TEES VALLEY RIGS GROUP NEWSLETTER

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PERUSat-1's first satellite image reveals Cuajone, a large copper mine in the south of the country

PUBLISHED TWICE ANNUALLY

CONSERVING GEODIVERSITY IN THE DISTRICTS OF

REDCAR & CLEVELAND · MIDDLESBROUGH · STOCKTON · HARTLEPOOL · DARLINGTON

CONTENTS

Greetings faithful reader and welcome to Issue 8 of the TVRIGS newsletter.

I can only describe 2016 - a year during which so much drama has unfolded on a global scale - as being a somewhat subdued one for our group.

Our annual collaboration with Winkie's Castle Museum in the summer proved a success and thanks are extended to all who planned or manned the event. Later in the year a presentation, on the local geology with special attention on Marske Quarry, was given at the Friends of Winkie's Castle A.G.M.

Logging activity at Belman Bank (NZ 622 148) in the summer has revealed a good deal of Thomas Chaloner's former alum quarry there. The group are in contact with the Forestry Commission about possible re-exposure of a section high on the SW of the site which (it is calculated) spans the Lower-Middle Jurassic transition. A horizon about which little seems to have been recorded in this locale.

The Lewis Hunton interpretation panel at Hummersea which suffered damage in the spring of 2016 has been repaired free of charge by SignArt Studios, and re-erected slightly east of its original position, but still on the Cleveland Way. We extend our thanks to Harry and Eddie Guy for their kindness.

Finally, a new project has been proposed for Eston Hills which, it is hoped, will cover all aspects of the outlier's history. A memorial to all of Cleveland's former miners is envisaged that will overlook Teesside from the cliffs above Eston Mine entrance. The last update was that this project was on hold, with a decision promised in the near future.

So, it only remains for me to (somewhat belatedly) wish you all a prosperous and peaceful New Year, and I look forward to seeing you all soon.

The Editor

News in Brief

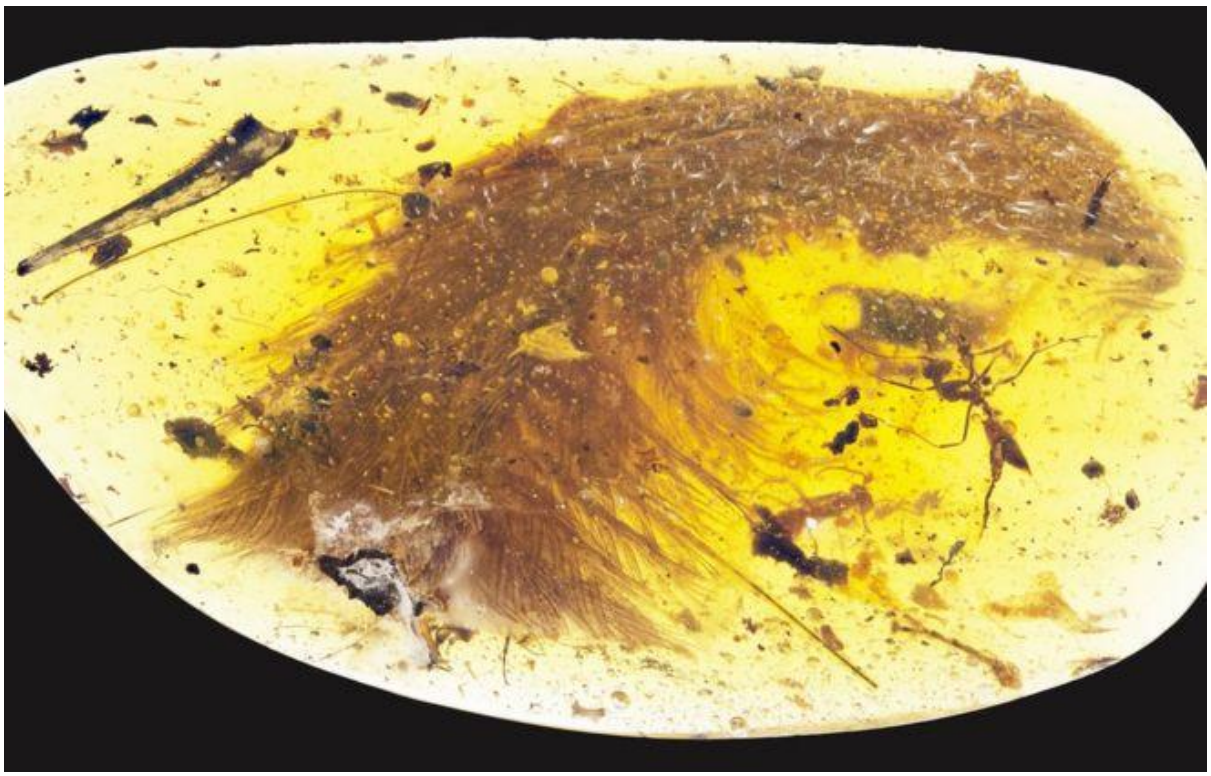
More Preservation in Amber

In Issue 3 of our newsletter (June 2014) we reported upon the discovery from Myanmar (formerly Burma) of delicate Mid-Cretaceous flowers exquisitely preserved in amber – the fossilised resin produced by trees.

Before its true origins were understood it is little wonder that amber, one of few natural substances able to exhibit electrical properties, was viewed as being almost magical. Natural Philosophers from Theophrastus to Dioscorides and Pliny the Elder believed it to be the petrified urine of the Eurasian Lynx (*Lynx lynx*) and hence it became known as *Lyncurium*. Pliny assuring us that the urine of wild males produced the most potent examples. This creature was deemed to have the sharpest eyesight in the animal kingdom and, as such, early apothecaries and physicians would utilise grindings of amber to treat poor or failing eyesight. But I digress...

Recently Paul Rincon (Science Editor on the BBC Science website) has reported on a new discovery, also from Myanmar, this time of a reptilian tail complete with feathers preserved in amber – his report is reproduced below:

The tail of a feathered dinosaur has been found perfectly preserved in amber from Myanmar.

