

Newsletter of The Farnham Geological Society

Volume 26, Number 2, May 2023

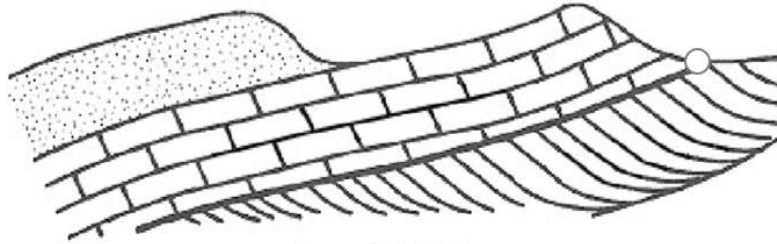


Sunrise over Mount Vesuvius and Naples harbour by Mike Weaver

Farnham Geological Society



*Farnhamia
farnhamensis*



Founded 1970



A local group
within the GA

Volume 26, No. 2

Newsletter

May 2023

Issue No. 120

www.farnhamgeosoc.org.uk

Editorial

Welcome to the latest edition of the FGS Newsletter. I hope you are all fit and well and enjoying the return to The Maltings for our monthly meetings.

I also hope you enjoy what for all of us is a unique or at least a very rare occasion, when King Charles III is crowned at Westminster Abbey on Saturday, 6 May. I'm sure it will be a fascinating occasion for everyone.

Our next lecture will be at **The Maltings** on **Friday, 12 May** when we welcome RHUL Emeritus Professor (Earth Sciences) **Dr. Andrew Scott** who will be talking to us about "**Fire in the Carboniferous Earth System**". Andrew will, I am sure, provide us with an exceedingly interesting presentation.

This will be followed at **The Maltings** by "**The Anthropocene: A new Geological Epoch**" by **Colin Summerhayes** on **Friday, 2 June**. As you may be aware the Anthropocene Epoch is the proposed unit of geologic time, used to describe the most recent period in Earth's history when human activity started to have a significant impact on the planet's climate and ecosystems.

Then on **Friday, 14 July** we will have our **Members Evening** at **The Maltings**, which will include a talk from the incoming Field Trip Secretary, **Tessa Seward**, entitled "**A Whistle Stop Geological Road Trip Through America's Old West**".

In addition, at 2:00pm on **Saturday, 10 June** at the **Churt Village Fete**, **Peter Luckham** (together with other members of the FGS) will be manning a display outlining the local geology of the area, as well as promoting the Society. Details of the fete can be found at <http://churfete.org/>. If you would like to help on the day please feel free to contact Peter (p_luckham@yahoo.co.uk).

We are still looking for members to both join the FGS Committee, as well as help with organising the Societies various activities. Please contact our Chair Liz Aston if you would like to help.

If there are any items you wish to be included in forthcoming Newsletters please feel free to forward them to myself, Mick Caulfield (caulfm@hotmail.com), for inclusion.

Obituary

- **Peter Norgate**, a long-standing active member of Farnham Geological Society, has sadly passed away. He attended virtually all our meetings and numerous field trips with his wife Christine and always added to the discussions with a happy quip. He will be sorely missed. Our deepest sympathy to his wife Christine and all his family and friends.

Front Cover

This month's Front Cover is another one of the entrants from the 2022 **FGS Photographic Competition**. By **Mike Weaver**, the photo was taken at sunrise on 23 April 2002 as the overnight ferry from Palermo was entering the harbour at Naples, Italy.

A full report of the trip is given in the **October 2002** and **February 2003** issues of the FGS Newsletter, available from the excellent FGS website ...

https://www.farnhamgeosoc.org.uk/newsletters/nwslet2001_2022.html.

All of the information contained herein, both graphics and text, is for educational purposes only, as part of the Society's objective. There is no commercial gain for their use.

The views and opinions represented in the articles do not necessarily represent the views of the FGS Editorial Board or the FGS Committee.

Contents

Editorial	2	UK windfall tax misleading	32
Front Cover: Summary	3	Kahraman Maras earthquake	33
FGS Committee	4	Turkey earthquake fault lines	34
Diary	4	Asteroid dust at Chicxulub Crater	36
Next Lecture: Fire in the Carboniferous	5	Pensacola discovery, SNS	38
Interesting Topics & Places 1	5	'Charmouth croc' .. new genus	39
Tice's Meadow: Geological Assessment ...	8	Rubble-pile asteroids	40
Cartoon Corner 1	13	Dark matter particle	42
Astronomy Picture of the Day	13	Rare Antarctic meteorite	43
The Sedgwick Museum, Cambridge	14	Fossilised dinosaur nests	44
Could dinosaurs have grown any bigger? ..	18	Bids to drill new NSea oil & gas fields	46
Jurassic bark? Rare fossil on display	20	Winchcombe meteorite	47
First CO2 storage in the North Sea	21	Queensland plesiosaur	48
'Gargantuan': China fossils	22	New map: tectonic plates	50
Hollow bones evolved at least 3 times	23	Interesting Topics & Places 2	51
Shutting down Scottish oil and gas	25	TV Preview: Secrets of Ju Dinosaurs	52
Oldest known pollinator fossils	26	Cartoon Corner 2	53
S Wales earthquake	28	TV Review: Dinosaur with Stephen Fry ..	54
Earth's inner core	28	Further Reading	55
Dinosaur footprint 166 Ma old	30	FGS Needs Your Help!	57
Earth's molten rock layer	31		

Farnham Geological Society Committee 2023

Chair	Liz Aston
Treasurer	Peter Luckham
Secretary	Judith Wilson
Programme Secretary	Janet Catchpole
Membership Secretary	Sally Pritchard
Field Trip Secretary	Tessa Seward*
Newsletter Editor	Mick Caulfield
Web Manager	Bob Rusbridge
Advertising	Peter Crow
IT/Sound	Mike Millar

*Will undertake the role in Summer 2023

Meeting Programme 2023

Please note **The Maltings** and **Zoom**
meeting times:

7.30 pm for 8.00 pm start.

Fire in the Carboniferous Earth System

Dr. Andrew Scott Fri, 12 May
RHUL

The Anthropocene: A new Geological Epoch

Colin Summerhayes Fri, 2 June
SPRI

Members Evening

A Whistle Stop Geological Road Trip Through America's Old West

Liz Aston Fri, 14 July
with Tessa Seward

Field Trip Programme 2023

Our programme for this year has yet to be finalised.

Geologists' Association Lecture Programme 2023

<https://geologistsassociation.org.uk/lectures/>



AGM & Presidential Address

Graham Hickman Fri, 12 May

Triassic islands of the Bristol area

Jack Lovegrove Fri, 2 June

BGS Geomaterials Collections: 200 years in the making

Mike Howe Fri, 7 July

Reading Geological Society Lecture Programme 2023

<https://readinggeology.org.uk/lectures.php>

Hydrothermalism, the Hunga Tonga Hunga Ha'apai eruption and submarine caldera volcanism

Dr. Izzy Yeo Mon, 15 May
The National Oceanographic Centre,
Southampton

Ice Ages of Lincolnshire

Prof. Peter Worsley Mon, 5 June
University of Reading

Mole Valley Geological Society Lecture Programme 2023

<http://mvgs.org.uk>

Is there anybody out there, or are we alone? Astrobiology for Earthlings.

Prof. Mark Sephton Thu, 11 May
Imperial College, London

How our understanding of subduction zone hazards has changed since the 2004 Indian Ocean earthquake and tsunami.

Dr. Rebecca Bell Thu, 13 July
Imperial College London

Horsham Geological Field Club Lecture Programme 2023

<http://www.hgfc.org.uk/>

AGM plus 'A Career in the Geophysical Industry'

Henry Timperley Wed, 10 May
HGFC

Volcanoes of the UK

Roger Smith Wed, 14 June

Sea level rise: an update

Dr. Jenny Brown Wed, 12 July
The National Oceanographic Centre,
Southampton

Next Lecture

Friday, 12 May 2023

7.30 pm for 8.00 pm

Fire in the Carboniferous Earth System

Dr. Andrew Scott, RHUL

Fusain occurs widely in Carboniferous coals and sediments. It is now recognised to represent charcoal and be the product of wildfire. The occurrence of fire is partly constrained by atmospheric oxygen levels, availability, and nature of fuel and by aspects of climate (rainfall and seasonability in particular). The majority of fires in the Carboniferous were probably started by lightning strikes or by volcanic activity. It is thought that fire plays a major role in many Carboniferous ecosystems.

