientific and Literary Institution at Brighton. 44pp.

In the *Philosophical Transactions of the Royal Society* 1841, Mantell.

"*Memoir on a portion of the lower jaw of the* Iguanodon *and on the remains of the* Hytaeosaurus *and other saurians discovered in the strata of Tilgate Forest, in Sussex.*" Illus.

*This paper was read in June, 1822.

In the *Annals and Magazine of Natural History*, August 1845, 24 pp :—Mantell.

"Notes of a microscopical examination of the chalk and flint of the South-East of England."

In the *Philosophical Transactions*, 1848 :—

Mantell.

"On the structure of the maxillary and dental organs of the Iguanodon," illus. (This describes specimens from Cuckfield.)

A pictorial atlas of Fossil remains consisting of coloured illustrations with descriptions. London : 74 plates. pp. 207. 4to. 1850.

In the *Philosophical Transactions* pp. 379—90 plates, pt. 2, 1850. 4to :—

"On the Pelorosaurus, an undescribed gigantic terrestrial reptile whose remains are associated with those of the Iguanodon and other saurians in the strata of Tilgate Forest in Sussex.

Same journal pp. 391—2 plates.

"On a Dorsal Dermal plate of the Hylodosaurus recently discovered in the strata of Tilgate Forest."

Mantell had a very famous collection of fossils which unfortunately were not retained in the County of its origin, (as the Worthing Museum was not then in existence), but was sold to the British Museum for £5,000.

Mantell also wrote an appendix to Horsfield's "Lewes"—"The outlines of the Natural History of Lewes," and in Cartwright's "Bramber"—"A sketch of the geological structure of the Rape of Bramber," and in Horsfield's "Sussex"—"Geology and mineralogy of Sussex."

WEBSTER.

In the *Transactions of the Geological Society*, Vol. 2, 1814, Thomas Webster "On the Freshwater formations in the Isle of Wight, with some observations on the

strata over the chalk in the South-East part of England." pp. 161-254. (Many references to Sussex.)

In the same journal, 2nd series, Vol. 2, pt. 1, 1826, Webster, "Observations on the strata at Hastings in Sussex." This paper was read in 1824.

Sir Alexander Crichton. Notice on some fossil shells from Langton Green, near Tunbridge Wells. *loc. cit.* Vol. 1, 41, 2nd series. pp. 173-4.

F. Sargent, Notice on Fuller's earth found in Chalk in Sussex. Read June 1st, 1821. *loc. cit.* Vol. 1, pt. 1, 1822.

J. S. Miller, "*Observations on Belemnites.*" Read April, 1823, refers to Sussex specimens. *loc. cit.* 2nd series, Vol. 2, pt. 1, 1826.

In the same journal, Miller. On the *genus Actinocamax* (Belemnite). (Read May, 1823, refers to Sussex Specimens.)

MURCHISON.

Geological sketch of the North Western extremity of Sussex and the adjoining parts of Hants and Surrey. (Read Dec., 1825.) In the *loc. cit.*, 2nd series, Vol. 2, pt. 1, 1826. Sir R. J. Murchison.

In the Quarterly Journal of the Geological Society, Vol. 7, 1851. Murchison. On the distribution of the flint drift of the South-East of England to the South and North of the Weald and over the surface of the South Downs.

MARTIN.

Peter John Martin, who was born at Pulborough in 1786, and died 1860, Published his "A Geological memoir on a part of Western Sussex, with some observations upon chalk basins, the Weald denudation and outliers-by-Protusion," in 1828.

London : 1828, 100 quarto pp. 3 plates and an excellent map and coloured sections. The Sub-divisions

shown by colours were Glauconite—malm galt, Shanklin sands, Wealden—Weald clay, wealden sand, Sussex Marble.

The Dictionary of National Biography mentions 4 plates in this work, but the copy in the Worthing public Library which is apparently complete, has only 3, the explanations also only deal with 3 plates.*

In the Philosophical Magazine, 1851, Vol. 2, he wrote, "On the anti-clinal line of the London and Hampshire Basins." The Geological Society also published many of Martin's papers in 1834, 1842, 1856.

FITTON.

Dr. William Henry Fitton, born 1780, died 1861. Dr. Fitton's best work was done between 1824 and 1836. He then defined the proper succession of the strata between the oolite and the chalk, separating the green sand into an upper and a lower division, divided by a bed of clay, the galt.

It was he who distinguished the alternating sands, sandstones, clay, etc., which form the central group of strata in that part of Sussex by the name of Hastings Sands." In 1833 he published his "geological sketch of the vicinity of Hastings," illus., 94 pp. This work forms a distinct landmark in the history of Sussex Geology.

In the *Transactions of the Geological Society of London*, Vol. 4, 1836, he wrote on "Observations on some of the strata between the chalk, Oxford oolite in the South-East of England."

He published altogether about 21 papers and many distinguished travellers received assistance from him in the science of practical geology.

HUNTER.

In the *Magazine of Natural History*, Nov. 1835 appears, by William Percival Hunter, "Some account

*As is often the case in these early works the plates varied, even when only one edition appeared.

of the Limestone quarries and petrifying spring at Pounceford in Sussex with preliminary remarks on the Wealden Rocks."

Hunter, "Geological notes comprising a description of the limestone quarries and petrifying spring at Pounceford, in Sussex," etc., 102 pp. illus., 1835, plates, maps.

In the *Magazine of Natural History* for Jan., 1840, appeared :—

James S. Bowerbank.

On the London clay formations at Bracklesham Bay, Sussex.

In the same magazine Feb., 1840 :—

John Edward Lee.

Remarks on the teeth of reptiles from the Tilgate grit of Battle and St. Leonards.

In the *Quarterly Journal of the Geological Society*, Vol 13, 1857 :—

R. A. Godwin-Austen.

"On the newer tertiary deposit of the Sussex coast."

In the same journal, Vol. 15, 1859 :—

Sir Joseph Prestwich.

"Westward extensions of the old raised beach at Brighton."

DIXON.

Frederick Dixon was born at Storrington, Pulborough, on March 16th, 1799, and died 1849.

Dixon was one of the active founders of the Sussex Archaeological Society. He was a surgeon—the originator and supporter of the first Worthing Dispensary, which was erected in Chapel Road, Worthing, in 1846.*

*A memorial window was publicly subscribed for and placed in the building and is now to be seen in the present Hospital.

Dixon was the author of *The Geology and fossils of the Tertiary and cretaceous formations of Sussex.* London, 1850, quarto, 424 pp., 40 plates and a geological map of Sussex reduced from the geological survey by W. Topley. Scale 4 miles to 1 inch. Prepared for the press by Sir Richard Owen. W. J. Smith, Brighton 1878, quarto, 470 pp.

This book was published after Dixon's death and although he had so liberally supported the Dispensary it was feared that the publication of his book would be delayed on account of the costly nature of the production of the plates which were over 40 in number. However, Mrs. Thwaytes, of Charman Dean, Worthing, who had also contributed to the Dispensary, came to the aid of Mrs. Dixon and supplied funds for the completion of the work. The 2nd edition was revised and augmented by Professor T. Rupert Jones.*

Dixon had a fine archaeological collection, and referring to it the Sussex Archaeological Society Report for the year 1852 says, "It is agreeable to know that his valuable museum has since found a worthy home in the choice collection at Alnwick Castle." I submit that this knowledge is most disagreeable as like Mantell's famous collection it is to be regretted that it did not remain in the county where the collection was made.

It is noteworthy that the 3 most important geologists born in Sussex—Mantell, Martin, and Dixon were all members of the Medical profession and devoted their spare time to the science of Geology as a hobby.

In *The Geologist* August 1863, S. J. Mackie, "Thoughts on Dover cliffs," (deals largely with Sussex Geology).

Frederick Drew, "The Geology of the County between Folkstone and Rye, including the whole of the Romney Marsh," *Geol. Survey Memoir*, London, 1864. 8vo.

*A review of his Geology of Sussex appears in the *Geological Magazine*, 1878.

In the *Proceedings of the Geological Society*, 1867 :—

Searles V. Wood.

On the structure of the post glacial deposits of the South-East of England.

In the *Journal of the Geological Society*, Vol. 27, 1871 :—

S. V. Wood.

"Denudation of the Weald Valley."

In Hardwicke's *Science Gossip*, Aug. 1869 :—

Henry L. C. Watts.

A "Sarment" in a Sussex Stone pit.

Caleb Evans.