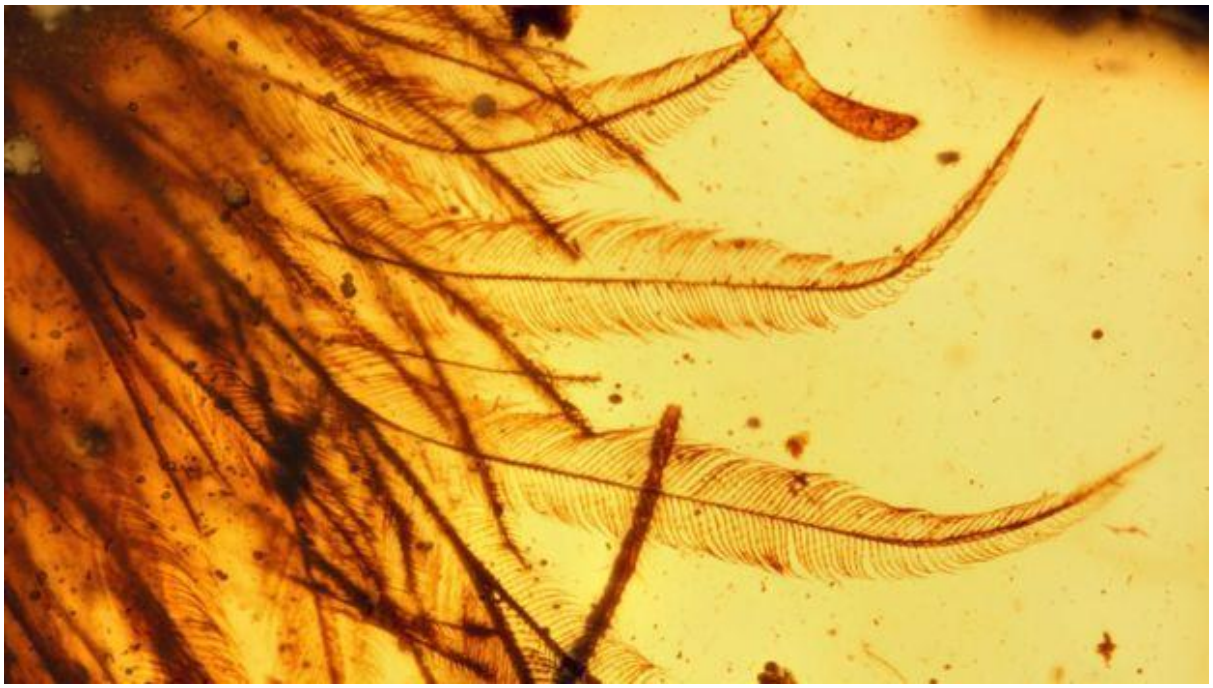


The feathered tail was preserved in amber from north-eastern Myanmar

The one-of-a-kind discovery helps put flesh on the bones of these extinct creatures, opening a new window on the biology of a group that dominated Earth for more than 160 million years. Examination of the specimen suggests the tail was chestnut brown on top and white on its underside.

"This is the first time we've found dinosaur material preserved in amber", co-author Ryan McKellar, of the Royal Saskatchewan Museum in Canada, commented.

The study's first author, Lida Xing from the China University of Geosciences in Beijing, discovered the remarkable fossil at an amber market in Myitkina, Myanmar. The 99-million-year-old amber had already been polished for jewellery and the seller had thought it was plant material. On closer inspection, however, it turned out to be the tail of a feathered dinosaur about the size of a sparrow.



Close-up showing feather detail

Lida Xing was able to establish where it had come from by tracking down the amber miner who had originally dug out the specimen. Dr McKellar said examination of the tail's anatomy showed it definitely belonged to a feathered dinosaur and not an ancient bird.

"We can be sure of the source because the vertebrae are not fused into a rod or *pygostyle* as in modern birds and their closest relatives", he explained. "Instead, the tail is long and flexible, with keels of feathers running down each side."

Dr McKellar said there are signs the dinosaur still contained fluids when it was incorporated into the tree resin that eventually formed the amber. This indicates that it could even have become trapped in the sticky substance while it was still alive.

Co-author Prof Mike Benton, from the University of Bristol, added: "It's amazing to see all the details of a dinosaur tail - the bones, flesh, skin and feathers - and to imagine how this little fellow got his tail caught in the resin, and then presumably died because he could not wrestle free." Examination of the chemistry of the tail where it was exposed at the surface of the amber even shows up traces of ferrous iron, a relic of the blood that was once in the sample.

The findings also shed light on how feathers were arranged on these dinosaurs, because 3D features are often lost due to the compression that occurs when corpses become fossils in sedimentary rocks. The feathers lack the well-developed central shaft - a *rachis* - known from modern birds. Their structure suggests that the two finest tiers of branching in modern feathers, known as barbs and barbules, arose before the rachis formed.

Kachin State, in north-eastern Myanmar, where the specimen was found, has been producing amber for 2,000 years. But because of the large quantity of insects preserved in the deposits, over the last 20 years it has become a focus for scientists who study ancient arthropods.

"The larger amber pieces often get broken up in the mining process. By the time we see them they have often been turned into things like jewellery. We never know how much of the specimen has been missed", said Dr McKellar. "If you had a complete specimen, for example, you could look at how feathers were arranged across the whole body. Or you could look at other soft tissue features that don't usually get preserved".

Other preserved parts of a feathered dinosaur might also reveal whether it was a flying or gliding animal.

"There have been other, anecdotal reports of similar specimens coming from the region. But if they disappear into private collections, then they're lost to science", Dr McKellar explained.

Dr Paul Barrett, from London's Natural History Museum, called the specimen a "beautiful fossil", describing it as a "really rare occurrence of vertebrate material in amber".

He told BBC News: "Feathers have been recovered in amber before, so that aspect isn't new, but what this new specimen shows is the 3D arrangement of feathers in a Mesozoic dinosaur/bird for the first time, as almost all of the other feathered dinosaur fossils and Mesozoic bird skeletons that we have are flattened and 2D only, which has obscured some important features of their anatomy".

"The new amber specimen confirms ideas from developmental biologists about the order in which some of the detailed features of modern feathers, such as barbs and barbules (the little hooks that hold the barbs together so that the feather can form a nice neat vane), would have appeared also".

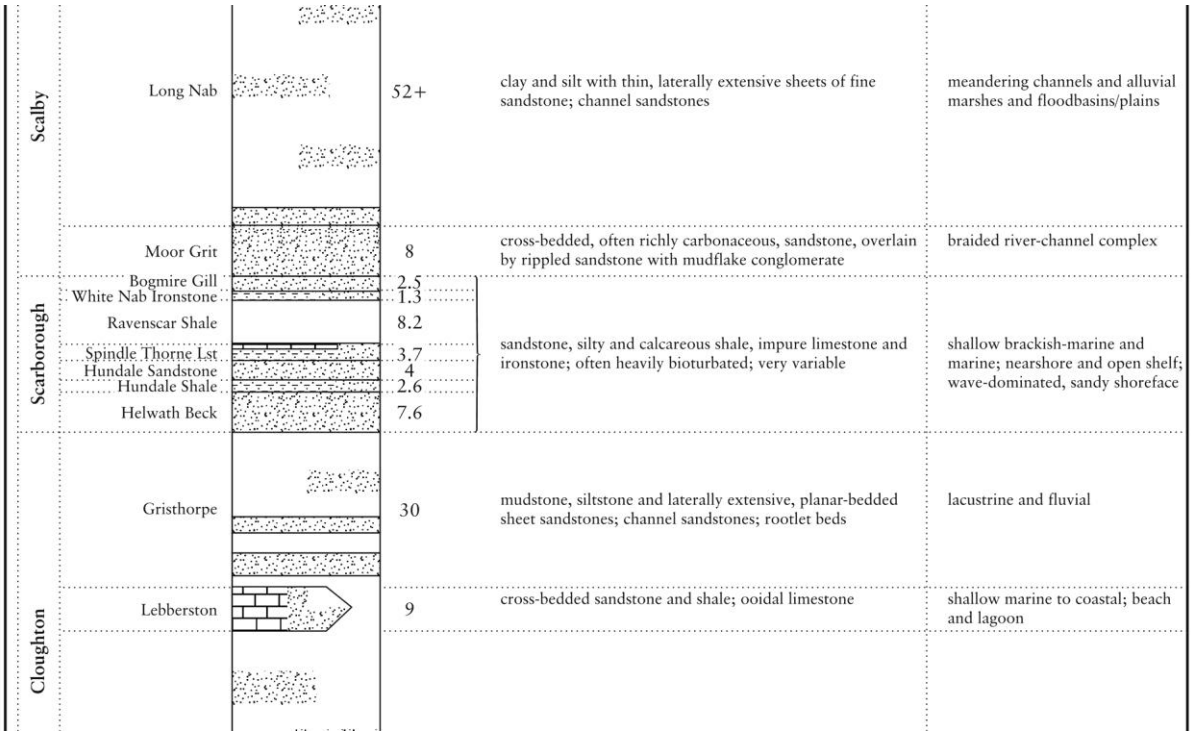
Earlier this year, scientists also described ancient bird wings that had been discovered in amber from the same area of Myanmar.