Dr. Andrew Scott

is a British geologist, and professor emeritus at Royal Holloway University of London. He won the 2007 Gilbert H. Cady Award



from the Geological Society of America for outstanding contributions to coal geology. He is widely regarded an expert on wildfire and charcoal and has highlighted the role of fire in deep time. He also contributes as a palaeobotanist and science communicator.

Interesting Topics & Places 1

Coastal Erosion poses a threat to the Atlantic coast of France

Date: 21 February 2023

Location: France

Credit: European Union, Sentinel-2 imagery

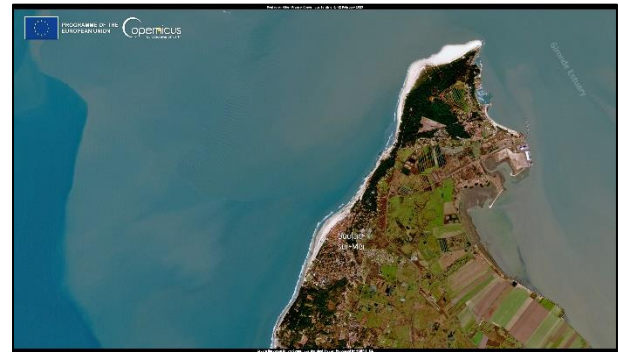


Image of The Day

Coastal erosion is rapidly changing the French coastline, particularly in areas along the coast of the Atlantic Ocean.

This image, acquired by one of the Copernicus Sentinel-2 satellites on 12 February 2023, shows the area of Soulac-sur-Mer, located at the northernmost tip of the Gironde estuary. In this area, beaches are receding at a rate of 2.5m per year due to rising sea levels. Recently, an apartment block that symbolised the touristic vocation of the town has been demolished due to its precarious location on a dune just meters from the water.

The Copernicus Land Monitoring Service product portfolio includes a Coastal Zones product, which has been developed to allow the monitoring of the complex dynamics of coastal environments and to support actions to mitigate the effects of climate change, and in particular, sea level rise.

Reference:

<https://www.copernicus.eu/en/media/image-day-gallery/coastal-erosion-poses-threat-atlantic-coasts-france>

Ga	(giga-annum)	billion years
Ma	(mega-annum)	million years
ka	(kilo-annum)	thousand years

Sediment patterns in Lake Erie

Date: 22 March 2023

Location: Lake Erie

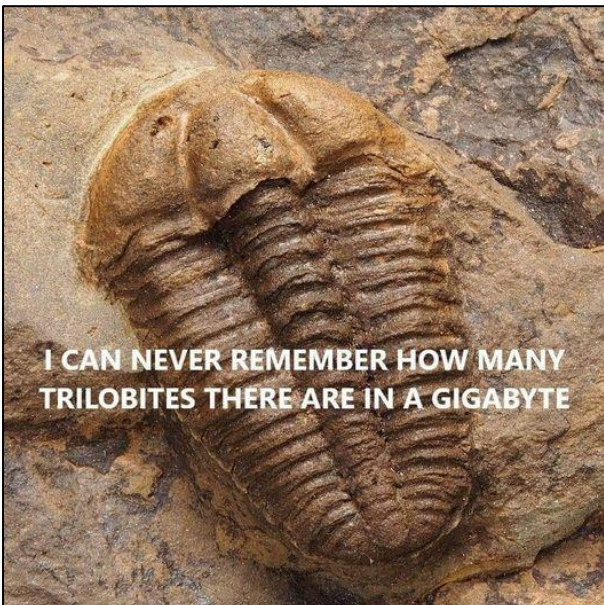
Credit: European Union, Copernicus Sentinel-3 imagery



Image of The Day

Over the weekend of 18-19 March 2023, the Great Lakes region was swept by powerful winds and freezing temperatures, resulting in significant sediment disturbances throughout Lake Erie. The strength of the winds created surface turbulence, agitating sediments, and generating multiple patterns of turbidity in the water, as visible in this Copernicus Sentinel-3 image acquired on 20 March.

Copernicus plays a crucial role in monitoring water quality worldwide by providing daily (clouds permitting) satellite observations that enable scientists to identify and track changes in water quality.



In Our Time Podcast: The Geological Formation of Britain

This excellent BBC podcast on the geology of Britain is well worth a listen. Editor



22 October 2009

Melvyn Bragg and guests Richard Corfield, Jane Francis and Sanjeev Gupta discuss the geological formation of Britain.

Around 600 Ma ago the island that we now call Britain was in two parts, far to the south of the Equator. Scotland and north-western Ireland were part of a continent (Laurentia) that also included what is now North America. To the south-east, near the Antarctic Circle, meanwhile, you would have found southern Ireland, England, and Wales. They formed a mini-continent (Avalonia) with what is now Newfoundland.

Over the course of hundreds of millions of years, as they inched their way north, the two parts came together - first as part of a vast unitary continent (Pangaea), later as a promontory on the edge of Europe, and eventually, as sea levels rose, as an island. The story of how Britain came to be where it is now, in its current shape - from the separation of North America and Europe to the carving out of the English Channel - is still being uncovered today.

Richard Corfield is Visiting Senior Research Fellow at Oxford University; Jane Francis is Professor of Palaeoclimatology at the University of Leeds; Sanjeev Gupta is a Royal Society-Leverhulme Trust Research Fellow at Imperial College London.

References:

<https://www.bbc.co.uk/programmes/b00n8t48>



Titanosaur: Life as the Biggest Dinosaur

Open 31 March 2023 - 7 January 2024

Step into the world of the colossal titanosaur *Patagotitan mayorum*, one of the largest known creatures to have ever walked our planet.

For the first time ever *Patagotitan mayorum* will be going on display in Europe at the NHM. At four times heavier than **Dippy the Diplodocus** and 12m longer than **Hope the blue whale**, this gigantic creature is a truly spectacular sight! Don't miss your chance to come and see this extraordinary dinosaur up close at the NHM's fun, interactive exhibition for all the family.

Surrounded by beautiful illustrations of Cretaceous plants and animals, you'll follow the life of titanosaur, from a football-sized egg plucked from its nest to a fully grown adult, bearing the marks of an encounter with a ferocious predator that took a bite out of its tail.

As you weave your way around the gallery, you'll handle specimens, explore interactives and learn how a creature of this colossal size could have survived, and thrived, on Earth. You'll discover how *Patagotitan* stayed safe, found food and grew to tower head and shoulders above its fellow Cretaceous critters. Get ready to size yourself up against its huge thigh bone, stare into its gigantic sauropod skull and even smell its poo!

After discovering what life was like as the biggest dinosaur, get to know the giants we

share our planet with today, learn about their lives, the challenges they face and how we can protect them.

Reference:

https://www.nhm.ac.uk/visit/exhibitions/titanosaur.html?utm_content=pod1-cta&utm_campaign=titanosaur&utm_medium=email&utm_source=2283152_ma-enews-whatson-20230126&dm_i=2XEG,1CXOW,6L3SCQ,5BMLU,1

Orogeny: A story told by the continents



<https://www.youtube.com/watch?app=desktop&v=N--HPPmcG-o&t=658s>

8 June 2022

Orogenies are the process of building mountains. These systems are responsible for geological hazards (earthquakes and volcanoes), they help drive geochemical cycles, and affect climate change and the nutrient supply for life.

This **YouTube** video by **Derrick Hasterok**, and suggested by **FGS member Angela Snowling**, walks through 26 orogenies that have left a significant imprint on the continental crust. It shows their geographic locations today and in the past.

This work is related to the recent paper: New models of global geological provinces and tectonic plates in *Earth Science Reviews*

Reference:

<https://www.sciencedirect.com/science/article/abs/pii/S0012825222001532?via%3Dihub>

TICE'S MEADOW Geological Assessment

Elizabeth Aston
B.Sc., ULSS, CGeol.
Chair, FGS

Tice's Meadow lies just to the North of the A31 / A331 in Aldershot (Fig. 1). The surface rocks are part of the **Thames Group** which comprises shallow marine clay, silt, sand, and gravel. They formed at approximately 34 to 56 Ma ago.

The approximate location of boreholes (BH) are shown by the symbol (*) in Figure 1.