"On some sections of chalk between Croydon and Oxted with observations on the classification of the chalk," being a paper read before the Geologists Association, Jan. 7, 1780. Lewes, printed by G. P. Bacon, Sussex plan 40pp.

In the *Geological Magazine*, 1871 :—

William Whitaker (Born 1836, died quite recently).

On the chalk of the cliffs from Seaford to Eastbourne. (A paper read before the Geological Society of London, Dec. 1, 1870). Compares chalk of Sussex with that of the Kentish Coasts.

In the *Geological Magazine*, May 1871 :—

On the chalk of the cliffs from Seaford to Eastbourne, Sussex.

In the proceedings of the Geological Society, 1871 :—

On the cliff sections of the tertiary beds West of Dieppe in Normandy and Newhaven in Sussex, 1871.

In the *British Association Reports*, 1885, appears a most valuable "Chronological list of works on the coast changes and shore deposits of England and Wales,"

which contains many items of Sussex interest too numerous for me to mention in this paper. A second list appeared in the *British Association Report*, 1895. (Contains a Bibliography from 1675-1895.)

W. Whitaker and C. Reid.

"The water supply of Sussex from underground sources," 255 pp., map 1899. (Memoirs of the Geological Survey.)

William Topley, Born in 1841, Died in 1894.

In the *Journal of the Royal Agriculture Society of England*, Vol. 8, part 2, 1872, "On the Agricultural Geology of the Weald," map.*

Topley's most famous book is of course "The Geology of the Weald, (parts of the counties of Kent Surrey, Sussex and Hants) in part from the notes and MSS of H. W. Bristow (and others), lists of fossils revised by R. Etheridge." *Memoirs of the Geological Survey of England and Wales.*) London, 1875.

In *Reports of the British Association*, 1872-1875, Messrs. Topley, Willett, Woodward, etc., "Accounts of progress of Sub-Wealden boring at Netherfield, near Brighton."

Topley's Geological Map of Sussex in Dixon's Geology (1850)† is also well known. His Report (to the Corporation) on the water supply of Hastings, Fol. 18 pp. Hastings 1875, has an Analyses of water by C. Ashenden.

H. Willett.

Record of the Sub-Wealden exploration. 8vo. Brighton, 1878.

Robert Etheridge.

Address to the Geological section of the British Association. Southampton, 1882.

*This article was reviewed in the *Geological Magazine*, 1873.
†Which see.

W. Jerome Harrison.

Geology of the Counties of England and of North and South Wales. London. pp. 346, illus. (Sussex on pp. 263-268.)

(Brought up to date in Kelly's Directory in 1907, in which publication the first edition originally appeared.)*

CLEMENT REID.

In the *Quarterly Journal of the Geological Society*, "On the origin of dry chalk valleys and of Coombe Rock."

In the same journal, Vol. 48. 1892. "Pleistocene deposits of the Sussex Coast."

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Sussex portions :—

Vol. 1.	Chap. 8.	pp. 114-125.
„ 2.	Chaps. 6 & 30.	pp. 64-78, 396-407.
„ 3.	Chaps. 3 & 4.	pp. 28-56.

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A new theory of the Denudation of the Weald.

Dr. Marie C. Stopes.
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Horace B. Woodward.
Stanford's geological atlas of Great Britain and Ireland with plates and characteristic fossils. 3rd edition, 1914 (contains coloured geological map of Sussex.)

H. A. Allen,
" Catalogues of types and figured specimens of British cretaceous Lamellibranchiata preserved in the Museum of practical geology, London." Appendix to summary of progress of the Geological Survey of Great Britain and the Museum of practical geology for 1914, 1915 (refers to specimens from Brighton, etc.)

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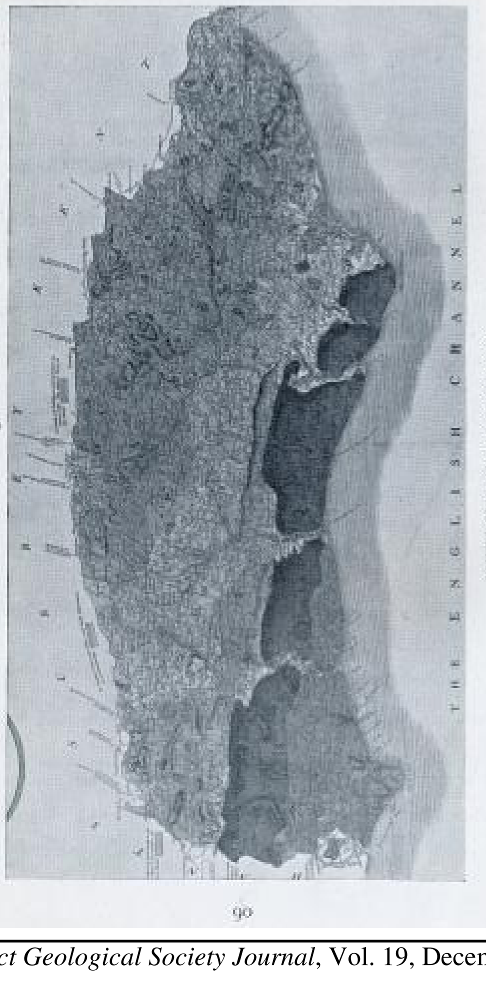
R. H. Brydone.
" The Marsupites chalk of Brighton."

This list is not complete, but I think I have given enough to show that the geology of Sussex is of no mean importance.



SMITH'S GEOLOGICAL MAP OF SUSSEX

Websites

by Peter Austen

A particularly good website for geological/scientific journals, both old and not so old, is the *Biodiversity Heritage Library*: http://www.biodiversitylibrary.org/ This site allows access to a large number of journals from their beginnings in the 19th century up to around 1922, as well as some more recent publications. Of particular interest to members may be volumes of the *Monograph of the Palaeontographical Society* (74 volumes from 1847 to 1922) and, of the more recent publications, volumes of the *Bulletin of the British Museum (Natural History), Geology Series*, and its continuation *Bulletin of the Natural History Museum (Geology)* (58 volumes from 1949 to 2002).

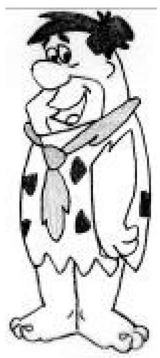
The Palaeontographical Society monographs include Richard Owen's classic early works on dinosaurs, *Fossil Reptilia of the Wealden and Purbeck Formations* (1853–1889), *Fossil Reptilia of the Cretaceous Formations* (1851–1866) and *Fossil Reptilia of the Mesozoic Formations* (1874–1889), which include specimens from the Hastings area, and from which, despite their age, much information may still be gleaned. Also available in the Pal. Soc. monographs are Arthur Smith Woodward's works *The Fossil Fishes of the English Wealden and Purbeck Formations* (1916–1919), and *The Fossil Fishes of the English Chalk* (1902–1912), relevant to both the Wealden rocks of Hastings and the chalk of Eastbourne and Lewes – these volumes are still an excellent reference source for both sequences. Unlike earlier versions available on the internet, large fold-out plates have been scanned in full and the text is fully searchable.

The Natural History Museum has given permission for all its Bulletins to be loaded onto the *Biodiversity Heritage Library*, even recent ones up to 2002. These include Patterson's *Wealden Sharks* (1966), Charig and Milner's *Baryonyx* (1997), the three volumes of Watson and colleagues *English Wealden Flora* (1969, 1990, 2001), plus volumes on ostracods, the armoured dinosaur *Hylaeosaurus*, and the crocodile *Theriosuchus*, all of which are relevant to fossils found in the Hastings area. There are of course many more journals available on this site including early volumes from the *Geological Society of London*, the *Geological Magazine* . . . the list goes on.

The Natural History Museum has an excellent site dedicated to Alfred Russel Wallace (1823-1913): http://www.nhm.ac.uk/nature-online/science-of-natural-history/biographies/wallace/ Wallace was an intrepid explorer and brilliant naturalist who co-published the theory of evolution by natural selection with Charles Darwin, and 2013 marks the centenary of his death. From this site you can also access *The Alfred Russel Wallace Correspondence Project*, the aim of which is to digitize all of Wallace's correspondence and assorted manuscripts, creating both a copy of the original documents and a searchable transcript. Since the commencement of this project more than 4,000 letters and other documents have been made available online and the site is constantly being added to. Completion is anticipated by 2018.

If you do not have access to a computer at home, all libraries in the UK are now equipped with computers with internet access for use by the general public.

Research has established that the people of Dubai don't like *The Flintstones* – but those of Abu Dhabi do!