Durham University Students Investigate the Scarborough Formation

The where, how and why of the Scarborough Formation of the Middle Jurassic in Cleveland has long been a puzzle to geologists, sandwiched between the better researched coastal outcrops around Scarborough, and the western outcrops in the Northallerton area – but seemingly different to both.

Whether this is completely accurate is now being studied by three students (Isabel, Alex and Josh) from Durham University Earth Sciences department who will advise whether any outcrops in the area merit conservation and protection.

Their studies should be completed by this spring and will be more fully covered in our next newsletter.



Generalised log of the Scarborough Formation

Site Visits 2016

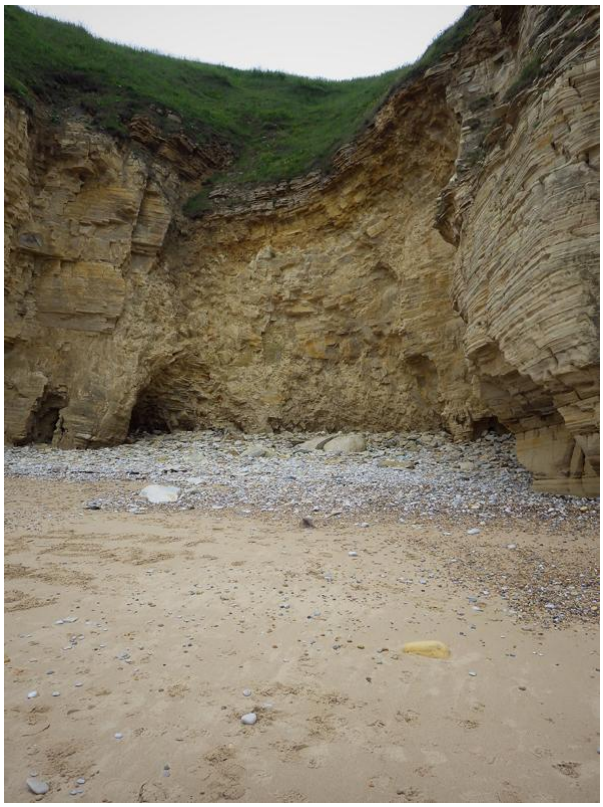
On 9th July 2016, a small group of TVRIGS (in association with Leeds Geological Society) walked the cliff-top and beach from Trow Point to Frenchman's Cove and Marsden Bay in the company of Michael Mawson who explained the various Permian exposures en-route.

On 27th July and 24th August your Chairman escorted groups of members of the public around Boulby and Loftus alum quarries respectively, describing the geology and industrial archaeology on the way.

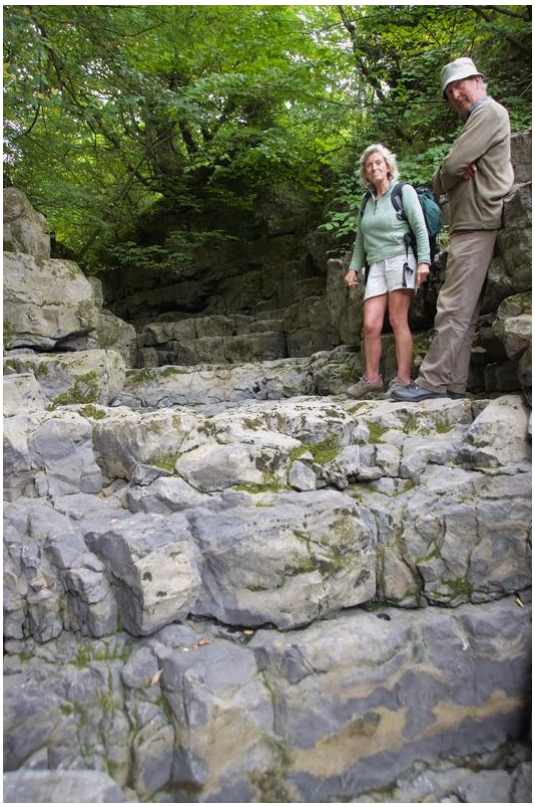
On1st September our esteemed secretary delivered a long-awaited visit to Harehope Quarry in Weardale where Frosterley Marble (limestone actually) was observed in the stream-bed, The Great Limestone was examined in the quarry faces. We then ventured higher up the dale to Westgate and traversed part of the Slitt Wood/West Rigg trail. Several cyclothems of limestone-shale-sandstone were examined, as were the ironstone workings and Slitt Vein (lead) at West Rigg.

On 14th September our annual trip with Cleveland Naturalists took place with a circuit around Boosbeck to discuss various aspects of its Quaternary history, ably guided by your newsletter editor.

Finally, in October, we organised a return trip to Marske Quarry for Michael Mawson to see our work on the Jurassic plant fossils there – supported in the field and back at Margrove by Chris Hill who was able to assist with identification of some of the plant fossils in TVRIGS' expanding collection.



North end of Marsden bay. On right laminated beds of carbonate turbidite.

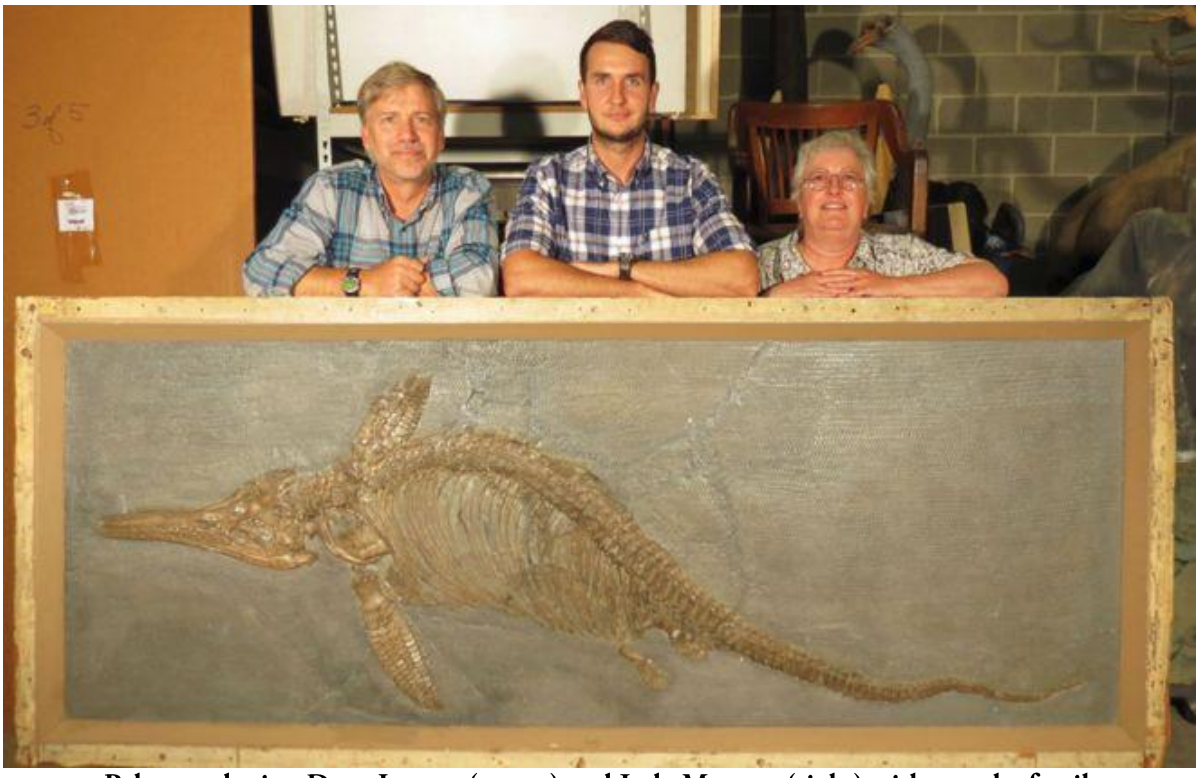


Dry stream bed in the Great Limestone just below the Frosterley Marble horizon.