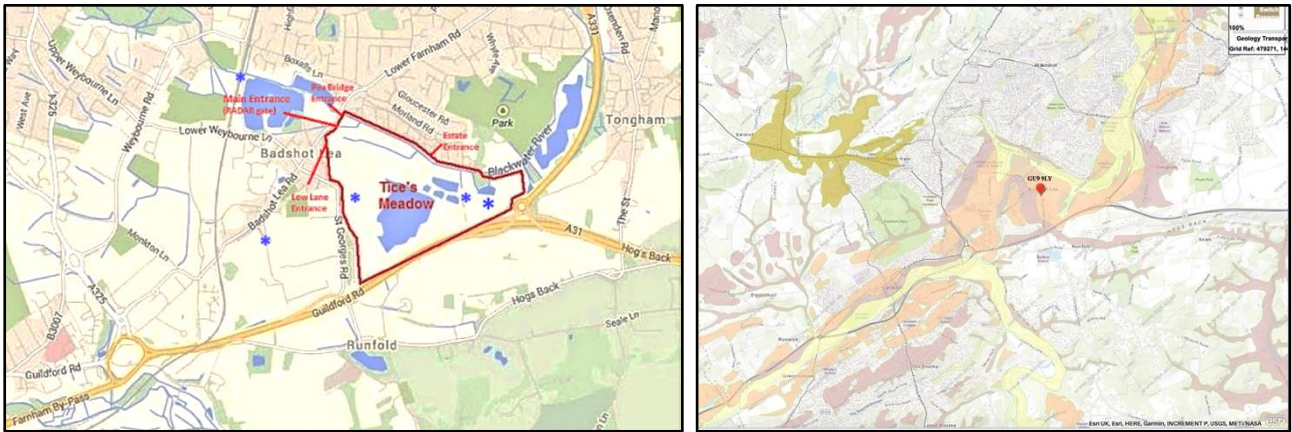


Figure 1: Location Map of Tice's Meadow & BHs (*). Figure 2: Surface Deposits – Alluvium, etc.

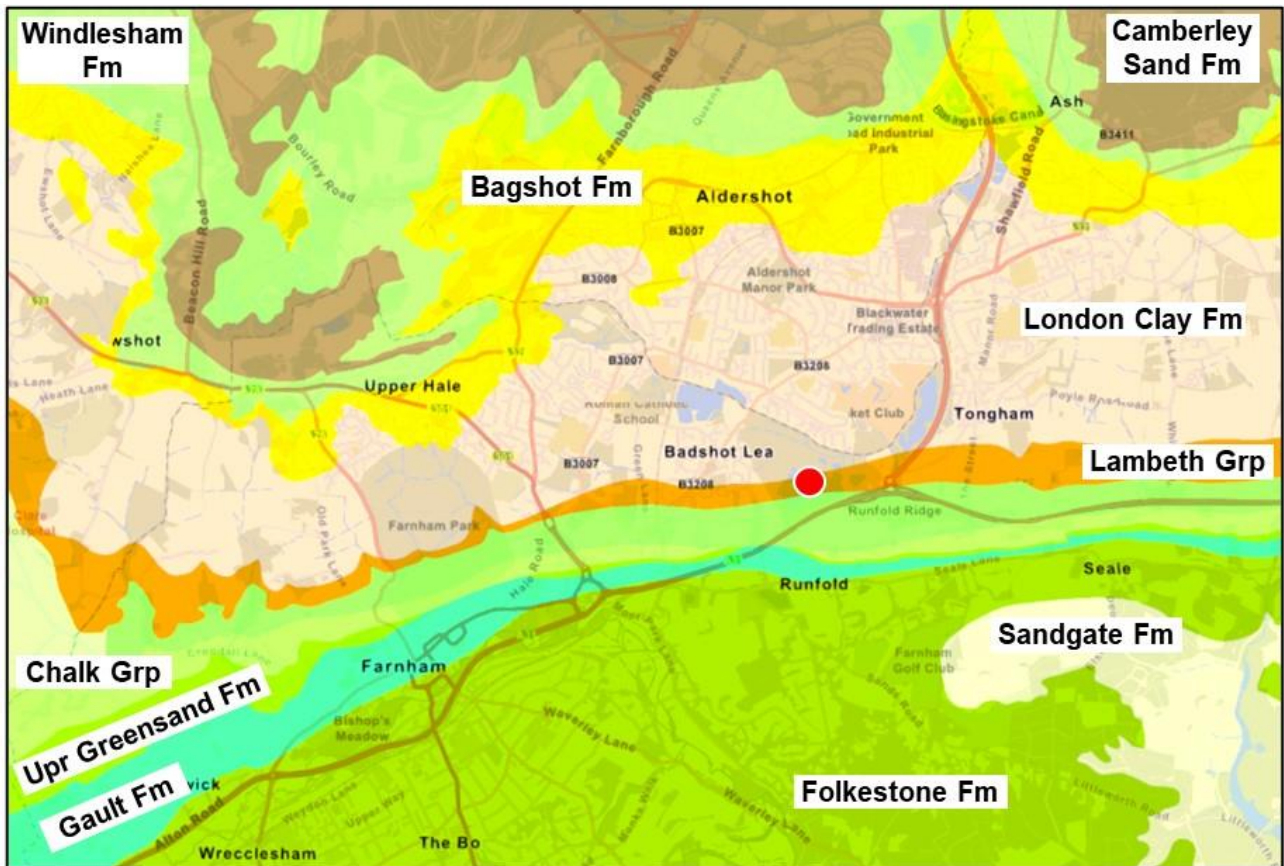


Figure 3: Geology of the area around Tice's Meadow ●

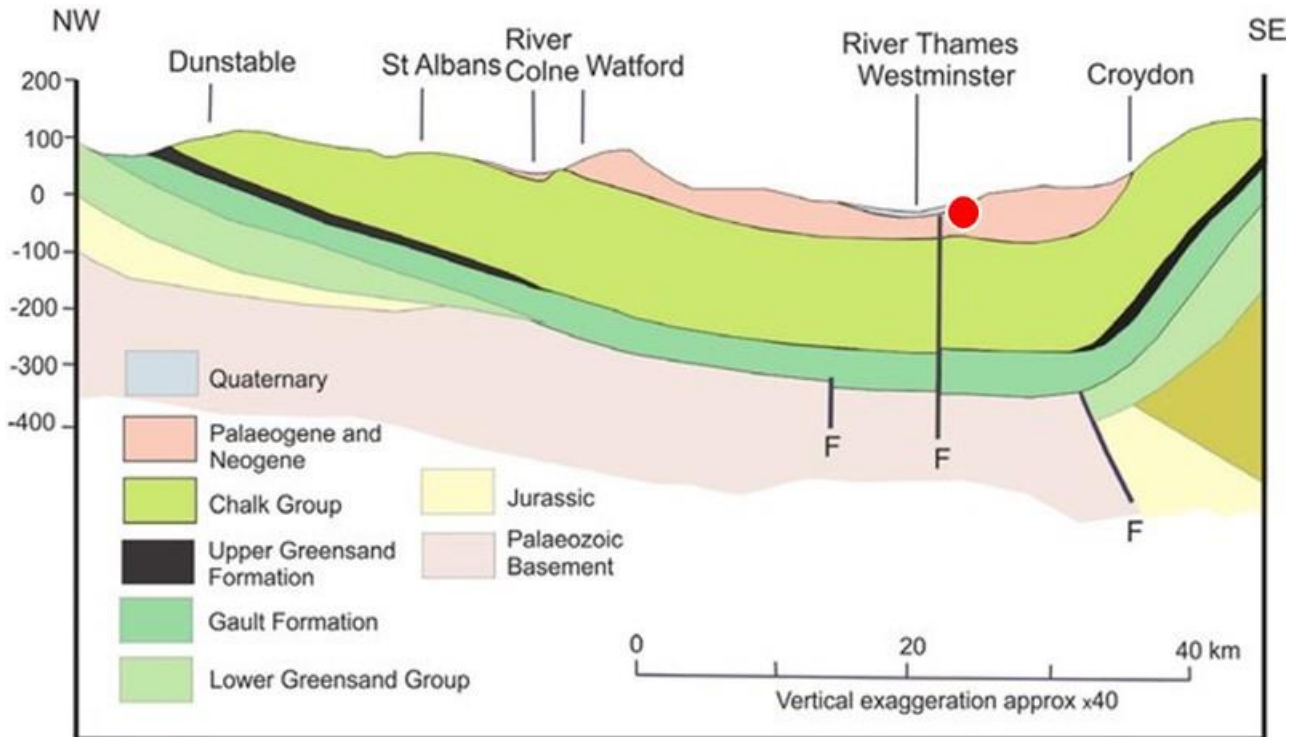


Figure 4: Schematic, simplified geological cross-section, oriented NW-SE through the London Basin. Major faults are indicated (F). Tice's Meadow = ● (Credit: Banks et al, 2015)

The structure that affects Tice's Meadow is an extension to that affecting London and shown in the Fig. 4 – except in this area the Chalk dip is almost vertical. Tice's Meadow is structurally at a position shown, just to the south of the City of London.