The Marsh Award for Palaeontology 2013

This year the Award has been presented to Peter Austen.

The Marsh Christian Trust was founded in 1981 to provide grants and, together with a number of nationally and internationally recognised bodies, present annual Awards. In partnership with the Natural History Museum it runs the Marsh Award for Palaeontology which is given to either amateur or professional palaeontologists who have made a significant contribution to work in the field.

Peter was nominated for this award by Dr. Steven Sweetman, Honorary Research Fellow at the University of Portsmouth, and himself a previous winner of the award. Earlier this year Steve presented his talk *In the Shadow of the Dinosaurs* to the H.D.G.S. The nomination was seconded by Professor David Batten of the University of Manchester.

The enormous and very understated contribution that Peter has made to palaeontology is best summed up in Steve's submitted nomination letter, as follows:

"In 1984, together with Ed Jarzembowski, Peter was responsible for organising regular rescue-collecting of fossil insects and other arthropods from the spoil heap at the Lower Writhlington Colliery, near Radstock, Avon. At that time the spoil was being worked for coal and by 1986, when this work was coming to an end, the significance of the site had become apparent. In order to conserve this valuable palaeontological resource Peter and Ed were successful in securing financial support from the Geologists' Association Curry Fund to have the contractors set aside 3,000 tons of the more fossiliferous spoil. This became the Writhlington Geological Nature Reserve (WGNR) and as Honorary Warden and key holder (and signatory to the lease taken out by the West London Wildlife Group), together with Ed Jarzembowski, he organised further rescue-collecting at the site between 1986 and 2000. Before Peter and Ed started work at Writhlington only 200 insect and arthropod specimens were known from the whole of the British Carboniferous but after establishment of the reserve they had secured for science between 1,300 and 1,400 specimens from this site. Since then various authors have contributed more than 25 papers to the scientific literature together with numerous informal articles. In 1998 Peter gave a presentation on Writhlington at an international conference at the National Museum & Gallery, Cardiff and he and his wife Joyce donated most of their significant collection of Writhlington fossil plants to the National Museum of Wales, Cardiff, with a representative collection also going to Taunton Castle Museum. They also donated a collection to Kew Gardens, which was used to assist in the production of the Carboniferous section of their Evolution House.

"Living as he does in Wealden country Peter has, since 1987 when he first moved there, organised regular field trips to various Wealden localities, including Smokejacks Brickworks and Hastings, and more recently to Langhurstwood Quarry, Warnham. In collaboration with others he amassed a collection of *Bevhalstia* material from Weald Clay localities over an 8-year period between 1985 and 1993. This permitted description of one of the earliest flowering plants, *Bevhalstia pebja* (Hill, 1996), which was also reported in the journal of the Hastings and District Geological Society, of which he has been Editor since 2006. In another collaboration with Ed Jarzembowski he discovered and recognised the *in situ* 'quillwort' bed at Cliff End, east of Hastings. Material from this site, which he is still working on with others, has been donated to the Natural History Museum, London. He has also donated a significant collection of fossil plants from the Wadhurst Clay to Bexhill Museum which is now on display there.

"Commencing in 2001 Peter, usually with co-authors, has produced yearly reports on Geologists' Association Wealden field trips for the GA Magazine. He has been Editor of *Wealden News*, an occasional newsletter of Wealden geology, freely available on line, since 2005. He is author or co-author of three chapters in the recently published Palaeontological Association field guide to fossils No 14, *English Wealden Fossils*, in which are figured some of the fossils he has donated to the NHM and Bexhill Museum."

The presentation ceremony, given at the Natural History Museum on 9th July 2013, was attended by members of the Museum staff and by Millie Kenyon and Jo Winyard from the Marsh Christian Trust. Dr. Paul Kenrick, Head of the NHM Invertebrates and Plants Division, gave a warm welcome, and

Millie Kenyon, a Trustee of the Marsh Christian Trust, read out the citation outlining Peter's achievements over the years. She then presented Peter with the award, and he responded:

> "I must say I feel very honoured to receive this award especially when I see the calibre of the previous recipients, and I'd like to thank the Marsh Christian Trust and the Natural History Museum for this recognition.
>
> To be honest, I feel a bit guilty about getting an award for something I've got so much enjoyment from over the years, but there's a few people I'd like to thank who've encouraged and inspired me throughout that time.
>
> One is someone many of you may be familiar with – Bob Symes, the former keeper of mineralogy here at the Natural History Museum. Bob was my tutor at evening classes when I first took an interest in geology, and although he was a mineralogist he could see my leaning towards palaeontology and in 1984 introduced me to someone I've collaborated with ever since – Ed Jarzembowski, a fossil insect specialist. That introduction sparked the beginning of a 16 year project at Writhlington in the Somerset coalfield, rescue-collecting fossil insects, and also of almost 30 years organizing field trips in the Weald of Surrey and Sussex.
>
> Thanks also to the Geologists' Association who've supported much of our fieldwork both at Writhlington and in the Weald, and particularly to Eric Robinson of the GA for his encouragement and support of our early work at Writhlington.
>
> One of the great things about palaeontology is the people you meet, both professional palaeontologists and the amateur collectors, many of whom have become good friends over the years. Obviously I can't mention them all here, but there are two Wealden 'amateurs' (amateurs in the broadest sense of the word) that really stand out and have been of immense help to me over that time. One is Ken Brooks of the Hastings & District Geological Society, with his wide-ranging knowledge of the Wealden Hastings Beds, and the other is the late Geoff Toye, a brilliant field geologist and naturalist, who had an extensive knowledge of the Weald Clay localities around his local Horsham area.
>
> I'd also like to thank Steve Sweetman who nominated me for this award and whose groundbreaking work on microvertebrates has inspired a new generation of workers to look more closely at the bone beds of the Weald.
>
> Thanks also to David Batten and Chris Hill, who have both encouraged my interest in palaeobotany. Chris Hill spurred my fledgling interest in fossil plants with an excellent palaeobotany course here at the Museum way back in 1985, and he later described and published our early flowering plant *Bevhalstia* which we'd spent eight long years collecting from the Weald. And I'm also grateful to David Batten for his encouragement over the years and for inviting me to contribute to three chapters in the Palaeontological Association Weald Guide, of which he was editor. To be given the opportunity to contribute to a publication like that was an honour in itself, even if it did rather take over my life for 18 months!
>
> And so finally my biggest vote of thanks goes to my dear wife Joyce for putting up with all that, and for being my constant support and companion in the field for the past 30 odd years. Joyce actually has a far better eye for finding fossils than me, although she would argue that's because I'm always too busy talking!
>
> And, on that note, I think I'd better stop and just say thank you again for such an amazing honour."

The presentation was followed by a lecture given by Dr. Martin Munt, Collections Manager of the Invertebrates and Plants Division of the NHM, on "Recreating Life in Wealden Times".

Warmest congratulations to Peter from all the members of the Hastings & District Geological Society for such a truly well-deserved award, and our special thanks to Joyce, without whom ... !

Diana Brooks

Martin Munt, Peter Austen, Joyce Austen

The Arthur Smith Woodward 150th Anniversary Symposium

Wednesday, 21st May 2014

An event I am sure readers will be interested in is being hosted by the Natural History Museum (NHM) on Wednesday, 21st May next year. Arthur Smith Woodward joined the NHM in August 1882 at the age of 18, progressed through the ranks to become Keeper of Geology in 1901 and was knighted on retiring from this position in 1924. He retired to Haywards Heath with his wife Maud and lived there until his death in September 1944 at the age of 80.

In 1882-83, the Museum acquired the fossil fish collections of Sir Philip Grey Egerton and William Willoughby Cole, the 3rd Earl of Enniskillen, undoubtedly the two most important collections of fossil fishes in the world. Louis Agassiz made extensive use of these collections when researching his monumental work on fossil fishes *Recherches sur les Poissons Fossiles* (1833-43). Consequently these collections contain many type and figured specimens that are still the focus of research today. The young Arthur Smith Woodward's first tasks involved labelling and mounting many of these fossils for display in the newly opened (1881) Museum building at South Kensington. Along with other important collections of fossil fish at the Museum (e.g. those of Mantell, Dixon and Bowerbank) he decided that this would be the focus of his studies and research. He was encouraged in this by his Head of Department, Henry Woodward, who suggested to him that he prepare for publication a catalogue of the fossil fishes in the Museum. The *Catalogue of the Fossil Fishes in the British Museum (Natural History)* was published in four parts between 1889 and 1901 and remains the starting point for any research on fossil fishes to this day. The images below show examples from the Egerton and Enniskillen collections that Smith Woodward described and named in Part IV of the "Catalogue".