A fine view of Harehope quarry.
[All Images kindly provided by Mark Stokeld]

British 'Sea Dragon' Fossils are New to Science

Scientific detective work on fossils collected in Victorian times has identified two new species of *Ichthyosaurs* - the giant reptiles that swam at the time of the dinosaurs. It brings to six the known species of *Ichthyosaurus* – 'sea-dragons' that ruled the oceans in Jurassic times. Both fossils were unearthed in Somerset in the 1800s.



Palaeontologists Dean Lomax (centre) and Judy Massare (right) with one the fossils

One specimen has been on display at Bristol University for decades, under the gaze of countless students. The other was donated to a museum in Philadelphia, US, by Thomas Hawkins, a well-known Victorian fossil collector. He amassed a huge collection of marine reptiles from Somerset in the first half of the 19th Century. Such was the Victorian craze for skeletons of ichythyosaurs - the first was found by Mary Anning on the Dorset coast - that they ended up in museums and collections right across the world.

Palaeontologists Dean Lomax of Manchester University and Judy Massare of Brockport College, New York, examined hundreds of ichthyosaur fossils in Europe and North America, including some that had been kept hidden for decades.

''These are two new species - brand new species to science, they show that during the early Jurassic - around 200 million years ago - the ichythyosaur, and specifically this particular type, was a lot more diverse than previously thought'', Dean Lomax said.

Ichthyosaurs were fierce predators, growing up to 15m in length. The dolphin-shaped creatures patrolled the seas at a time when the UK was a series of small islands. They were among the first skeletons to be discovered by early British fossil-hunters, at a time when theories of evolution and

concepts of geology were in their infancy. The reptile fossils were categorised as new species on the basis of distinctive features of their skull and other bones.

The Bristol specimen has been named *Ichthyosaurus larkini*, after scientist Nigel Larkin

One of the new species was identified from a complete skeleton of an ichthyosaur that has been on display at the University of Bristol for more than 30 years. The other - originally found in a quarry in Glastonbury - was donated to Philadelphia's Academy of Natural Sciences in 1847. The specimen had been in storage, and few people even knew of its existence.

''It's been hidden away behind the scenes for such a long time'', said Dean Lomax. ''It was quite amazing when Judy Massare and myself examined the specimen and then found that it was a practically complete skeleton and in my personal opinion the best example ever of the ichthyosaur genus to be collected and studied''.

The Philadelphia specimen has been named *Ichthyosaurus somersetensis*, in honour of the county where so many specimens have been dug up or found in quarries. The Bristol University fossil has been called *Ichthyosaurus larkini*, in honour of British palaeontologist Nigel Larkin, whose whose family has lived in the Bristol area for centuries. A scholarly paper describing the research is published in the journal Papers in Palaeontology.

Dinosaur-era 'swordfish' discovered in outback Australia

"Extremely rare" fossils from a swordfish-like creature which lived 100 million years ago have been discovered in the Australian outback. Two families on holiday unearthed the prehistoric predator at a free fossil-finding site in north-west Queensland.

The remains are thought to be from the *Australopachycormus hurleyi*, a 3m-long ray-finned fish with a pointed snout. "Part of what makes this specimen so special is that it is so complete," Dr Patrick Smith, curator of *Kronosaurus Korner*, advertised as being '*Australia's premier marine fossil museum. It showcases nearly 1,150 unique fossil specimens from Richmond, Outback Queensland*'.

An artist's impression of what the ancient marine predator may have looked like
Credit: Kronosaurus Korner

Dr.Smith says that Kronossaurus Korner has assembled the ancient creature's skull, backbone and fins. "We know that it was a high-tier carnivore and that it ate other large fast-moving fish, a bit like marlin do today," he said. "Because it does fit that swordfish-like shape we know he probably lived in that same ecological niche."

He wants to encourage other amateur palaeontologists to make their way to the tiny outback township 1,700km (1,000 miles) from Brisbane.

"Come to Richmond, because there's an awful lot of material to be collected," he said.

Fossils have been turning up since the 1930s in the region of north-west Queensland, which is described as "Australia's Dinosaur Trail".

The remains of *Australopachycormus hurleyi* are on display at the Kronosaurus Korner museum
Credit: Kronosaurus Korner

Strange Reptile Fossil Puzzles Scientists

A 200-million-year-old reptile is rewriting the rulebooks on how four-legged animals conquered the world. Newly discovered fossils suggest *Drepanosaurus* had huge hooked claws to dig insects from bark, much like today's anteaters in the forests of Central and South America. Scientists say the creature defies the convention on how reptiles evolved and flourished. Their research is published in the journal *Current Biology*.

The new fossils, found in a New Mexico quarry, suggest *Drepanosaurus* was the size of a cat and lived in the trees. It had a bird-like head on a chameleon-like body, but the most unusual feature was its forearms, said Dr Adam Pritchard, of Yale University, who led the research.

Massive arms

"*Drepanosaurus* itself has extremely massive arms and forearms - very muscular," he said.

"The index finger is much much larger than any of the other fingers and supports this gigantic claw, which is easily the most massive bone of the entire arm."

The forelimbs of tetrapods are known for their versatility, used to walk, dig, fly or swim. However, the basic plan of the forelimb has stayed much the same throughout 375 million years of evolution.

"The arm of tetrapod animals almost always follows some very consistent rules," Dr Pritchard said.

The Pygmy anteater has similar adaptations for digging
Photo: THINKSTOCK

Melting pot

The US team made 3D reconstructions of the reptile based on micro-CT (computerised tomography) scans of dozens of bones. Other fossils that have been unearthed were partly crushed, making interpretation difficult.

"In your forearm, in the forearm of *Tyrannosaurus rex*, in the forearm of an elephant, you have two bones - the radius and the ulna, which manifest as these elongate, slender, parallel shafts," he explained. But the *Drepanosaurus* did not have these parallel bones.

"So all of these consistent patterns that we see across a huge range of tetrapods, regardless of their ecology, regardless of their ancestry, are violated by this animal. On the one hand, it extends the bounds of what we think the arm of tetrapod animals - those four-footed animals in the world - is capable of in terms of its development, in terms of evolution. And, it is also remarkable in what it evidences about the ecology, the lifestyle of the animal, in that it seems to have quite independently developed adaptations that we see today in modern groups like anteaters." Dr Pritchard said.

Palaeontologist Dr Nicholas Fraser, of National Museums Scotland said the Triassic period was a "melting pot of experimentation. The unconventional rules in the Triassic. Here is another animal which is completely unconventional in the way it has got this system of bones in the limb to help it dig - those are massive claws too." he said.

Drepanosaurus ripped away tree bark with a massive claw to get at hidden insects
Photo: Victor Leshyk

Invaded land

Drepanosaurus disappeared at the end of the Triassic and did not lend its form to any future creatures.

"It was only useful in this one particular instance, where you have got a really specialised fossorial animal - a digger. But it is the first real departure like this in the basic ground plan that you see ever since the first tetrapods invaded land 365 million years ago." Dr Fraser said.

The researchers say they are continuing to excavate the quarries in New Mexico, with the hope of finding more discoveries.

"There's a lot - especially in terms of the smaller animals in the fossil record - that has remained undiscovered," said Dr Pritchard. "I don't see an end to it."