I am not a civil engineer nor a hydrologist, so I have concentrated on the regional / local geology using the data from the available boreholes (BHs) in and around Tice's Meadow. There are many boreholes, but I have used the five that I consider have the best quality data. The older ones will have poorer height / location data (no GPS). Those for water table depth can have minimal geological information. I have dealt with a lot of BHs from the London area (part of a recent symposium) and am used to the types of data / terminology of the BH drillers.

The five BHs are:

1. TM – within Tice's Meadow (TM); drilled in 1976 and used as the datum to which the others are measured.
2. BH ~1200m north (N) of TM; drilled in 1989.
3. BH ~800m west (W) of TM borehole; drilled in 1996.
4. Two BHs ~900m east (E) of TM, drilled in 1998.

The ground levels indicate that there is a gentle hollow with Tice's Meadow nestling right in the middle of it, which will make it susceptible to 'flooding'.

The basic information on ground level, resting water levels, rock types and depths, and stratigraphy in the BHs are shown in the following table.

'm' = meters OD = ordnance datum or sea level.

Feature in BH	BH ~500m W of TM	BH ~1200m N of TM	Tice's Meadow BH (TM)	BH1 ~900m SE of TM	BH2 ~900m SE of TM
Ground Level (m above OD)	84	73.69	73	68.3	71

Resting Water Level (RWL) (m above OD)	64.3 In Chalk	54.42	69.4 ?perched water table	61.4	Not recorded
Terminal Depth (m above OD)	34	26.8	63	50	61
Brief Description of Rock type and Stratigraphic Interval	Roadstone 0.4	Topsoil 0.2	Soil 0.3	Absent ?eroded ?not deposited	Sandy clay Alluvium
	Sandy clayey Alluvium 2.6	Sandy clay Alluvium 0.8	Clayey Sand Alluvium 1.7		
	Sand & Gravel RTD 1	Gravels RTD 3.2	Gravel & Sand RTD 1.9	Gravel & sand RTD 4.3	Gravel & sand RTD 8.4
	Blue - grey clay London Clay 3	Blue - grey clay London Clay 32	Blue - grey clay London Clay 5.5	Absent ?Faulted Out?	
Dirty Chalk 1	Brown clay & sand 28.4	Red brown clay & sand >0.7 (TD)			
Thicknesses in m					
TD - terminal depth	Clean White Chalk >42 (TD)	Chalk >26.6 (TD)		Chalk >9.4 (TD)	Clean White Chalk >1m (TD)

Discussion on Water Levels at Tice's Meadow

The resting water levels identified in the wells vary from ~55 to ~69m (the latter at TM - I felt this might be a perched water table as I was reviewing the BH data). The variations may be due to height discrepancies or times of the year and different meteorological conditions. So, these data with the suggested water levels quoted in your report namely a Mean Water Level of 68.00m above OD with seasonal High-Water Level of 70.50m above OD and Low Water Level of 66.00m above OD.

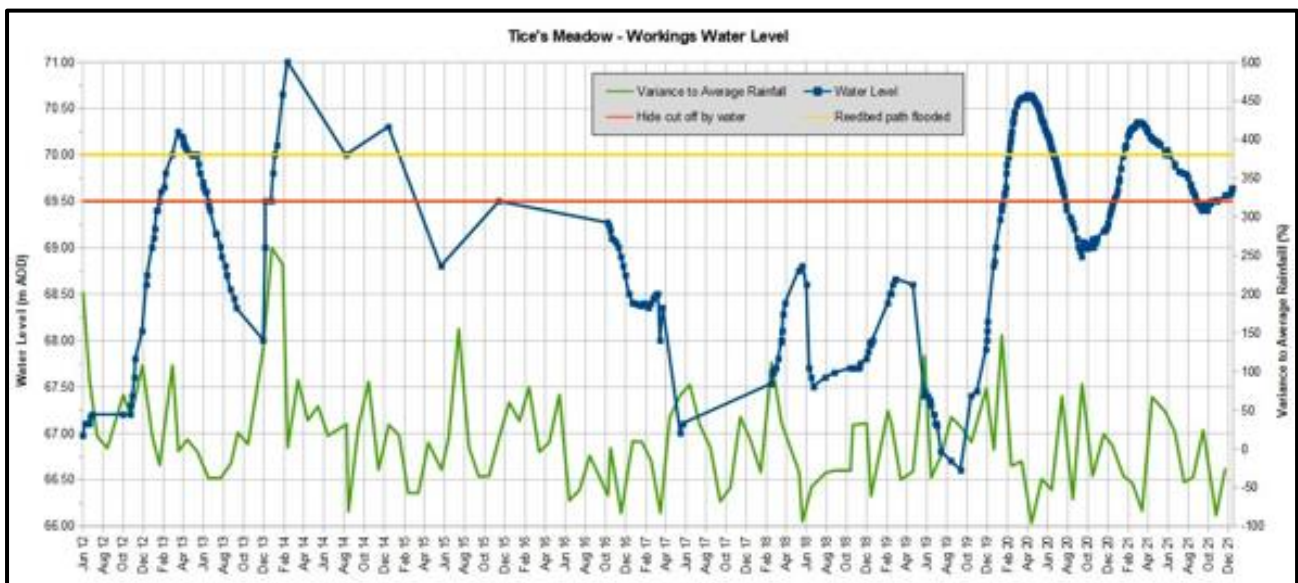


Figure 5: Tice's meadow – Workings Water Level June 2012 to December 2021.

The sudden increases in water level are clearly shown in Fig. 5. The 'variance in rainfall' increases sharply from December 2013 to February 2014 and is accompanied by a massif increase in water level at TM to 71m above OD. The previous and later major rises – namely in April 2013, February

2020 & February to April 2021 are not associated with a sudden increase in the 'variance in rainfall' graph. These increases are significant.

The non-geological impacts on the Resting Water Level can be:

- Heavy/excess rain in Chalk beds (i.e., high porosity and permeability rocks) of the North Downs (i.e., The Hogs Back) immediately to S of the area can create a high artesian flow resulting in a natural increase in water level (even a 'fountaining' effect) in Tice's Meadow (natural artesian fountains were present in Trafalgar Square in historical times) and TM nestles in the centre of the hollow.
- Similarly heavy/excess rain in the Bagshot-Windlesham-Camberley Sand Group (BWC Group - another high porosity and permeability suite of sediments) outcrop to the N of the area and separated from it by the London Clay outcrop. These too can create a similar artesian impact on the ground surface water. (I saw a manhole cover 'floating' on the top of a large fountain which was exiting the manhole at incredible speed. The manhole was at the base of the BWC Group in Yateley. There were floods as well across the valley.)

The pressure from such heavy water episodes can be very high and the artesian effect (from the Chalk) would be highly likely for Tice's Meadow.

- Disturbance of or disruption to underground water flow due to recent building projects – either dense housing estates, deep foundations to tall building where the basement (if in Ancient River Terrace Deposits (RTD) gravels and pebbles) is valuable so is dug out and sold as hoggin, etc.).
- Slight depression of the ground surface due to the density of houses, etc., hence the water table becomes nearer the surface.

These can all have small effects on the water table fluctuations and if they all occur in one location then they could contribute to minor flooding.

A Possible Geological Reason

- The two boreholes in the SE of the Meadow have penetrated a fault.
- A fault abruptly 'cuts off' the W end of the Hogs Back with a downthrow to the W (upthrow to E). This explain the steep rise at the W end of the Hogs Back and the lowering of the Chalk to at or below ground level further to the W.
- The fault caused the sudden 90° bend of the headwaters of the River Wey as it leaves Farnham to swing SE to join the rest of the River Wey. (The current River Wey headwaters were originally the headwaters of the River Blackwater – in glacial times it was significantly larger and wider than today, creating the wide Blackwater Valley and extensive RTD gravels).
- The current headwaters of the River Blackwater rise N of the Weybourne area and run from NW to SE down to the corner of Tice's Meadow where the river then turns sharply to flow N towards Frimley. I believe these NW-SE headwaters of the River Blackwater (which run inside the E boundary of Tice's Meadow) follow a fault system with similar alignment to the many faults seen along the edge of the Chalk in Fig. 6. (i.e., NW-SE). It would be responsible for the missing section of London Clay and Reading Beds in the two BHs in the SE corner of Tice's Meadow. It is very difficult to explain their absence by sudden uplift and erosion of this small area when the strata concerned are extensive marine deposits which are found consistently across the whole district.
- This fault in the BHs probably has similar alignment to those mentioned above (i.e., NW-SE) **and** probably runs from the Weybourne area down towards the SE corner of Tice's Meadow - mimicking the small faults in this area. (Faults and associated fractures follow specific alignments dependent on the overall stress pattern – thus it is most likely that small faults follow the larger

ones and in this case that direction is aligned dominantly NW-SE with a lesser 'conjugate' sector aligned NE-SW).