Eurypholis pulchellus Woodward, Egerton Collection. (Image by permission of the NHM)

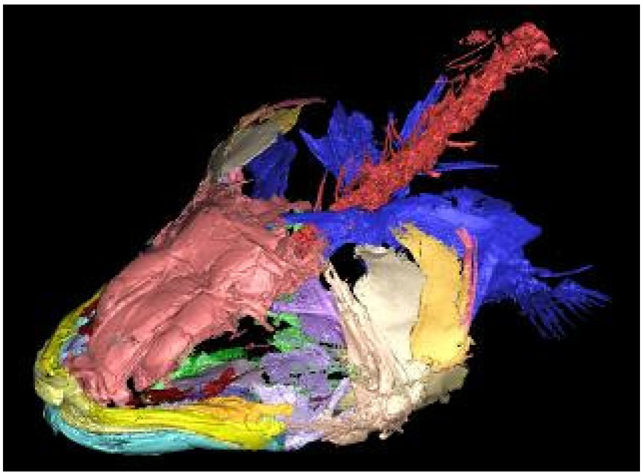
Clupea catopygoptera Woodward, Enniskillen Collection. (Image by permission of the NHM)

Smith Woodward also published two important monographs through the Palaeontographical Society; *The Fossil Fishes of the English Wealden and Purbeck Formations* (1916-19) and *The Fossil Fishes of the English Chalk* (1902-12). These publications, along with hundreds of papers and the description of nearly 300 new species, led him to becoming the world's foremost authority on fossil fishes.

The one day symposium will be held in the Flett Theatre at the NHM. Attendance is free but you are required to register as numbers are limited. Ten speakers will give presentations covering his life, his contribution to palaeoichthyology and how this is being taken forward by today's scientists. The speakers are the historian Karolyn Shindler, Peter Forey and Chris Duffin (NHM Scientific Associates), John G. Maisey (American Museum of Natural History), Mike Smith (NHM volunteer), Chris Dean (UCL), Paul Barrett (NHM), Charlie Underwood (Birkbeck), Joe Keating (University of Bristol), and Matt Friedman (Oxford University).

As a very specific example Matt Friedman will talk about some of the work being done at Oxford University in collaboration with the NHM. New information is being derived from fossil specimens by the use of modern non-destructive techniques such as CT (computed tomography) scanning. The images below show one of Smith Woodward's type specimens and the image produced by careful (and laborious!) processing of the CT scan. Clearly the scan image reveals details that Smith Woodward was unable to see and thus include in his description.

Sardinioides illustrans Woodward.
(Image by permission of the NHM)



Sardinioides illustrans Woodward – CT scan.
(Image courtesy of Hermione Beckett, Univ. of Oxford)

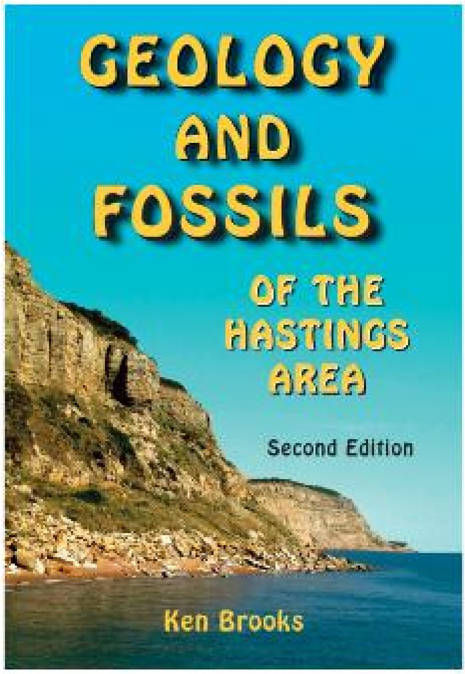
In the Flett Theatre foyer you will be able to view specimens that have not been on display for over 30 years (including important type specimens). There will also be a unique opportunity to view a display of archive material and personal memorabilia.

To attend the symposium and view the displays please register via the NHM website. Go to the Museum website, http://www.nhm.ac.uk/ and type Woodward150 in the search box on the front page. Don't forget, attendance is free! For this I would particularly like to acknowledge the generous financial support provided by the Palaeontological Association, the Geological Society and the Natural History Museum thus ensuring the symposium reaches the widest possible audience.

Mike Smith, Meeting Coordinator.

GEOLOGY AND FOSSILS OF THE HASTINGS AREA

(Second edition)



Ken Brooks, HDGS Chairman, has now produced a second edition of his excellent guide, *Geology and Fossils of the Hastings Area*, in which the text and photographs have been extensively revised, updated and expanded.

The book provides an illustrated account of the many interesting features to be seen along the beach between Bexhill and Pett Level. It includes two field trips, where various rocks and fossils are identified and then used to reconstruct a vivid picture of South-east England over 100 million years ago. For example, huge, three-toed footprints provide evidence that dinosaurs walked here, and numerous fish and shark remains indicate rivers and lakes teeming with life. It's amazing how much is contained within this clearly written, fascinating book. There are 84 pages, including 16 in full colour, and an excellent centre page spread which shows SE England in Lower Cretaceous times.

Not only is it an excellent guide to the geology of the area, but there are also some very useful additions including a good section on local fossils, a glossary, references and suggestions for further reading, and a handy list of local museums and societies in the area. This is certainly a welcome addition to the bookshelf of anyone wanting to learn something of our local geology, and considering its extensive content is very reasonably priced at just £8.

Geology and Fossils of the Hastings Area will be available for purchase from Spring 2014 at HDGS meetings and through bookshops locally.

Geologists' Association Regional Conference

Geology and History in Southeast England

Saturday, 29th November 2014

9.00 am to 6.00 pm

Amberley (Chalkpits) Museum and Heritage Centre

On behalf of the Geologists' Association I am organising a Regional Conference with the broad theme of Geology and History in Southeast England. By Southeast is meant the counties of Kent, Surrey and Sussex; or, more geologically, the whole dimensions of the Wealden Anticline; and the terms Geology and History should be considered as widely and generously as possible. There will be nine presentations during the day on a wide range of topics around this theme: a lively programme is envisaged, appealing to a broad spectrum of interests. A full list of speakers and topics, and a Registration Form, will be available in due course.

If any of your members have recently undertaken research bearing on any aspect of this broad theme and area (or part thereof), and would like to tell us about their results and ideas, please urge them to contact me as soon as possible.

Anthony Brook
(GA Council Member)
anthony.brook27@btinternet.com

Palaeontology in the News

A review of recent research and discoveries

Edited by Peter Austen

Introduction

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. Special thanks to Christine Wagner for bringing to my attention several of the news items included below.

Feather structure in early birds

It has previously been assumed that wing feathers in the Jurassic bird *Archaeopteryx* and Cretaceous feathered dinosaurs had the same arrangement as modern birds. However, a study conducted by Nicholas Longrich of Yale University, New Haven, Connecticut, USA, and his colleagues, has shown this not to be the case (*Current Biology*, 2012, Vol. 22, Issue 23, p. 2262–2267). All present-day birds share a common wing design, with a single feather layer, but in their study of the Jurassic bird *Archaeopteryx lithographica* (Fig. 1) and the Cretaceous feathered dinosaur *Anchiornis huxleyi* they identified separate feather layers. The slender feather shafts in these early feathers would make them weaker than modern feathers, but, when stacked, they formed a structure strong enough to generate lift. However, the layers would have limited airflow through the wing, which modern birds use for take-off and low-speed flight. The authors suggest these early flyers probably glided or parachuted down from trees.

Fig. 1. Reconstruction of the Jurassic bird, Archaeopteryx lithographica.
Image: Carl Buell/Jakob Vinther/Bristol Univ.

Reference

ANON. 2012. Birds of a different feather. *Nature*, **491**, 641.

Earliest primate was tree-dwelling

Most of the modern primates make their homes high up in the branches of trees, but scientists have long argued about when this habit first appeared. However, the discovery of some ankle bones of the earliest primate, *Purgatorius*, which display considerable flexibility, suggests that the primates were tree-dwelling from the very beginning. *Purgatorius* lived around 65 million years ago, and is well known from the Garbani Channel fossil location in Montana, USA, but as is the norm with early mammal fossils, until now they have been known only from their teeth, which survive owing to the presence of protective enamel. The bones were collected by field crews led by William Clemens* at the University of California, Berkeley, and identified as belonging to *Purgatorius* by Stephen Chester at Yale University in New Haven, Connecticut, and Jonathan Bloch at the University of Florida in Gainsville. Their findings were presented to the annual meeting of the Society of Vertebrate Paleontology in Raleigh, North Carolina, USA, in October 2012. The team also pointed out that flowering plants were going through a period of major diversification as *Purgatorius* was emerging, and suggest a connection between primates and plant evolution, with fruits playing a role in luring them up into the trees.