From the Archive

The following is from a paper first published in *Proceedings of the Yorkshire Geological and Polytechnic Society* (1883), New Series, Vol VIII, Part 2, pp220-226, describing the occurrence and interpretation of raised beaches on this part of the coast, by W.Y. Veitch.

ON THE RAISED BEACHES ON THE NORTH EAST COAST OF YORKSHIRE. BY W. Y. VEITCH, ESQ., M.D. (PL. XI.)

At the estuary of the Tees, and on the adjoining coast, there are several indications that alterations in the sea level have taken place, embracing a period ranging from pre-glacial to recent times. They are, perhaps, of sufficient interest to be recorded, and this ought to be done as nearly as possible in the order in which they probably occurred.

Ancient river beds. — The most convenient physiographical records as a starting point, are the ancient river beds. The numerous borings taken in this district, prove that the pre-glacial stream which carried off the water to the sea from this neighbourhood, did so at a level considerably below the present low water mark. Its bed is traceable from the river Tees, near Newport, where it enters the county of Durham, and takes the direction of Saltholme, where it is ascertained by a boring to be 98ft. deep, and filled with sand and gravel;

The following is the section :

	FEET.
Sand	35
Warp (a fine carbonaceous mud)..	5
Sand	23
Warp	23
Gravel	2
Into the red sandstone	1
TOTAL	99

It is next traced to Port Clarence, where boulder clay at a depth of 77ft. was proved, according to the following section :

	FEET.	INCHES.
Soil	1	6
Clay	4	0
Dark Sand	7	6

Clear Sand	26	0
Red Clay	3	0
Sand and Gravel	8	0
Boulder Clay	27	0
Into the red. marl.		

By the following boring it is indicated at the works of Messrs. Bolckow, Vaughan & Co., at Middlesbrough:

Made ground (Slag, Chalk &c.)	11
Dry Slime or River mud	8
Sand with water	10
Hard Clay (dry)	10
Red Sand with a little water	1
Loamy Sand d°.	3
Hard Clay	15
Rock, mixed with clay and water	11
Rock, mixed with clay, dry	1
Into Gypsum.	
TOTAL	70

On the south side of the Tees, at the Tees Tilery, near Eston ironworks, boulder clay was proved over 100ft. deep. The valley pursued its course past Kirkleatham to near Marske, where it joins the German Ocean, from under the boulder clay cliffs which guard this part of the coast. Borings near North Skelton, four miles south of Marske, show that the stratification has been washed out to a depth much below the bed of the present stream, and has been replaced by boulder clay, the inference being that this indicated the bed of a stream probably tributary to the one just described, which must have carried its water much further east than the present coast, to join the sea.

Glacial Era — Making these river beds the starting point, next came the glacial disturbance, about which my remarks will be limited to the evidence it furnishes me bearing upon my subject. It almost overwhelmed this district, grinding up the country, leaving striations recording the direction it travelled upon the local rocks, making Eston Nab, Hob Hill, and Roseberry Topping outliers, bringing debris and boulders from the western part of the island, and filling up the submerged river beds. There being no boulders or drift above 800ft. in Cleveland, this, therefore, marks the highest point to which the water attained, although the ice must have passed over the Pennine range at an altitude of 1,450ft., to bring over the fragments of Eden valley and lake district rocks, which are scattered so plentifully about.

Perforated stones at Wilton — Having been informed upon very good authority, that there were to be found on the Wilton Castle escarpment, near Redcar, blocks of perforated rocks having the shells of *Pholadomya* still retained in their cavities; the blocks being stones from a higher horizon than the rocks on the adjacent coast, all of the same kind of stone as the stratification near to which they were found, led me to believe that they might possibly record a beach somewhere about 150ft. above the present sea level, probably marking a pause in the upheaval which followed the submergence just referred to. I visited this part of the district in search for the *Pholas* bored blocks, but failed to find them. Subsequently I again searched, being this time accompanied by my friend, Mr. Barrow, of H.M. Geological Survey; disappointment again resulted. Mr. Barrow is, nevertheless, certain of their existence, and undertakes to point them out after referring to his map. It will, therefore, be unnecessary to say anything further upon this part of the subject at present.

Submerged Forest — The next to be considered is what are generally termed the peat beds of Hartlepool and Redcar. Situated on both sides of the mouth of the river Tees, there are large tracts of peat and wood, suggesting either that they are the remains of an ancient forest, or accumulations of vegetable matter brought down from higher ground. On the north bed of the river the peat at the sea shore overlies the new red sandstone between the Stranton beach and the Longscar rocks. On the south side a similar bed is found over the Lower Lias between Redcar and the Saltscar rocks. After rough seas they are sometimes bared, and may be noticed to rest immediately upon fine blue clay, here and there stumps are to be seen with roots spreading through the peaty matter into the blue clay below, evidently in the position in which they originally grew. This same fact was observed by Mr. Charles Harrison, while engaged in superintending the construction of the Hartlepool Docks, where the same forest remains were come upon. Logs of wood, branches, twigs, and nuts are embedded in the mass, there being recognisable, oak, beech, and hazel, together with its leaves and nuts The Tees Conservancy Commissioners in their dredging operations near Middlesbrough and Eston have brought up huge trunks of oak and vast quantities of vegetable matter, in fact, forest remains similar to the components of the sunk forest at Hartlepool and Redcar. Several antlers of the red deer have also been taken from amongst the vegetable remains. One of these trunks of oak is preserved in the Albert Park, Middlesbrough, and when placed there it weighed eleven tons. Thinking it possible that the deposit might extend inland, that is, to the west at Stranton, I obtained the following section from borings made in search of a water supply:

> Boring at the West Hartlepool Ironworks : — Passed through 50ft. of gravel and clay before penetrating the new red sandstone. Boring at the Seaton Carew Ironworks, half-a-mile to the south of the last boring: — Passed through 60ft. of gravel only, before reaching the new red sandstone.

Attention will now be drawn to four sections which will throw some light upon the probable time at which this mass of vegetable matter was formed. In clearing away matter to form the central dock, at West Hartlepool, the following notes were taken:

	FEET
Gravel	3
Peat with numerous trees in situ.....	0 to 8
(This bed thickens towards the timber ponds where it becomes 40ft. thick)	
Blue Clay varying from	2 to 0
Boulder Clay bored into[1]	20

We must now go to the Saltholme boring of Messrs. Bell Bros., where we have;

	FEET
Peat, earth and clay	8
Blue Clay	32
Brown and Red Boulder Clay	56

Passing on to the south of the river Tees to the Middlesbrough Graving Dock, there is;

	FEET
Peat	7
Silt	3
Into Boulder Clay	5

A section near Lackenby, beginning 9ft. below high water mark, gives;

	FEET
Sand and Silt	22
Blue Clay	3
Into Red Clay, no doubt Boulder Clay	

[1] It is most probable that the thickening of the bed at this point is due to the gradual dissolving and washing out of the Permian limestone below it during the growth of the forest, as it is here that the Magnesian Limestone crops out from under the new red sandstone.