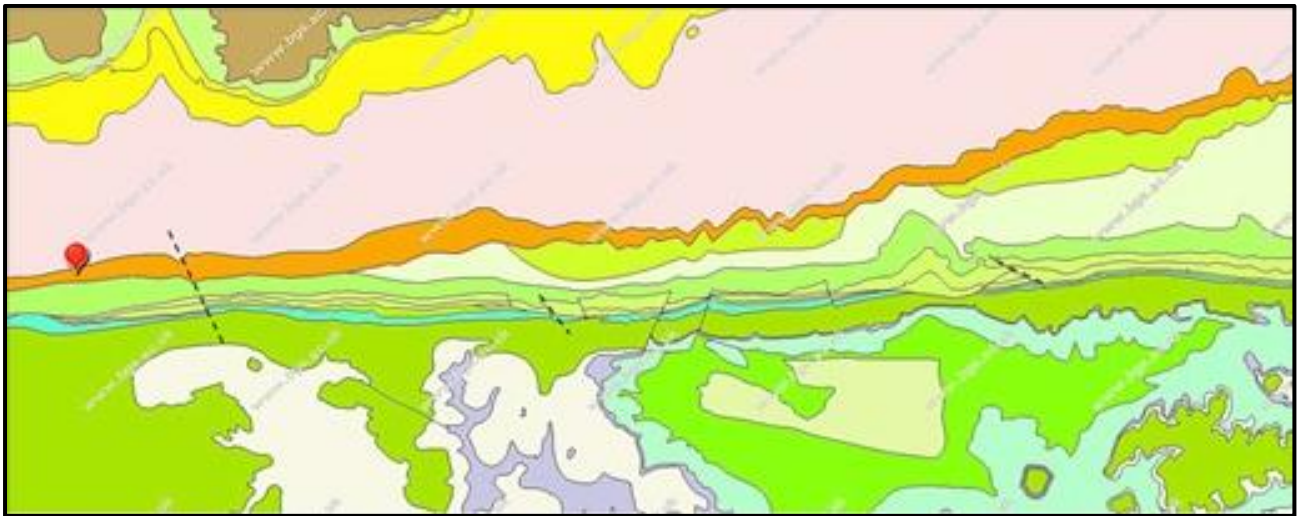


Figure 6: Geological map along The Hogs Back.

- I live on the top of the BWC Group of sandstones in Sandhurst and following any rain, but especially heavy rain, individual clay-rich layers (between the water-logged thicker sandstone beds which have excellent porosity and permeability) create individual springs, with sufficient pressure to cause removal of road surface and paving across drives to houses.

If all of this is true then it is not difficult to imagine an artesian flow of rainwater from the vast Chalk reservoir of the Hogs Back into Tice's Meadow and similarly groundwater from the Bagshot-Windlesham-Camberley Group to the N flowing though ground water and in particular the fracture system of the fault which runs along the E edge of Tice's Meadow causing rapid increases in the volume of the lake.

A small increase in the average rainfall measured from meteorological equipment across the area around Tice's Meadow would become a large volume of water from the pore space of either the Chalk of the Hogs Back or of the sandstones of the Bagshot Sand Group.

Both of these strata naturally have good permeability which that would become dramatically enhanced if the water accessed a set of fractures – straight from N (probably from both N and S) to the centre of the intervening hollow which happens to be Tice's Meadow.

These sudden and unusually dramatic influxes are not the result of normal groundwater level fluctuations and I believe the only realistic reason for the sudden influxes of water are from either artesian and/or fracture/fault water contributions to the site – the fact it nestles in the shallow saucer shaped dip is unfortunate.

References:

<http://www.ticesmeadow.org/>

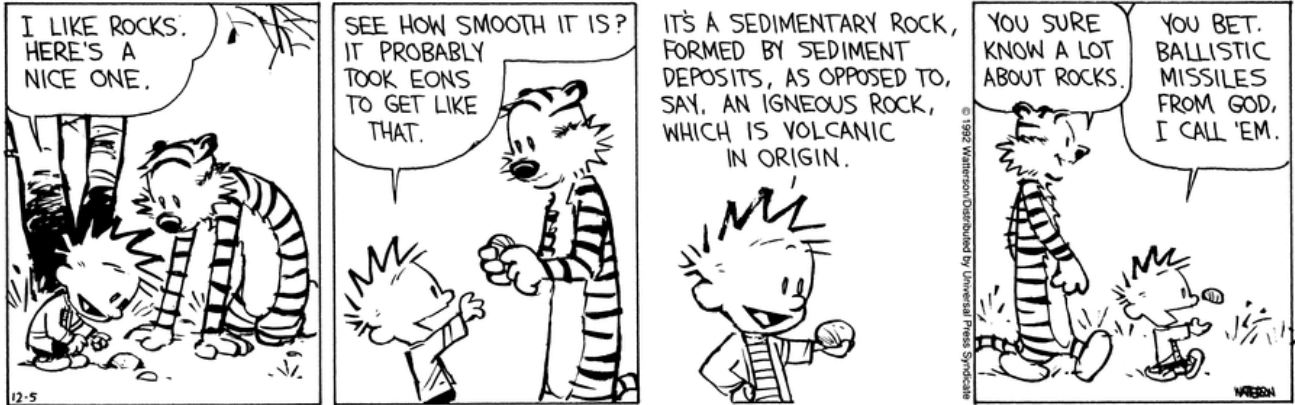
<https://www.surreycc.gov.uk/culture-and-leisure/countryside/sites/visitor-information/tices-meadow>

<https://geologyviewer.bgs.ac.uk/>

<https://mapapps2.bgs.ac.uk/geoindex/home.html?layer=BGSBoreholes>

March 2015, V.J. Banks, S. H. Bricker, K. R. Royse, P.E.F. Collins. Anomalous buried hollows in London: Development of a hazard susceptibility map, *Quarterly Journal of Engineering Geology and Hydrogeology* 48 (1): 55-70.

Cartoon Corner 1



Credit: Calvin and Hobbes by Bill Watterson, 5 December 1992

Astronomy Picture of the Day



Comet ZTF over Mount Etna

28 January 2023

Comet-like plumes are blowing over the volcanic peaks of Mount Etna in this wintry mountain-and-skyscape from planet Earth.

The stacked and blended combination of individual exposures recorded during the cold

night of January 23, 2023, also capture naked-eye Comet ZTF just above Etna's snowy slopes.

Of course, increasing sunlight and the solar wind are responsible for the comet's greenish coma and broad dusty tail.

This weekend Comet ZTF is dashing across northern skies between north star Polaris and

the Big Dipper. From a dark site you can only just spot it as a fuzzy patch though. That's still an impressive achievement if you consider you are gazing at a visitor from the distant Oort cloud with your own eyes.

(Image Credit & Copyright: Dario Giannobile)

Reference:

https://apod.nasa.gov/apod/ap230128.html?fbclid=IwAR0813LXwyyGGZnd_YNq4fvEMMOikaUUdizwGJGPiivS0LavfH_zwt9bc

Article

The Sedgwick Museum of Earth Sciences, Cambridge

Mike Millar (with thanks to the Museum website and Wikipedia).



Figure 1: The Sedgwick Museum (Wikipedia)

The **Sedgwick Museum** (Fig. 1) is part of the Department of Earth Sciences and is located on Downing Street, in central **Cambridge**. It was opened in March 1904 and includes a collection of around 2 million rocks, minerals and fossils, spanning a period of 4.5 billion years. The highlights include a complete replica skeleton of an Iguanodon gifted by the

King of Belgium in 1896; a replica skull of *Tyrannosaurus Rex* 'Stan' found in South Dakota; the antlers from the Pleistocene giant Irish elk *Megaloceros*; and a William Smith Map, first published in 1815.

The Museum's founding collection was the Museum Woodwardianum, the oldest intact geological collection in the world. **John Woodward** (1665 – 1728) was an English naturalist, antiquarian and geologist, and founder by bequest of the Woodwardian Professorship of Geology at the University of Cambridge. Over 35 years, he collected and catalogued nearly 10,000 specimens. He kept these in five walnut cabinets, two of which he bequeathed to the university in his will. The university later purchased another two, and the fifth was added in the 1840s. Some of these cabinets are on display in the museum.