***Editor's note:** William Clemens played a key role in collecting and describing mammal teeth from the Cliff End Bone Bed at Pett Level in the 1960s and 1970s.

Earliest flying fish fossil found in China

Fig. 2. Earliest flying fish, Potanichthys xingyiensis *(length 14 cm). Image: Royal Society*

The oldest known flying fish has been discovered in middle Triassic rocks of the lower part of the Zhuganpo Member, Falang Formation, Xingyi, Guizhou Province, China. The fish, *Potanichthys xingyiensis* (Fig. 2), was described by Guang-Hui Xu of the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China, and colleagues (*Proceedings of the Royal Society B: Biological Sciences*, 2013, Vol. 280, No. 1750, published online before print 31 October 2012 doi:10.1098/rspb.2012.2261, 7 pp.). The remarkably well preserved fossils show that *Potanichthys* had a pair of large pectoral fins, like modern flying fish, that probably functioned as its main wings, and pelvic fins that were used as secondary wings. A large and asymmetric tail probably provided thrust to launch the fish into the air. The authors suggest that the fish made prolonged jumps out of the water and, if it was anything like modern flying fish, could glide tens of metres. However, *Potanichthys* is not an ancestor of today's flying fish. It was related to a now-extinct family of gliding fish known as thoracopterids, fossils of which have been found in the 200 million year old late Triassic rocks of Italy and Austria, tens of millions of years younger than the middle Triassic Chinese fossils. It is thought that some fish evolved gliding flight to escape predators, and the authors suggest that *Potanichthys*' gliding ability is more evidence that the oceans bounced back fairly quickly from the end-Permian mass extinction which wiped out up to 95% of marine life.

Reference

SUBBARAMAN, N. 2012. Oldest flying fish fossil found in China. *Nature News*, doi:10.1038/nature.2012.1170.

Earliest arthropod from the Burgess Shale

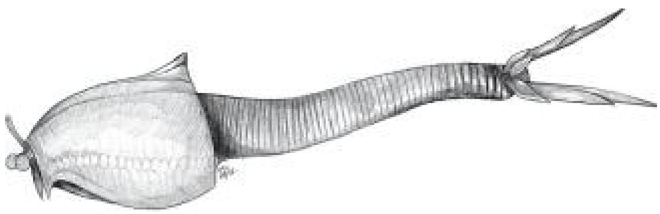


Fig. 3. Reconstruction of the early arthropod, Nereocaris exilis *(length 14 cm). Illustration: David A. Legg*

The discovery of the most primitive arthropod yet to be found has thrown new light on the origins of the arthropods, the group which includes spiders, insects and crabs. The 500 million year old arthropod was found in the Tulip Beds locality, Campsite Cliff Shale Member, Burgess Shale Formation, Mount Stephen, Yoho National Park, British Columbia, Canada. The new arthropod, *Nereocaris exilis* (Fig. 3), was described by David Legg of Imperial College, London, UK, and colleagues (*Proceedings of the Royal Society B: Biological Sciences*, 2012, Vol. 279, No. 1748, p. 4699–4704). The arthropod had a bivalved main shell and an elongated abdomen covered with a hard, jointed exoskeleton, a characteristic of the arthropods. As the limbs were too thin for walking the authors propose that the earliest arthropods evolved a jointed exoskeleton initially as an adaptation for swimming, and that these jointed suits of armour were adapted only later to support life on the ocean floor. The authors also suggest that unlike today's arthropods which are mostly active predators, the anatomy of these early arthropods suggest that they were predated upon by other Cambrian beasts.

Reference

ANON. 2012. Humble arthropod beginnings. *Nature*, **490**, 313.

Brittlestars survived in harsh environments

Present day echinoderms, such as brittlestars and sea urchins, are only found in the open sea, but a discovery of fossils of the brittlestar, *Aspiduriella similis*, from Wojkowice Quarry, Southern Poland, suggests that this has not always been the case. The 240 million year old fossils were found in a Middle Triassic limestone, and analysis of the rocks suggest that the fossils formed in conditions with very high salt levels, such as those present in hypersaline coastal waters. There were few other fossils found in the rocks suggesting a harsh environment. Previously, echinoderm fossils have been used as indicators of open marine environments, but the authors led by Mariusz Salamon of the University of Silesia, Sosnowiec, Poland, suggest that the discovery of these fossils in this hypersaline environment invalidates this assumption, and suggest that caution needs to be taken when using fossil echinoderms in palaeoenvironmental reconstructions (*PLoS ONE* 7(11): e49798 (2012)).

Earliest dinosaur relative

It had been thought that dinosaurs originated around 230 million years ago near the start of the Upper Triassic, but a new discovery moves their origin back a further 15 million years to shortly after the largest mass extinction of all time, the Permo-Triassic extinction event of 252 million years ago. The fossils were discovered in the Middle Triassic Lifua Member of the Manda beds, Ruhuhu Basin, southern Tanzania, in the 1930s by Rex Parrington, a palaeontologist at the University of Cambridge, UK. The late Alan Charig, formerly Curator of Fossil Reptiles and Birds at the Natural History Museum, was a student of Parrington's and studied *Nyasasaurus* for 50 years. He thought the bones represented either the earliest dinosaur or close dinosaur relative yet found, but he passed away before a formal description could be published. A study by Sterling Nesbitt, a palaeontologist at the University of Washington in Seattle, USA, and his colleagues, which completes the work that Charig started, confirms Charig's views and names him as a co-author (*Biology Letters*, 2013, Vol. 9, No. 1, published online before print 5 December 2012 doi:10.1098/rsbl.2012.0949, 5 pp.). At 243 million years old, *Nyasasaurus parringtoni* (Fig. 4) is the oldest known dinosaur or close dinosaur relative yet found, 15 million years earlier than the previous oldest dinosaur, *Eoraptor*, from South America. Although the description of *Nyasasaurus* is based on fairly fragmentary material, the authors believe it was a leggy, long-necked bipedal creature about "the size of a Labrador retriever", and its origin in Tanzania supports the case for dinosaurs first evolving on what would have been the southern region of the supercontinent Pangaea.

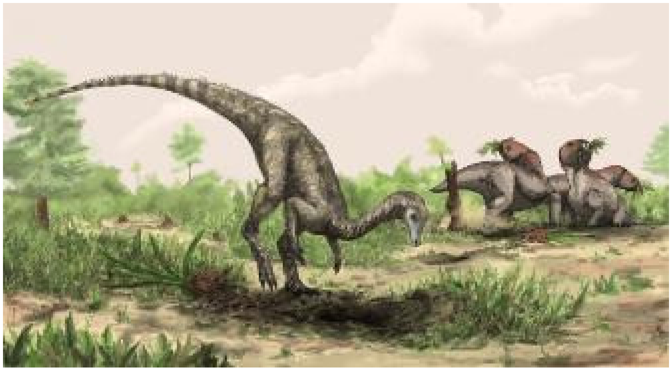


Fig. 4. Earliest known dinosaur relative, Nyasasaurus. *Image: Mark P. Witton/Natural History Museum, London*

Reference

SWITEK, B. 2012. Earliest known dino relative found. *Nature News*, doi:10.1038/nature.2012.11959.

First freshwater mososaur from Hungary

The bones of the first freshwater mososaur have been found at two sites in Hungary, providing the first evidence that these giant, aquatic lizards lived in both freshwater and marine environments. Thousands of mososaur specimens are known from all over the world, but until now it has been assumed that they were exclusively marine predators. The first freshwater specimens were found in 1999 in the waste dump of a coal mine in Ajka, Western Hungary. Since then more specimens, including bones from the skull, have been discovered at a nearby open-pit bauxite mine at Iharkút in the Late Cretaceous Csehbánya Formation (85.8–83.5 million years old), which represents a dried-up river system. The finds of the mososaur, *Pannoniasaurus inexpectatus*, were reported by a team, led by palaeontologist László Makádi from the Hungarian Natural History Museum (*PLoS ONE* 7(12): e51781 (2012)), and were from a range of individuals large and small, young and old. By comparing the specimens with other mososaurs it is thought that it could have grown up to six metres long. It appears to have been specialized for its freshwater environment, with a flattened skull like a crocodile for ambushing prey in both shallow water and on land, and while there is little evidence for the structure of its limbs, the researchers suggest that it could have had limbs like a terrestrial lizard.