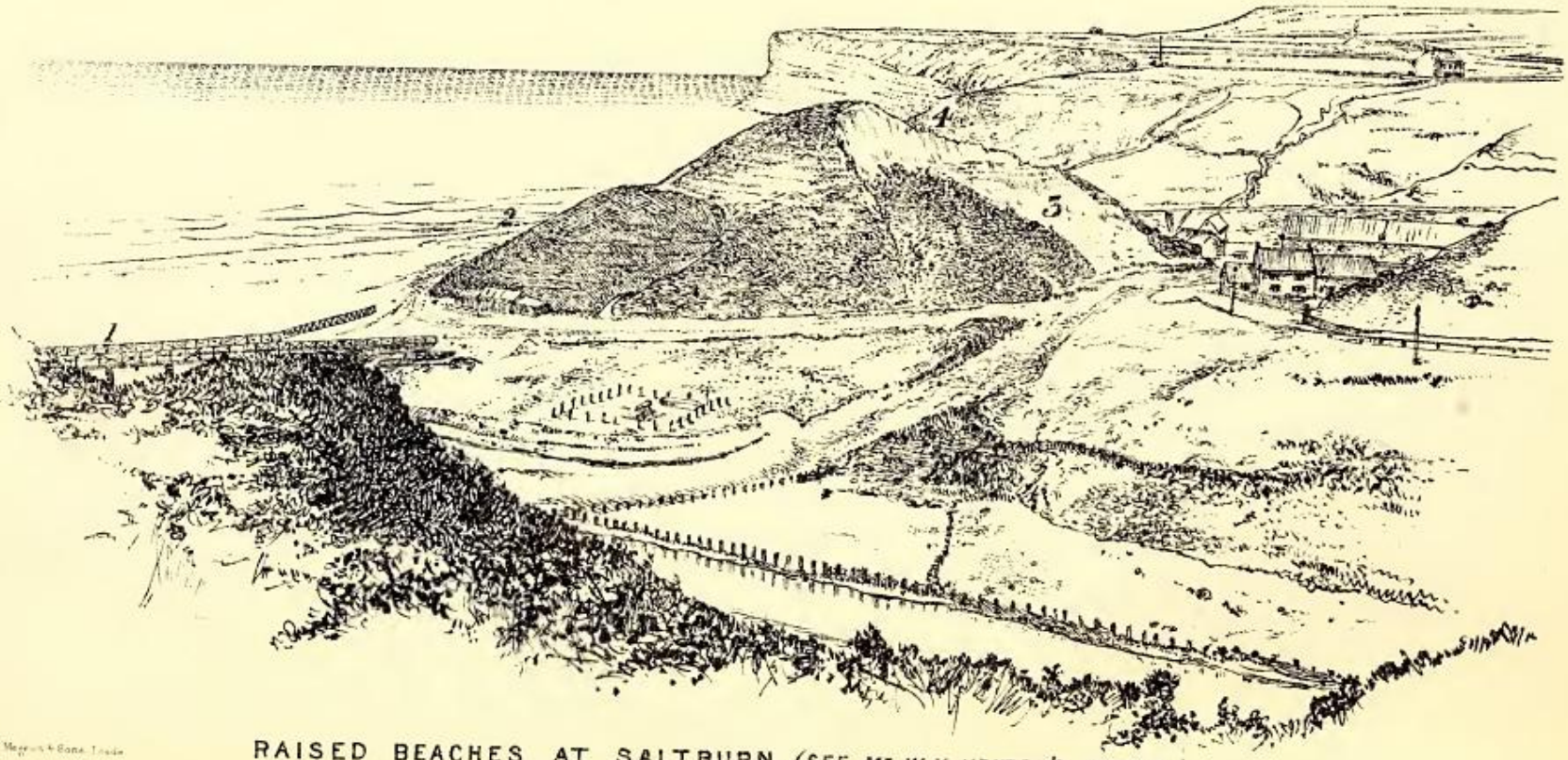
These sections prove conclusively the post-glacial position of the forest remains. The presence of large numbers of the trees in the position in which they grew, and the absence of shells and other estuarine debris in the peat satisfies me that the deposits are not estuarine accumulations drifted from a higher level, but are the remains of a forest still located in its original locality. If these observations are accurate, they indicate a further upheaval followed by a submergence.

Raised beach at Saltburn — A record of this kind of movement exists at Saltburn, where clear evidence of a raised beach, resting upon mid-glacial drift is noticeable; it is 35 feet above high-water mark, and consists of a band of alluvial sand containing shells and fragments of shells, such as *Purpura*, *Litorina litoreae*, *Trochus cinerarius*, *Natica globosa*, *Lachesis minima*, and *Cypraea Europaea*; the two last being less common than the others.

The Saltburn Improvement Company have laid this beach bare along the precipitous drift cliff; extending 70 or 80 yards from the bridge up Saltburn Beck, where it abruptly comes to an end. In baring and altering this cliff evidences of ancient kitchen middens, which once existed, have been completely effaced. Last year Mr. Teall, Mr. Howell, and myself, jointly examined the beach, and shortly afterwards Mr. Barrow, Mr. L. Griers, and I extended the inspection. On the south of the beck referred to, there is an isolated conical hill, named Cat Nab, well-known to all who have visited Saltburn, and is a physiographical problem in itself. We searched this hill for a continuation of the beach, but being so completely overgrown and covered with soil, it was difficult to trace. The characteristic shells showing themselves at the expected horizon, satisfied us as to its existence there (2). The west side shows a clear section of drift owing to the undermining action of Brotton Beck, but no trace of the beach exists there (3), not having been deposited so far inland. Continuing the search towards Huntcliff it was again recognised at the same level (4). Here and there in it are dark looking patches containing sea-coal, similar to deposits frequently left in patches on the sea-beach of today. The existence of this raised beach at Saltburn only, on this part of the coast, indicates the extremely slow denuding action carried on at Saltburn.

The rate of the sea's encroachment is trifling indeed when compared with the action of the sea upon other parts of the coast take Robin Hood Bay for instance, where the sea's action is accurately marked, its inroad being 20 feet a year, three coast-guard flag-staffs having been washed away in 20 years, these having been placed 140 feet from the shore.

In leaving these notes for your consideration, I beg to express my thanks to T. E. Harrison, Esq., Engineer-in-Chief to the N. E. Railway, and to Chas. Harrison, Esq., for their kindness in placing, for my consultation, the numerous sections of borings, and specimens they have preserved at Newcastle.



RAISED BEACHES AT SALTBURN. *(SEE Mr W. Y. VEITCH'S PAPER.)*

Freebrough Hill

Edited details from the TVRIGS Site Management Plans of 2010

Summary

Freebrough Hill is a prominent conical hill on the south side of the A171 Guisborough-Whitby Road near Moorsholm village. It is not a man-made feature, as some authors have previously suggested, its existence being due to geological and geomorphological processes, particularly fluvial and glacial processes creating an outlier from moorland to the south, giving the feature its present form. It is composed of sedimentary deltaic and marine rocks deposited toward the end of the Middle Jurassic c.176Ma. Some of the marine rocks are poorly exposed in a quarry towards the top of the hill with further former workings around Dimmingdale Farm.

Fig 1. A wintery view of Freebrough Hill from Stanghow Ridge
Photo: Andy Cooper

Site Description

Freebrough Hill forms an impressive isolated conical hill adjacent to the A171 opposite Freebrough Road which runs north to Moorsholm village. Its grid reference is NZ 689 126. Geologically and geomorphologically it is an outlier from the north-facing escarpment of Moorsholm Rigg about 1 kilometre to the south. It rises from a base level of about 200 metres O.D. to a height approaching 250 metres O.D. and resides within the boundary of the North York Moors National Park.