The museum is named after **Adam Sedgwick** (1785 – 1873), one of the founders of modern geology. In 1819 Sedgwick was appointed Woodwardian Professor of Geology at Cambridge, and in 1829 became President of the Geological Society. He was a friend of Roderick Murchison, and they jointly studied of the rocks of Scotland and Wales (Fig. 2).



Figure 2: Sedgwick's field boots from 1827, left behind at Charles Lyell's house on a tour of Scotland. (Photo: Mike Millar)

Sedgwick began the process of expanding the Woodwardium Collection and purchased several ichthyosaur skeletons from Mary Anning (Fig. 7). He persuaded the university to set aside space in the Cockerill Building for the collection, but by the time he died, the

collection was too large for that space, so it was decided there should be a museum set up in his memory. Construction of the Sedgwick Museum was supervised by Thomas McKenny Hughes, who also raised over £95,000 by a public appeal.

You get a "warm" welcome as you enter the museum, with the replicas of Stan's skull (*Tyrannosaurus rex*) and a *Deinonychus antirrhopus* skeleton (Fig 3), both from the Cretaceous Period, displayed in the entrance area. Many of the displays in the museum come with excellent information boards (Fig 4).

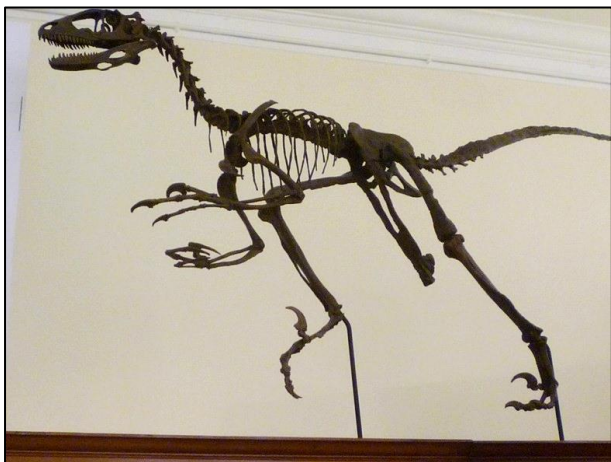


Figure 3: *Deinonychus antirrhopus* skeleton, the "counterbalanced terrible claw". (Photo: Mike Millar)

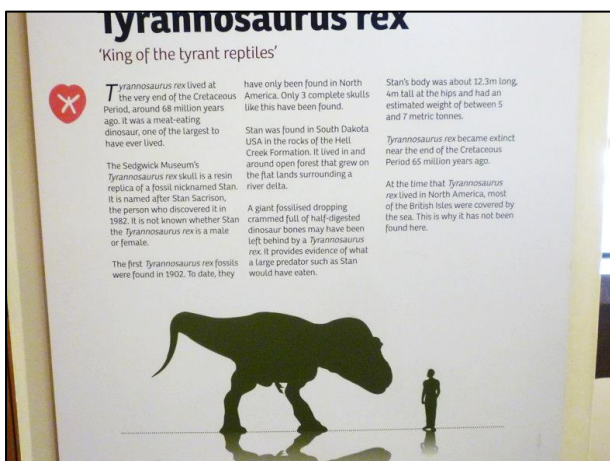


Figure 4: Example information board. (Photo: Mike Millar)

The museum is arranged in time order, you can travel backwards or forwards, between the Pleistocene and the Cambrian. There is also a gallery dedicated to **Charles Darwin**, who was alumnus of Cambridge. This includes materials and samples he collected on the Beagle

voyage. There are also sections on minerals and gemstones (Wherwell Gallery), meteorites and metamorphics (Planet Earth), and lavas (The Restless Earth).

The Tertiary gallery is sub-titled **Volcanoes, Rivers and Seas**, and there is so much stuff in this collection. It displays fossils from all over the world, including plants, molluscs and fish from Europe preserved in spectacular detail, and mammals from the United States. British fossils include molluscs, crabs, fish, crocodiles (Fig. 5), turtles and plants from rocks such as the London Clay and Bagshot Fm. The Red Crag, exposed on the Suffolk coast, is a rich source of more recent fossils, including a wealth of fish and whale remains such as giant fossil shark teeth (Fig. 6) and whale ear bones.



Figure 5: Eocene crocodile from Hordle Cliff, Hampshire. (Photo: Mike Millar)



Figure 6: Teeth from giant shark, *Otodus megalodon*, 20 - 3.6 Ma. (Photo: Mike Millar)

The Cretaceous gallery is sub-titled **The Chalk Seas** and displays British chalk fossils alongside those from Europe and North America including the jaws and teeth of the gigantic mosasaurs (Fig. 7). Also on display

are sea-urchins and shells, similar in form to modern sea-creatures.



Figure 7: Mosasaur skull fossil from the uppermost Cretaceous. (Photo: Mike Millar)

The Warm, Shallow Seas of the Jurassic gallery includes the remains of ichthyosaurs, including several discovered by **Mary Anning** (Fig. 8). On display are excerpts from Mary Anning's letters to Sedgewick, which clearly show her good general knowledge of the science and anatomy of these creatures.



Figure 8: A Mary Anning ichthyosaur. Bought by Sedgewick in 1843 for £4. (Photo: Mike Millar)

The Jurassic gallery also includes fossils from the Solnhofen limestones of Bavaria These were formed on the bottom of a shallow tropical lagoon and these quiet conditions favoured preservation, so the level of detail is remarkable. The fossils include *Archaeopteryx*, *Compsognathus* (Fig. 9), *Cycleryon* and fish.

The Permian and Triassic gallery is sub-titled **Deserts, Evolution and Extinction**. On display are fossil tracks from animals living in hot, dry climates during the Permian and Triassic periods as well as the imprints of raindrops. Some of the tracks are believed to have been made by *Procyonosuchus*, an extinct genus of cynodonts from the Late Permian.

These were mammal-like reptiles, early ancestors of mammals.

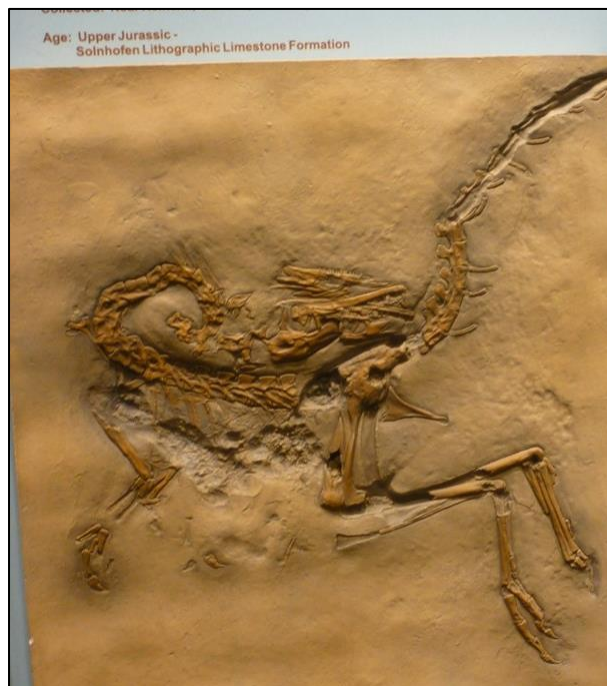


Figure 9: *Compsognathus*, a genus of small, bipedal, carnivorous theropod dinosaur. (Photo: Mike Millar)

The Carboniferous gallery is sub-titled **Forests and Shallow Seas**. Large parts of this Era were dominated by warm wet climates, which led to the growth of forests and swamps that extended from North America through Europe and into Russia. The trees which grew in these tropical forests were quite different from those of modern forests. They included giant tree-sized clubmosses and horsetails, whose modern species are mostly less than a metre high. There were also many kinds of ferns, fern-like plants and some conifers, but none of the modern flowering plants. The collection includes lots of examples of these trees.

However, the real star of the collection is *Arthropleura*, believed to be the world's largest millipede. Arthropods were both well-developed and numerous during the Carboniferous. Their large size can be attributed to the dampness of the environment (mostly swampy fern forests) and the fact that the oxygen concentration in the Earth's atmosphere in the Carboniferous was higher than today. This required less effort for respiration and allowed arthropods to grow

larger with the up to 2.6-metre *Arthropleura* being the largest-known land invertebrate of all time. *Arthropleura* was found on the Northumberland coast in 2018.

Seas, Lakes and Rivers describes the Devonian gallery. The Devonian is sometimes called the 'Age of the Fish' - there are examples of jawless fish, fish with armoured heads and lungfish. It also marks a time when both plants and backboned animals first began to colonise land as well as the water. On display are early land plant fossils, as well a cast of *Acanthostega* (Fig. 10), an extinct genus of stem-tetrapod, among the first vertebrate animals to have recognizable limbs. It appeared in the late Devonian, about 365 Ma ago, and was anatomically intermediate between lobe-finned fishes and those that were fully capable of coming onto land.