Ediacaran life on land?

Ediacaran fossils are widely regarded as early ancestors of the animals that appeared in the Cambrian explosion. They range in date from 542 to 635 million years old, and occur throughout the world in a variety of sedimentary deposits, which until now have been interpreted as shallow to deep marine origin. A controversial new study by Gregory Retallack of the University of Oregon, Eugene, Oregon, USA, raises doubts over whether the Ediacaran organisms were all marine (*Nature*, 2013, Vol. 493, No. 7430, p. 89–92). Retallack has proposed a new interpretation of the fossilized soils (palaeosols) from South Australia which suggests that at least some of the organisms lived on land, and that some Ediacaran fossils were large sessile (immobile) organisms of cool, dry soils. His findings are compatible with observations that Ediacaran fossils (Fig. 5) are similar in appearance and preservation to lichens and other microbial colonies of biological soil crusts, rather than marine animals.

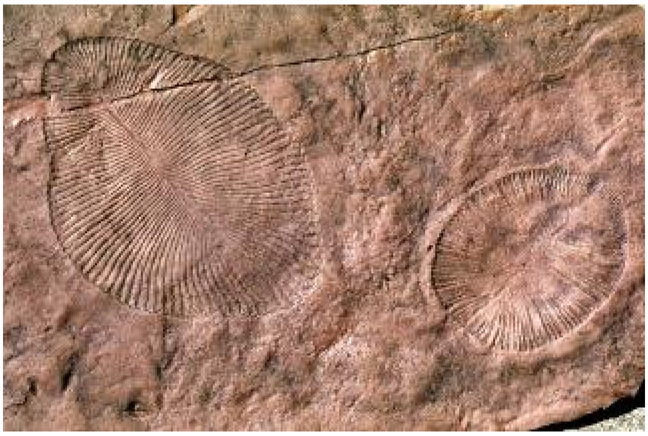


Fig. 5. Ediacaran fossils, Dickinsonia *– worms or lichen?*
Image: Gregory J. Retallak

Reference

SWITEK, B. 2012. Controversial claim puts life on land 65 million years early. *Nature News*, doi:10.1038/ nature.2012.12017.

Latest technology applied to earliest vertebrates

A backbone of interlocking vertebrae is a prerequisite for all tetrapods (vertebrates living on land), but until now the skeletal details of the earliest tetrapods have been very hard to make out, as they are often encased in a rocky matrix. This difficulty has now been overcome by a team of researchers led by Stephanie E. Pierce of the University Museum of Zoology, University of Cambridge, Cambridge, UK (*Nature*, 2013, Vol. 494, No. 7436, p. 226–229). The team took the three best-known early tetrapods, *Ichthyostega*, *Acanthostega* and *Pederpes*, and applied the latest synchrotron microtomography technology, giving a previously unseen view of the three-dimensional structure of the vertebral columns of these three tetrapods. This study totally revises the previous understanding of vertebral column evolution in the earliest limbed vertebrates and raises questions about the presumed vertebral architecture of the preceding tetrapodomorph fish and also later tetrapods.

Early bird ate insects

Whereas most fossil early birds have simple teeth, a newly described fossil from China has large, grooved teeth and it is the first bird fossil to show specialized enamel. The new fossil bird, *Sulcavis geeorum*, has been described by Jingmai O'Connor at the Natural History Museum of Los Angeles County in California, and her colleagues (*Journal of Vertebrate Paleontology*, 2013, Vol. 33, No. 1, p. 1–12). It is from the early Cretaceous Jehol Group of northeastern China, and has teeth 1–3 milli-metres in length with longitudinal grooves that have never been seen before in a bird. Normally small, smooth teeth are indicators of a herbivorous diet, but it is thought that *Sulcavis geeorum* may have used its hard, powerful teeth to crunch creatures with tough exoskeletons, such as insects.

Earliest ancestor of placental mammals

A team of scientists from the USA and Canada have used anatomical and molecular data from both fossils and present-day species of placental mammals to reconstruct the appearance and anatomy of the forebear of all placental mammals. The team led by Maureen O'Leary, a palaeontologist at the State University of New York at Stony Brook, USA, analysed more than 4,500 anatomical traits, almost ten times as many as any previous study, including traits from 86 living and extinct mammals (*Science*, 2013, Vol. 339, No. 6120, p.662–667). This supposed early mammal was a tree-climbing, furry-tailed insect eater that weighed anything between 6 and 245 grams (Fig. 6). It gave birth to blind, hairless young, one at a time, and it had three pairs of molars in each jaw. The data also suggested that the placental mammals diversified a few hundred thousand years after the non-avian dinosaurs went extinct. This conclusion is supported by the fact that no fossils of placental mammals have been found from before the extinction of the dinosaurs 65 million years ago, but it contradicts previous genetic studies that place the origin of placental mammals at around 100 million years ago.

Fig. 6. Supposed ancestor of all placental mammals.

Image courtesy of Carl Buell

Reference

YONG, E. 2013. Face-to-face with the earliest ancestor of all placental mammals. *Nature News*, doi:10.1038/nature.2013.12398.

Late Devonian insect???

In the 2012 issue of the *HDGS Journal* we reported on the discovery of the earliest fossil insect, *Strudiella devonica*, from the 370 million year old Strud Quarry (Upper Famennian, Late Devonian), Namur province, Belgium, by Romain Garrouste of the Muséum national d'Histoire naturelle, Paris, France, and colleagues (see 'Late Devonian insect', *HDGS Journal*, Dec 2012, Vol. 18, p.53). A team of scientists led by Thomas Hörnschemeyer of Georg-August-University Göttingen, Germany, have now undertaken a thorough re-investigation of the specimen, and concluded the features seen by Garrouste and his team have been 'over-interpreted', while essential structures were missed (*Nature*, 2013, Vol. 494, E3–E4 doi:10.1038/nature11887). Based on their observations of the specimen they believe its interpretation as an insect is unwarranted. In reply Garrouste and his team have vigorously defended their interpretation (*Nature*, 2013, Vol. 494, E4–E5 doi:10.1038/nature11888).

Arctic camels

The remains of a 3.5 million year old camel have been found in the Old Crow Basin, Yukon, in the Canadian Arctic. The find by Natalia Rybczynski at the Canadian Museum of Nature, Ottawa, Ontario, Canada, and her colleagues was of fossilized fragments of a large leg bone, and analysis of the preserved protein showed that the bone belonged to an extinct giant camel (*Nature Communications*, 2013, Vol. 4, Article no. 1550, doi:10.1038/ncomms2516). At this time the region was densely forested and considerably warmer than today. The discovery is the most northern evidence of camels, and suggests that camel traits such as wide flat feet and even the hump may have evolved as specializations for living in the Arctic forest, not in the desert where most of today's camels live.

Early birds

Researchers have suggested that the first birds may have used four feathered limbs to stay aloft. The researchers, led by Xing Xu, a palaeontologist at the Institute of Geology and Paleontology, Shandong, China, looked at a number of early birds from the Lower Cretaceous Jehol Group in China and found evidence of feathers on the hindlimbs (*Science*, 2013, Vol. 339, No. 6125, p. 1309–1312). On some of the specimens studied, the feathers appeared to be veined flight feathers that stood perpendicular to the leg bones, similar to those in the basal bird *Archaeopteryx*, although there is no definitive indication how these early birds used their rear set of feathers, whether for gliding assistance, for steering or both. Since these early birds, scales have replaced most feathers on modern birds' legs, although some modern birds have not lost all their leg plumage, which is now downier and used for warmth. The authors suggest that downsizing from four wings to two may have helped early birds by allowing the hindlimbs to become dedicated legs that could help them get around better on the ground.

Diet of four-winged raptor

The 120 million year old four-winged feathered raptor *Microraptor gui* is often used to understand the origins of flight. Previous fossils of this dinosaur have been found with a bird and a potentially tree-climbing mammal preserved in their guts, implying that *Microraptor* hunted in an arboreal environment, but now a specimen of *Microraptor gui* has been found with a partially digested fish in its stomach. Lida Xing of the China University of Geosciences, Beijing, China, and colleagues, describe features of *Microraptor gui*, such as front teeth that project forward, that are similar to those seen in fish-hunting animals, and suggest that it was a generalist predator in both arboreal and aquatic habitats (*Evolution*, 2013, Vol. 67, No. 8, p. 2441–2445).