Geology

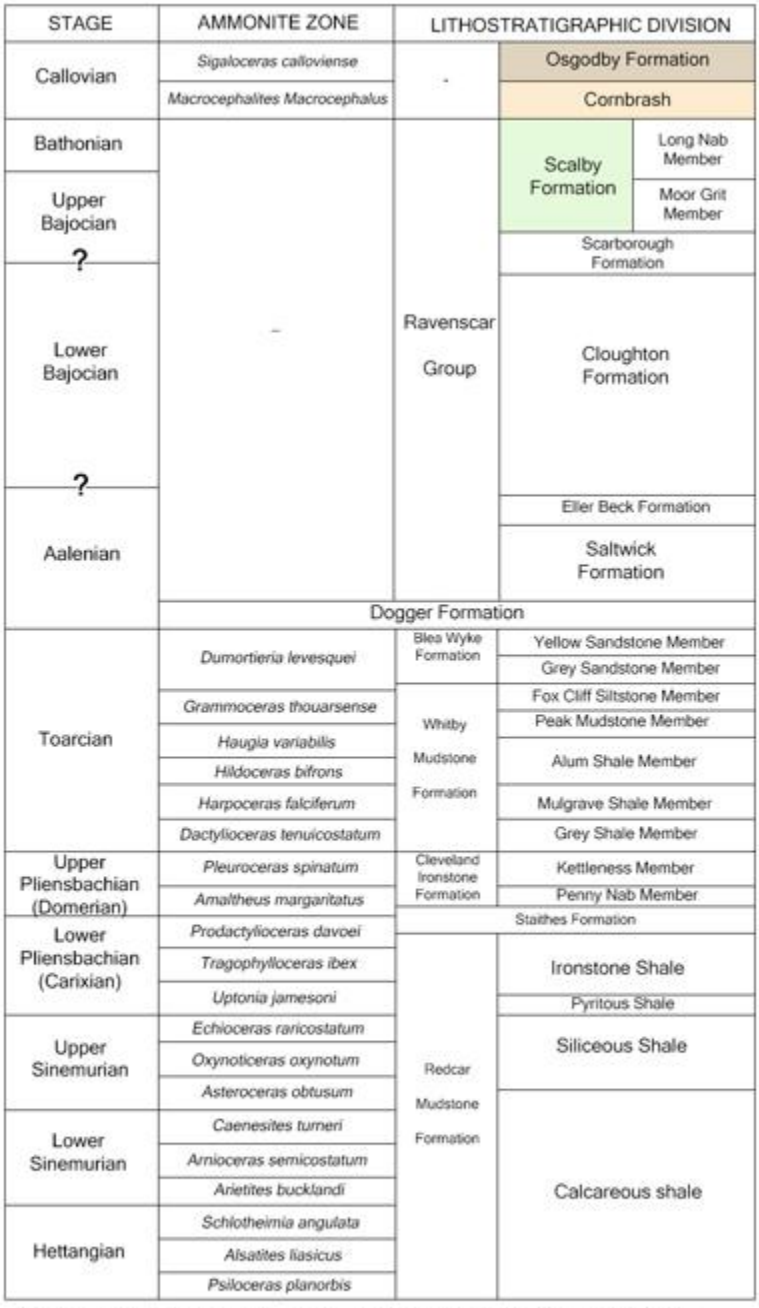
The Cleveland area was surveyed by the Geological Survey in the late 19th century with resulting 1:10,560 and 1:63,360 scale maps and accompanying memoirs (Barrow 1888 and Fox-Strangways 1892). Recent maps at a scale of 1:50,000 are based almost entirely on the original editions with amendments by J.E Hemingway, R.W.O'B Knox, J.H. Powell, P.F. Rawson, J.K. Wright, and others. There has been little detailed investigation and recording of the geology of the Freebrough Hill RIG site since the original survey. Middle Jurassic sedimentary rocks, laid down between c.176Ma and c.180Ma underlie the moorland in this part of East Cleveland.

Freebrough Hill is formed from deposits laid down in the latter part of the Middle Jurassic as shown in Figure 2. Distinguished from the totally marine Lower Jurassic, the Middle Jurassic in Yorkshire was subject to uplift with deposition in alternating deltaic and marine environments, the former dominating in terms of thickness of deposit (30-60 metres in each case). The area became a large delta with floodplain deposits, thin coal seams and river channel deposits. The environment produced river channel and flood-plain deposits both of which locally contain fossil plant debris. However it is in the floodplain deposits that the best preserved fossil plants are found. The marine formations are usually no more than 12 metres thick individually and locally less than that, and record a marine fauna dominated by bivalves, with brachiopods and gastropods, though ammonites are less common.

Lithology of the Late Middle Jurassic

Figure 3 illustrates the composition of Freebrough Hill from its base in the Scalby Formation, through the Cornbrash Formation, to its summit in the Osgodby Formation. The general position of these beds in the geological column is given in Figure 2 (not specific to Freebrough Hill).

The Scalby Formation: This comprises two recognised deposits in the Cleveland Basin and is up to 60 metres thick. It forms the top of the Ravenscar Group of rocks and extends from the Upper Bajocian to the Bathonian stage. The Moor Grit Member is the older deposit and is not exposed immediately around Freebrough Hill. It is white, brown or grey, fine- to medium-grained cross-bedded sandstone with quartz content up to 98% (orthoquartzite). The Moor Grit has few fossils but wood fragments are occasionally found. The Long Nab Member is the younger deposit and is composed of white or grey laminated mudstones and siltstones with yellow-grey fine- to medium-grained level-bedded and cross-stratified flaggy sandstones deposited during periods of flood. Trough cross-bedded channel-fill sandstones are also present. Plant fragments, rootlets and drifted wood casts are common together with occasional thin coals and mudstone seat-earths. Dinosaur footprints are occasionally found.



Adapted From: *The Yorkshire Coast* by PF Rawson & JK Wright (1992)

NOTE: Colours show the level in the succession at which the site exists and corellate with the colours used on the geological map.

Fig 2. Log showing Jurassic succession with beds making up Freebrough Hill coloured

The Cornbrash: With the commencement of the Callovian marine transgression over Yorkshire the dominantly non-marine Middle Jurassic episode precariously balanced between marine and non-marine environments began to end. Throughout the succeeding Upper Jurassic almost to the end of the Kimmeridgian the basic depositional pattern in the Yorkshire Basin reverted to marine conditions with shale initially less important than shallow water limestone and sandstones. The boundary of the Cornbrash with the Scalby Long Nab Member is generally unconformable. The Cornbrash deposit is up to 5 metres thick and at its type section at Cayton Bay is composed of red-brown sandy nodular bioturbated (and therefore poorly bedded) medium- to fine-grained limestone with oysters and other bivalves; U-shaped burrows extend down from the base of it into the underlying Long Nab Member. The appearance of the rock is generally bluish-grey when fresh but it weathers to yellowish-brown. Thin argillaceous interbeds of calcareous mudstone may occur.

The Osgodby Formation: This was formerly also known as the Kellaways Rock Member and the Redcliff Rock Member. It rests conformably on the Cornbrash and throughout is a fine to medium-grained flat-bedded sandstone laid down in a shallow marine environment. It appears blue-grey when fresh but weathers to rusty brown. The sandstone beds (and occasional limestone beds) have abundant chamosite ooliths and sometimes large calcareous concretions occur. The chamosite-bearing beds have been used in other parts of North East Yorkshire to create subdivisions of the formation. The beds are variably fossiliferous, but especially in bivalves (*Ostrea* sp., *Astarte* sp., *Pinna* sp.) and with many ammonites and belemnites.

Exposed Geology around Freebrough Hill

Freebrough Hill comprises three Late Middle Jurassic formations that collectively mark a change in depositional environment whereby the delta-marsh environment of the Scalby Formation's Long Nab Member is succeeded by a return marine conditions represented by the Cornbrash and Osgodby Formations.

Scalby Formation (Long Nab Member): These delta-marsh sediments comprise the low-lying land around the hill as well as the lower 30 metres or so of the hill itself. Though exposed in a number of riparian sections within the vicinity, these rocks are nowhere exposed within the current RIGS designation.