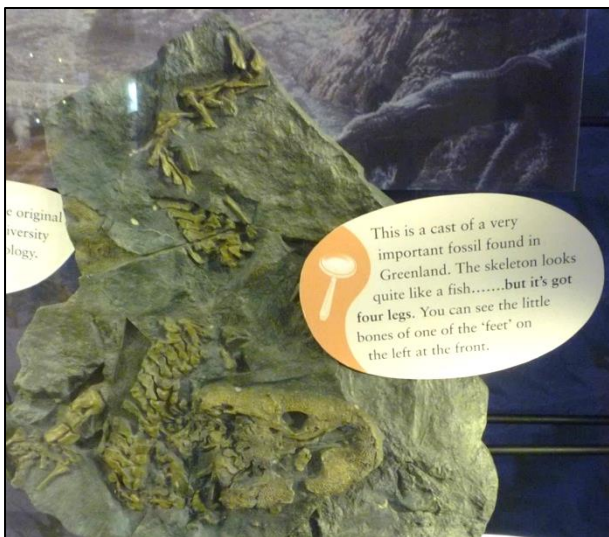


Figure 10: Skeleton of *Acanthostega gunnari* from the Famennian of East Greenland. (Photo: Mike Millar)



Figure 11: Native copper (Photo: Mike Millar)
The **Whewell Mineral Gallery** displays some of the finest specimens from their collection of

40,000+ minerals (Fig. 11) and gemstones from around the world. The gallery is named after **William Whewell** (1794-1866), who was the third Professor of Mineralogy at the University of Cambridge. The minerals are displayed by chemical group and mixed with scientific information about their chemistry and structure, as well as general knowledge about their use.

The Sedgwick is a fabulous museum, well presented and full to the rafters with interesting and exciting exhibits.

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1. <http://www.sedgwickmuseum.org/>
2. https://en.wikipedia.org/wiki/Sedgwick_Museum_of_Earth_Sciences
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4. <https://twitter.com/SedgwickMuseum>



Sedgwick Museum
of Earth Sciences

The Earth is estimated to be approximately 4.56 billion years old. Earth's history is subdivided through time into smaller units: eons (half a billion years or more), eras (several hundred million years), periods (tens to one hundred million years), epochs (tens of millions of years), stages (millions of years) and zones (thousands of years).

(Credit: The Etches Collection)

News

Could dinosaurs have grown any bigger?

By Kamala Thiagarajan, BBC Future
6 April 2023



P. mayorum on display at the Natural History Museum in London (Credit: Getty Images)

Titanosaurs were some of the largest animals to walk the Earth, but if the reign of the dinosaurs hadn't been cut short by an asteroid, could they have evolved to be even bigger?

In 2001, palaeontologists Kristina Curry Rogers and Catherine Forster found a single rib bone in Madagascar that was nearly 3m (9.84 ft) long, roughly the length of a table tennis table. They had discovered a new species of titanosaur – a kind of colossal, plant-eating dinosaur – that was later named *Rapetosaurus krausei*.

"One of the great things about working with titanosaurs is their 'titanic' proportions," says Rogers, a DeWitt Wallace professor of biology and geology at Macalester College in Minnesota, USA. "[But] this makes titanosaurs tough to excavate – a single skeleton can take an entire field season or more to extract from the rocks."

Titanosaurs, literally meaning "gigantic lizards", were the last surviving sauropod dinosaurs, whose members were a diverse bunch of herbivores with very long necks, long tails and relatively small heads. When they were discovered, scientists had already made the famous finds of species like *Brachiosaurus*, *Diplodocus* and *Apatosaurus*, which lived in

the Jurassic era, 201 to 145 Ma ago. But they thought that sauropods had not survived until the end of the Cretaceous period, which spanned from 145 to 66 Ma ago, says Matthew T Carrano, a paleobiologist at the Smithsonian Institution in Washington DC.

Palaeontologists working with titanosaurs often marvel at their sheer scale and size. "A single leg bone is longer than I am, from head to toe," says Rogers, adding that sometimes a single toe bone is as big as an arm bone in a human. "Holding a titanosaur's leg in your hands is pretty remarkable," she says.

But how did they get so large in the first place? And given more time, could they have evolved to be even larger?

All titanosaurs started life relatively small. "They hatched from eggs that were between the size of a softball and a soccer ball," says Rogers. "As brand-new hatchlings they would've been just about the size of a chihuahua. It appears that there wasn't much parental care among these big sauropods, and that babies were out foraging on their own, right out of the nest." Over time, she says, they achieved their colossal size by doing what most sauropods do – eating and eating.

Scientists believe that titanosaurs grew quickly and didn't slow down until they reached their massive adult sizes. "When we compare their growth rates throughout life to [those of] living animals, it comes closest to the growth rates we observe in whales. That's incredibly fast," says Rogers.

Titanosaurs, unlike whales, didn't have the benefit of consuming high-protein, nutritious milk provided by their mothers, adds Rogers. Instead, these dinosaurs were out finding their own food. "Keeping their growth rates high is one way in which most sauropods differ from their meat-eating dinosaur relatives, which seem to have paused their growth more often as they got older."

And while titanosaurs were the largest sauropods, Carrano points out that their ancestors among sauropods were already pretty big. "Evolving to be 70-80 tonnes from a 20-30 tonne ancestor probably didn't require

that much evolutionary innovation," he says. He explains that all the structures and systems were already set up for success at huge sizes.

"Sauropods developed long necks early on from their primitive cousins, the sauropodomorphs," says Skye Walker, a field assistant at the Elevation Science Institute for Natural History Exploration, which conducts field work in Montana and Wyoming. "This allowed them to have varied diets, giving them access to a range of nutritious food," she says.

Because of their increasing size, sauropods developed "pneumatic" air sacs in their bones, to make their skeletons lighter. "These air sacs were made up of soft tissue connected to the lungs," says Walker. "This made their weight easier to bear and allowed for more efficient oxygen supply throughout the body. Unlike mammals, sauropods had this to thank for there being almost no limits to how large they could grow."

Predatory dinosaurs had pneumatic air sacs, as do modern-day birds, says Carrano, and these probably evolved from a common ancestor. However, they are also thought to have evolved independently in other groups, including pterosaurs and sauropods. "This would have increased breathing capacity and lightened these huge bones without sacrificing their strength." Carrano explains that sauropods also had short feet and pillar-like limbs to support their enormous weight. "These are all features taken to extremes in the largest titanosaurs," he says.

Titanosaurs also had adaptations hidden in their joints. Armita Manafzadeh, a postdoctoral fellow studying biology at Yale University, points out that smaller non-avian dinosaurs like *T. rex* had tight-fitting joints in which their bones interlocked precisely, much like our own. In contrast, titanosaurs had joints with enormous volumes of squishy cartilage at the ends of their bones. This difference in joint structure, she says, especially at key limb joints such as the hip, is thought to be an adaptation for better sustaining the animal's massive body weight.

However, according to Carrano, what's less clear is how the titanosaurs managed to

outgrow their sauropod ancestors. Perhaps they simply had more time to evolve larger bodies, after their Jurassic predecessors were gone. On the other hand, they may have acquired new innovations – tweaking their existing anatomy so that they could get even bigger. "But there's not a huge difference that makes the answer obvious. It's also possible that they may have benefited from the availability of new foods, specifically flowering plants, that weren't around in the Jurassic," says Carrano.

The jury is still out on whether titanosaurs could have become even bigger, had dinosaurs not gone extinct.

"I think that there could have been somewhat larger sauropods, perhaps, but not dramatically so," says Carrano. He says that it helps to think in terms of "orders of magnitude", which technically refers to change by factors of ten, to think about major shifts in size. For example, going from one tonne to 10 tonnes is a big deal, he says – significantly more so than going from 10 to 20 tonnes. "There's a shift in scale in the former but not the latter."

However, there may have been an upper size limit sauropods simply couldn't have gone beyond, says Carrano. "So, we already have 70-80 tonne titanosaurs. Could they have reached 100 tonnes? Perhaps. But 200 tonnes, that I would doubt. Even whales don't get that big, and they live in a buoyant medium all their lives. I think sauropods were in the maximum size range for terrestrial animals," he says. By the time they went extinct, sauropods had already been around for almost 150 Ma. Carrano explains that it's possible the added time wouldn't have made that much difference.