The colour of dinosaur feathers – Part 2

In the 2010 issue of the *HDGS Journal* we reported on the discovery of 100 million year old colour-producing sacs in the fossilized feathers of small theropods from the early Cretaceous Jehol site in northeastern China by a team of palaeontologists led by Michael Benton of the University of Bristol, UK, and Zhonghe Zhou of the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing (see 'The colour of dinosaur feathers', *HDGS Journal*, Dec 2010, Vol. 16, p.39). The shape of these sacs – sausage-shaped organelles called eumelanosomes which would have produced black feathers, and spherical organelles called phaeomelanosomes which would have produced reddish feathers – have since been used to reconstruct the colours of a number of theropods and early birds. However, a team of palaeontologists led by Maria McNamara, at the University of Bristol, UK, and her colleagues, say that some of these reconstructions may be inaccurate. McNamara and her colleagues mimicked the process of fossilization by placing modern bird feathers in an autoclave, a machine that sterilizes lab equipment with 250 times atmospheric pressure and temperatures of 200–250 °C. They claim that "A brief spell in an autoclave can reasonably simulate the effects of temperature and pressure during burial over millions of years." They found that the melanosomes survived, but they also shrank (*Biology Letters*, 2013, Vol. 9, No. 3, published online before print 27 March 2013 doi:10.1098/rsbl.2013.0184, 6 pp.), and McNamara says that the extent of the distortions depends on how the feathers are preserved; those from hotter and deeper deposits would be more heavily deformed than those from shallower regions. Jakob Vinther, a molecular palaeobiologist also at the University of Bristol, UK, who has been using the shape and distribution of the organelles to infer the colour of prehistoric feathers since 2007 (Fig. 7), says that he was already aware that melanosomes shrink during fossilization and that he had adjusted for these changes in his recent papers.

Fig. 7. Reconstruction of coloured feathers in the early bird, Anchiornis huxleyi. *Image: Imaginechina/Corbis*

Reference

YONG, E. 2013. Dust-up over dinosaurs' true colours. *Nature News*, doi:10.1038/nature.2013.12674.

Oldest dinosaur embryo fossils found in China

Palaeontologists working in China have unearthed the earliest collection of fossilized dinosaur embryos to date (Fig. 8). Robert Reisz, a palaeontologist at the University of Toronto in Mississauga, Canada, and his colleagues discovered the sauropodomorph (sauropods and their ancestral relatives) fossils in a bone bed in Lufeng County, China that dates to the Early Jurassic period, 197 million to 190 million years ago, more than 100 million years older than any previous finds (*Nature*, 2013, Vol. 496, No. 7444, p. 210–214). The discovery included eggshells and more than 200 disarticulated bones, and represented the remains from many individuals at different developmental stages, providing a unique opportunity to investigate the embryonic development of a prehistoric species. When different sized bones in various stages of development were compared, they found evidence of rapid, sustained embryonic growth and short incubation times. The authors suggest that the dinosaurs probably maintained this extreme rate of growth after hatching in an effort to evade predation by outgrowing their predators.

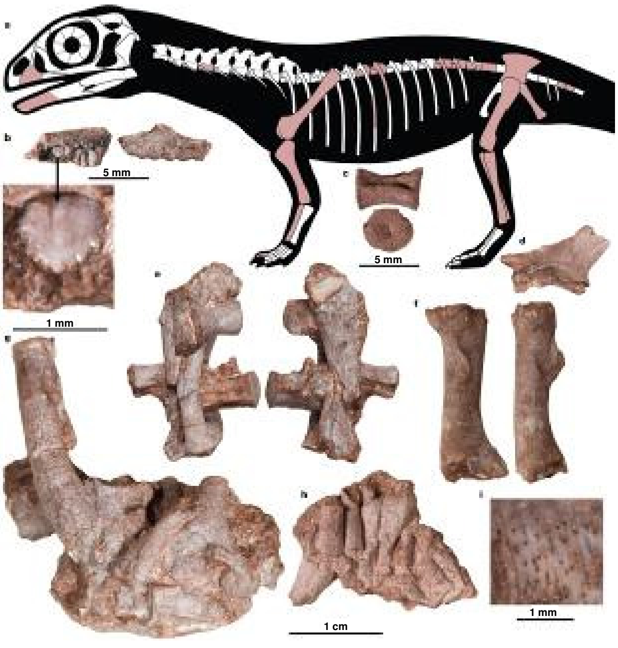


Fig. 8. Sauropodomorph dinosaur embryonic skeletal elements from the Lufeng bone bed. Image: D. Scott

Reference

REISZ, R. R., HUANG, T. D., ROBERTS, E. M., PENG SHINRUNG, SULLIVAN, C., STEIN, K., LEBLANC, A. R. H., SHIEH DARBIN, CHANG RONGSENG, CHIANG CHENGCHENG, YANG CHUANWEI and ZHONG SHIMING. 2013. Embryology of Early Jurassic dinosaur from China with evidence of preserved organic remains. *Nature*, **496**, 210–214.

End-Triassic extinctions linked to massive volcanism

Scientists have long suspected that the mass extinctions at the end of the Triassic, 200 million years ago, were linked to volcanism occurring at around that time. Now a study by Terrence Blackburn, a geochronologist at the Carnegie Institution for Science, Washington DC, USA, and colleagues, has determined the exact timing of those volcanic eruptions with unprecedented precision (*Science*, 2013, Vol. 340, No. 6135, p. 941–945). The team used the radioactive decay of uranium isotopes to lead in zircon crystals found within ancient lavas at a number of sites in eastern North America and Morocco. They established that there were four phases to the volcanism; the first at 201.56 million years ago, followed by a further three phases at 60,000 years, 270,000 years and 620,000 years after the first phase had begun, but the first phase was by far the largest, releasing more than one million cubic kilometres of magma, and it coincided with the start of the mass extinction.

New discovery strengthens *Archaeopteryx*'s position as an early bird

The recent discovery of a small theropod dinosaur with well-preserved feathers in the Middle–Late Jurassic Tiaojishan Formation of Liaoning Province (northeastern China) has strengthened *Archaeopteryx*'s position as an early bird. Previously in the *HDGS Journal* we reported on the discovery of a feathered dinosaur from the Liaoning province of China which suggested that *Archaeopteryx* was not an early bird at all[*1], followed by further work looking at both fossils and genetic data, that re-established *Archaeopteryx* as an early bird[*2]. At between 150 million to 160 million years old, this newly discovered half-metre feathered dinosaur, *Aurornis xui* (Figs 9–10), is believed to be the earliest known member of the bird family tree. Pascal Godefroit, who is at the Royal Belgian Institute of Natural Sciences in Brussels, found it last year in the museum at the Fossil and Geology Park in Yizhou, China, and he and his colleagues, as well as describing this new bird, *Aurornis xui*, conducted a

Fig. 9. Skeleton of Aurornis xui.
Image: Thierry Hubin/IRSNB

Fig. 10. Reconstruction of Aurornis xui.
Artist's impression by Masato Hattori

comprehensive phylogenetic analysis for the basal birds and bird relatives (*Nature*, 2013, Vol. 498, No. 7454, p. 359–362). The team concluded that *Aurornis* had several features, including its hip bones, that clearly mark it out as a relative of modern birds, but that it probably could not fly, most likely using its wings to glide from tree to tree. Their analysis placed *Aurornis xui* at the base of the bird family tree, and confirmed the avialan status of *Archaeopteryx*, but further up the family tree of birds. These results are consistent with early diversification of birds in Asia during the Middle–Late Jurassic, and a single origin for avian forelimb-powered flapping flight. Godefroit also suggests that there may be many more new specimens lying in institutions such as the museum in Yizhou waiting to be discovered and described. Watch this space!

[*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.

Reference

GODEFROIT, P., CAU, A., DONG-YU HU, ESCUILLIÉ, F., WENHAO WU and DYKE, G. 2013. A Jurassic avialan dinosaur from China resolves the early phylogenetic history of birds. *Nature*, **498**, 359–362.
WOOLSTON, C. 2013. New contender for first bird. *Nature News*, doi:10.1038/nature.2013.13088.