Cornbrash: According to Barrow (1888), this rock unit comprises c.3 metres of soft shale resting upon c.1.2 metres of sandy ferruginous marl. These shales produce a spring-line around much of their sub-crop. Stratigraphically, the Cornbrash is described by Barrow as being part of the Estuarine Shale of the formerly named Middle Oolite (now Middle Jurassic). No exposure of these beds currently exist within the RIG site boundary.

Osgodby Formation: Formerly known as the Kellaways Rock, the Osgodby Formation constitutes the youngest lithostratigraphic unit of the Middle Jurassic and forms the summit of

Freebrough Hill. Barrow (1888), states, *"...but perhaps the most interesting of all the exposures is Freebrough Hill, which consists of Estuarine shale capped by Kellaways Rock...this hill may be seen from a great distance and meetings of the inhabitants are supposed to have been held there."*

The Osgodby Formation here crops out as a number of minor exposures toward the hill's summit, not least within the heavily slumped and overgrown disused quarry high on the south eastern flank. Here the rock is a close-grained hard sandstone, green when freshly-broken and weathers to a rusty yellow colour. A more competent exposure crops out c.750 metres south close to Dimmingdale Farm. Below and within the quarry is a great spread of fragmented sandstone with pieces attaining a size of only a few centimetres across. Small in-situ exposures on the hill display extensive fracturing with breakages cutting the natural bedding at a high angle. Under a hand-lens, the rock is seen to contain numerous green inclusions, implying we are looking at weathered Osgodby Formation. Some fragments bear signs of bioturbation in the form of burrows.

Collectively, the Cornbrash and Osgodby Formations rarely attain a thickness in excess of 12 metres locally, but are laterally persistent implying that the late Middle Jurassic marine transgression occurred across a relatively flat plain.

Faulting of the strata: A fault is shown on the B.G.S. 1:50,000 Sheet 34 (Guisborough), and trending NW/SE which impinges on the south-west edge of the RIG site. It does not have visible effect on the landscape nor does it affect the geological sequence of rocks in the site.

Quaternary Features

Freebrough Hill is a distinctive grass-covered landform which rises c.50 metres above the surrounding country. The hill has an almost circular base around 300 metres wide and rises steeply on its northern, eastern and western flanks to a summit slightly elongated in a NNE-SSW direction.

To the south, toward the higher ground of Moorsholm Rigg, the slope is less severe to a point around half-way up the hill, before the gradient increases to match that of the other sides.

Elongation of the top of the hill, gives a clue suggestive of Late Devensian ice advancing from the NNE and sculpting the hill into its present shape. Till cloaks the lower slopes to a height of c.230m O.D, containing a suite of water-worn erratics and locally-derived angular fragments. Erratic material appears absent above c.230m O.D., where the till is replaced by a more humic soil with many angular fragments. Despite this a bed of yellow sand almost half-a-metre thick with rabbit holes can be found on the east side of the summit (see Fig. 4).

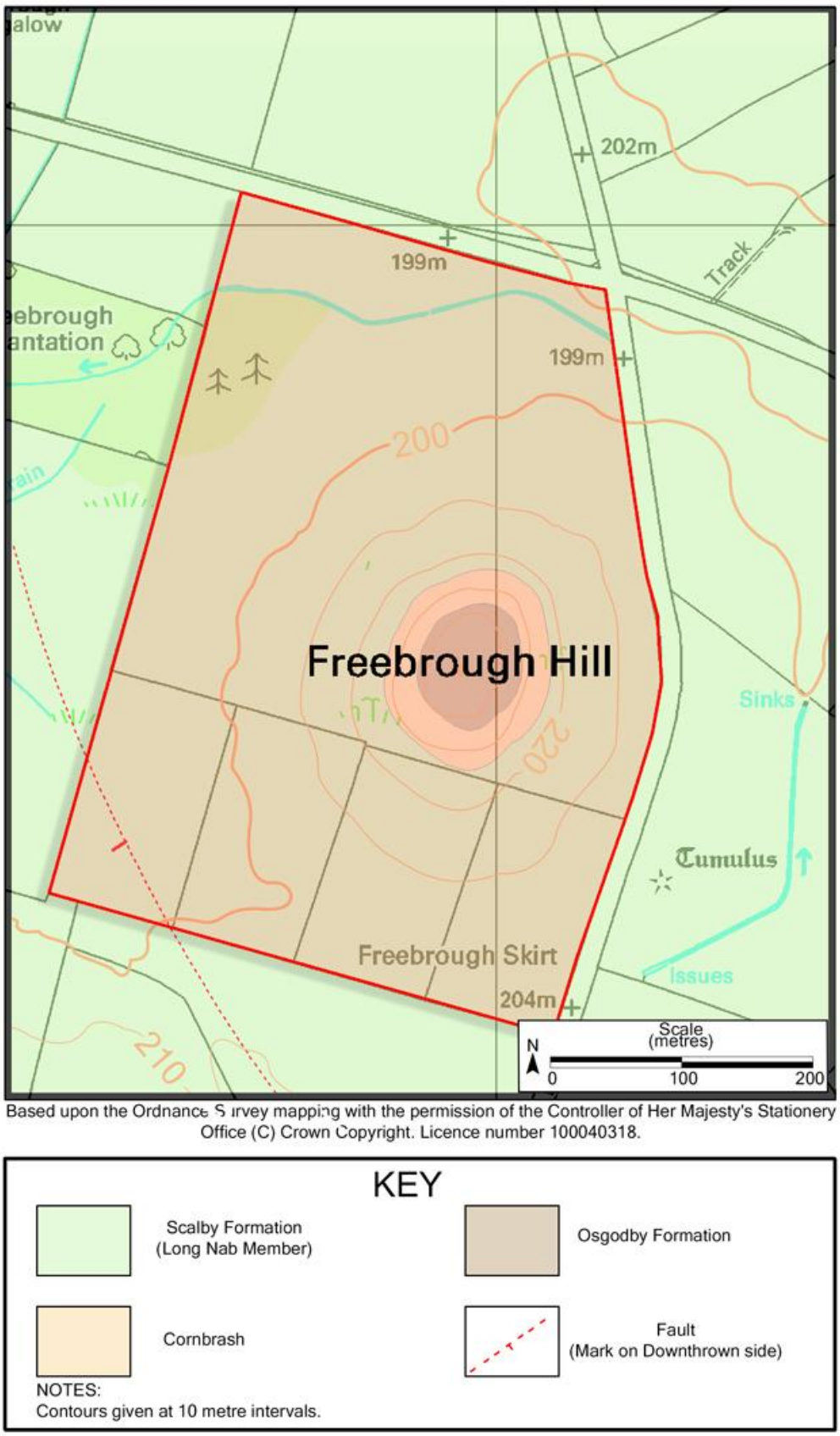


Fig 3. Map showing extent of Freebrough RIG site boundary

Other Quaternary Features in the Vicinity:

To the south of the RIG site at Moorsholm Rigg, and within approximately 2 kilometres of Freebrough Hill, can be found a number of well-marked features formed by meltwater as the Devensian ice sheet retreated at the close of the last glacial period. In the opinion of the authors, these are probably some of the best preserved such features able to be found within England, and possibly the UK as a whole. They occur in the form of channels cut by the meltwater as it found escape both along and through the receding ice-front, before crossing a watershed south into Eskdale via Ewe Crag Slack, at a time when the northerly trend of modern-day drainage, was impeded by ice. It is hoped that these features can also be designated as RIG sites in due course.

Fig 4. Bed of sand (arrowed) utilised by rabbits at the hill's summit
Photo: Andy Cooper