Early primate discovered

The near complete remains of an ancient primate have been discovered in a 55 million year old layer of shale formed from sediments deposited in a lake in what is now eastern China. The fossil, *Archicebus achilles* (Fig. 11), was described by Xijun Ni of the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China, and colleagues, and appears to be the earliest known ancestor of the tarsiers (*Nature*, 2013, Vol. 498, No. 7452, p. 60–64). The mammal sports an odd blend of features, with its skull, teeth and limb bones having proportions resembling those of tarsiers, but its heel and foot bones more like anthropoids (which include the monkeys, apes and humans). It was about the size of a modern pygmy mouse lemur, and its skeletal features suggest that it was an agile insectivore that hunted during the day. The discovery also suggests that the anthropoid lineage diverged from the other primates very early, before 55 million years ago.

Fig. 11. Reconstruction of Archicebus achilles.
Image: Xijun Ni

Reference
PERKINS, S. 2013. Oldest primate skeleton unveiled. *Nature News*, doi:10.1038/nature.2013.13142.

First horse appeared 4 million years ago

A draft genome sequence has been obtained from the bone of a horse found frozen in the permafrost of Yukon Territory in the Canadian Arctic. The bone has been dated to around 560,000–780,000 years before present, and the genome sequence is the earliest so far determined. The work was led by evolutionary biologist Ludovic Orlando of the University of Copenhagen, with colleague Eske Willerslev (*Nature*, 2013, Vol. 499, No. 7456, p. 74–78). The data from the bone was compared to draft genome sequences for a 43,000-year-old Late Pleistocene horse, those of five contemporary domestic horse breeds, a Przewalski's horse and a donkey. The results suggest that the *Equus* lineage giving rise to all contemporary horses, zebras and donkeys originated 4.0–4.5 million years ago, much earlier than previously suspected. The data also suggests that Przewalski's horses (Fig. 12) represent the last surviving wild horse population.

Fig. 12. The Przewalski's horse.
Image: Claudia Feh, Association pour le cheval de Przewalski

Reference
HAYDEN, E. C. 2013. First horses arose 4 million years ago. *Nature News*, doi:10.1038/nature.2013.13261.

Origin of the modern jaw

The development of the jaw is one of the key episodes in vertebrate evolution, but the fossil record showing the transition from jawless to jawed vertebrates is very poor. However, the discovery of a three-dimensionally preserved 419-million-year-old placoderm fish (armoured fish) from the Silurian Kuanti Formation, Yunnan, China, has now thrown new light on that transition. Min Zhu, a palaeontologist at the Chinese Academy of Sciences, Beijing, and his colleagues have described this new placoderm, *Entelognathus primordialis* (Fig. 13), which has full body armour but with jaw bones similar to those of modern bony fish, something not previously seen in this group, and the earliest known species with a modern jaw (*Nature*, 2013, Vol. 502, No. 7470, p. 188–193). Placoderms had a bony skull with simple beak-like jaws built out of bone plates, and before this discovery most scientists believed that the placoderms became extinct and the modern bony jaw developed independently of them. This discovery turns that view on its head, although some scientists still think it possible that the bony fish evolved their jaws independently of *Entelognathus primordialis*.

Fig. 13. Reconstruction of the jawed placoderm Entelognathus primordialis.
Image: Brian Choo

Reference
BARFORD, E. 2013. Ancient fish face shows roots of modern jaw. *Nature News*, doi:10.1038/nature.2013.13823.

Blood-sucking mosquito

For the first time, researchers have identified a fossil of a female mosquito with traces of blood in its engorged abdomen (Fig. 14). The discovery, from the 46 million year old Middle Eocene Kishenehn Formation in northwestern Montana, USA was reported by Dale Greenwalt at the US National Museum of Natural History in Washington DC, USA, and colleagues (*Proceedings of the National Academy of Sciences*, 2013, *PNAS* 2013; published online before print 14 October, 2013, doi:10.1073/pnas.1310885110). The insect was found not in amber, but in oil shale sediments, and although after 46 million years any DNA would be long degraded, Greenwalt's team showed that the insect's abdomen still contained large traces of iron and the organic molecule porphyrin, both constituents of haemoglobin, the oxygen-carrying pigment found in vertebrate blood. The fossilized mosquito extends the existence of blood-feeding behaviour in this family of insects back to 46 million years.

Fig. 14. Fossil of blood-engorged female mosquito.
Image: The National Museum of Natural History, Washington

Reference

YONG, E. 2013. Blood-filled mosquito is a fossil first. *Nature News*, doi:10.1038/nature.2013.13946.

Did dinosaurs keep growing?

Recent work by the palaeontologist Jack Horner of the Museum of the Rockies in Bozeman, Montana, USA, suggests that a number of dinosaurs continued growing into adulthood and beyond. At the Society of Vertebrate Paleontology's meeting in Los Angeles, California, USA, in October, Horner reported that he had sectioned the bones of a number of dinosaurs in his collections and found that most showed signs that they were still growing at the time of their death.

Fig. 15. T. rex *chasing down its prey.*
Computer artwork by Mark Garlick/SPL/Corbis

In the bones of juvenile dinosaurs, the outer bone layers contain canals that would once have held blood vessels, as well as cells that are important for bone formation (osteocytes). However, Horner found similar signs in adult fossils, suggesting growth was still occurring. In most animals alive today, the skeleton tends to stop growing once adulthood is reached. Signs of this arrested growth are closely packed bone layers with no evidence of osteocytes and blood vessels and, although Horner found this in a few specimens, the majority of bones he studied showed continued growth: this included the largest *Allosaurus* in his collection, plus the remains of six *Tyrannosaurus rex* fossils. Horner argued that this continued growth meant that the animals got bulkier, rather than longer and taller. Kevin Padian, a palaeontologist at the University of California, Berkeley, USA, said "For years we've been finding robust and gracile forms of skeletons that are otherwise very similar, ... Some have suggested the robust ones were males and the gracile ones were females. Others have argued they were different species. Now it looks like they were actually just different ages."

Could this have implications for the various robust and gracile forms of iguanodont that we find in the Wealden deposits of the UK, including here at Hastings?

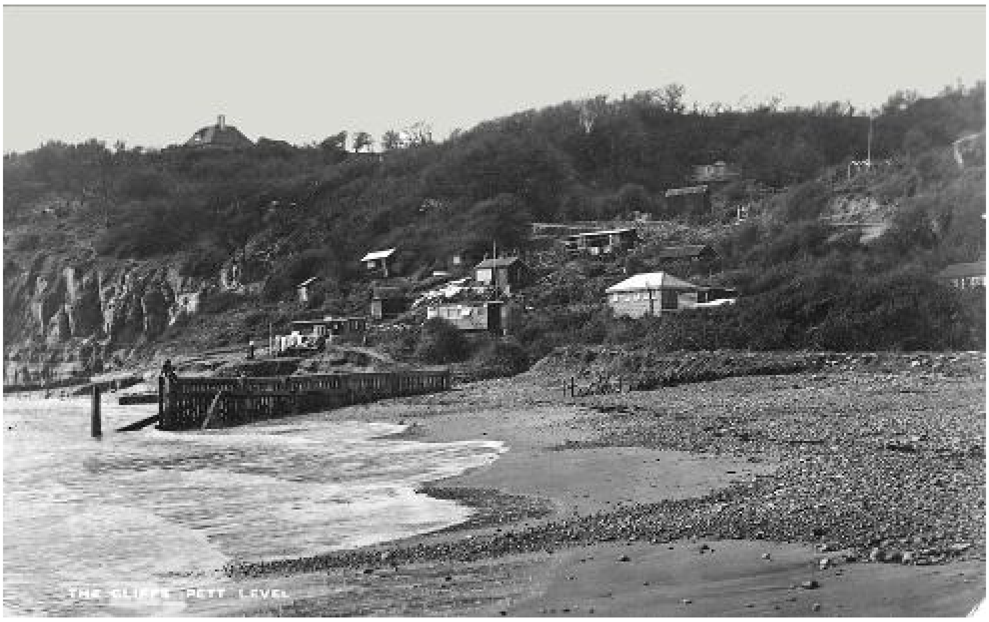
Reference

KAPLAN, M. 2013. *T. rex* grew beefier than museum fossils suggest. *Nature News*, doi:10.1038/nature.2013.14086.

Postcards from the Past

One of our most popular and enjoyable local field trips entails fossicking along the beach from Cliff End to Fairlight Cove, followed (or preceded!) by refreshments at a local hostelry, *The Smuggler Inn*.

Ken Brooks recently obtained copies of several historic Hastings postcards – the two below being of particular relevance to a favourite local perambulation!



The cliffs, Pett Level, 1934

Beach Club & Café, Pett Level, 1946
(now The Smuggler Inn)