However, some palaeontologists say further evolution could have been possible, especially since there's a lot we still don't know about these creatures.

Titanosaur specimens, though widespread, are largely incomplete, says Walker. "New titanosaurs are still being discovered, so it's really exciting and optimistic to be able to say that we don't know everything yet and we probably never will. We are discovering new

things about these animals every single day and bringing more of their mysteries to light."

Over the last 20 years, new titanosaurs have been named at an astonishing rate, says Rogers. "I think that now there are over 100 named species," she says. "It drives home the point that globally distributed dinosaurs like these found a niche and were an incredible evolutionary success story. If not for that rock from outer space, they probably would've continued evolving and diversifying."

Reference:

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Jurassic bark? Raffle the dog's rare fossil find goes on display in Dorset

Public finally able to see 3D remains of plesiosaur discovered on Lyme Regis beach 16 years ago

Steven Morris
16 March 2023



Tracey Barclay and Chris Moore at the Charmouth Heritage Coast Centre next to the plesiosaur fossil that Raffle the dog found on Monmouth beach. (Photograph: Graham Hunt/BNPS)

At first when Raffle the dog began scratching at something on the beach at Lyme Regis, Tracey Barclay thought he had probably found a boring old stick or stone. But when she

looked closer, Barclay realised Raffle had happened upon something much more interesting – the remains of a plesiosaur, a marine reptile that swam off modern day Dorset 200 Ma ago.

After **16 years of painstaking work**, extracting, cleaning and piecing together the 750 fossilised bones that were eventually found on the spot, the plesiosaur – nicknamed Raffle in honour of the finder – has been put on display at **Charmouth Heritage Coast Centre**.

"It's brilliant to see him there in all his glory," said Barclay, 59. Raffle is one of only a few **Lower Jurassic** specimens in the world preserved and mounted in 3D, as usually the bones are found pressed flat. "The 3D makes it much more vivid, almost brings him to life," said Barclay.

She had been walking along the famed "ammonite pavement" at **Monmouth beach at Lyme Regis** in 2007 with her partner, Chris Moore, who runs a fossil shop and preparation business, and a group of friends.

"It's a fabulous place to walk but Chris and his friends had walked on. I sat down with Raffle. He suddenly got up and started scratching away." She realised that what Raffle, a rescue dog with bits of pointer and labrador in him, had found was a vertebra. "I moved some rocks to see if there were any other bones and spotted a paddle bone – which suggested it could be a plesiosaur. "Chris was miles away and the tide was coming in. I thought: 'Oh gosh. It can't really be a plesiosaur can it?' I've only ever found pyrite ammonites – the sort of thing kids find all the time – before. Chris came back and confirmed what it was."

A lengthy process began of keeping an eye on the find and, when it was clear that it was something very special, getting the correct permissions to extract it.

The bones were taken to Moore's workshop and then sent away to be cleaned before being mounted and finally put into place at the heritage centre. "There was a bit of trepidation as it went up," said Barclay. About 70% of the fossilised skeleton, which is 3.2 metres long,

has been found, with missing bones cast and modelled from the other bones.

The remains of plesiosaurs have long been found in Dorset. Mary Anning, the pioneering palaeontologist, and fossil collector, found the complete skeleton of a plesiosaur in 1823. So strange did it seem that there were rumours that it was a fake. But the 3D aspect of Raffle makes it all the more special.

Grant Field, from the heritage centre, said: "There are only a handful of these 3D specimens in the world, so this was a very rare find. It's the sort of thing you would get in the natural history museums in London or New York. Our centre is free to enter so everyone can come along and see Raffle the plesiosaur."

Barclay is delighted the plesiosaur has been named after her dog. "It seems only right; after all, it was his find."



Tracey Barclay with Raffle the dog on the beach. (Photograph: BNPS)

Raffle was nine at the time of the find and has since gone to the great beach in the sky. Barclay has another dog – Ted. "He hasn't found anything of interest yet, but we keep looking," said Barclay. "There's always hope."

Reference:

https://www.theguardian.com/science/2023/mar/16/raffle-dog-rare-plesiosaur-fossil-find-dorset-display?CMP=share_btn_fb&fbclid=IwAR3XOD-xMByxlfWQQBrKnO8-OLNP1WGEeKw67iowuXxbZQSWNJZ1etAr3gk

History written offshore Denmark: First CO2 storage in the North Sea

*by Nadja Skopljak, Offshore Energy
9 March 2023*

INEOS and Wintershall Dea marked a major milestone and a world first on 8 March with the first-ever injection of CO2 in the North Sea as part of **Project Greensand**.

Project Greensand includes capturing CO2 at an INEOS Oxide site in Zwijndrecht, Belgium, which is transported cross-border and stored in the Nini field in the Danish North Sea. The CO2 injected is stored at a depth of about 1,800m below the seabed.

The project envisages CO2 being transported by the offshore supply vessel Aurora Storm, which has been adapted so that it can safely transport containers of liquid CO2. In time, another type of vessel known as a CO2 carrier will be used for large volumes.

His Royal Highness Crown Prince Frederik of Denmark officially initiated the injection of carbon dioxide at the event held in Esbjerg, Denmark, to celebrate the achievement. Lars Aagaard, the Danish Minister for Climate, Energy and Utilities, was also present, while President of the European Commission Ursula von der Leyen delivered a video address.

"This is a big moment for Europe's green transition, and for our clean tech industry. The first-ever full value chain, for carbon capture and storage in Europe. You are showing that it can be done," said Von der Leyen. "That we can grow our industry through innovation and competition, and at the same time, remove carbon emissions from the atmosphere,

through ingenuity and cooperation. This is what Europe's competitive sustainability is all about."

By early April, residual emissions from the Belgian industrial plant, collectively representing up to 15,000 tonnes of CO₂, will be stored during the ongoing demonstration phase.

In the short run, Project Greensand can store up to 1,5 million tonnes of CO₂ per year in 2025/2026. In the final expansion phase, scheduled to begin in 2030, the project aims to store up to 8 million tonnes of CO₂ per year in the area, 40 per cent of Denmark's total emission reduction target.

Besides INEOS and Wintershall Dea, more than 20 other partners are involved in the project, including start-ups, independent institutes, and the Geological Survey of Denmark and Greenland (GEUS), an institution within the Danish Ministry of Climate, Energy and Utilities. The Danish Government is supporting the project with a total of €26 million in public funding.

Transporting the CO₂ from Belgium and Denmark has been made possible by a bilateral agreement that these two countries concluded last year. In December 2022, the Danish Energy Agency granted Project Greensand permission to store CO₂ in the Danish subsoil as part of the pilot phase.

This February, INEOS and Wintershall Dea received the first full-scale CO₂ storage permit for the Danish North Sea.

The FID for a full-scale project will commence after proof of concept, planned in the second half of 2023, and will have an estimated delivery duration of around two years after which carbon storage could be operational from around 2025.

"If Project Greensand and other CCS projects in the North Sea are to be successfully implemented, policymakers must establish the appropriate regulatory framework," said Hugo Dijkgraaf, Member of Wintershall Dea's Board of Executive Directors and the company's Chief Technology Officer.

"The first steps have been taken. Now we need more bilateral agreements to link emissions-intensive industries to CO₂ storage sites in the North Sea."

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'Gargantuan': China fossils reveal 70-tonne dinosaur had 15-metre neck

Analysis of bones found in 1987 suggest Jurassic-era sauropod was animal with longest known neck

**Ian Sample, Guardian Science editor
15 March 2023**



A rendering of the sauropod known as Mamenchisaurus sinocanadorum, an herbivore that roamed what is now east Asia. (Photograph: Júlia d Oliveira/Natural History Museum)

A dinosaur that roamed east Asia more than 160 Ma ago has been named a contender for the animal with the longest neck ever known.

A new analysis of bones from the beast's neck and skull revealed that the dinosaur, known as *Mamenchisaurus sinocanadorum*, sported a neck 15m long, or one-and-a-half times the length of a double decker bus.

The fossilised remains of the creature were recovered in 1987 from 162 Ma old rocks in the

Xinjiang Uyghur Autonomous Region of north-west China, but the full length of the animal's neck was only recently reassessed by scientists.

The dinosaur was one of the huge herbivorous sauropods that grew to 50m from snout to tail and weighed more than 70 tonnes. Despite only a handful of bones remaining of the beast, researchers were able to estimate the length of its neck by comparing the remains with complete fossils belonging to closely related dinosaurs.

"*Mamenchisaurus sinocanadorum* might be the longest-necked sauropod discovered so far, but odds are that there were larger, longer sauropods roaming around the Late Jurassic of what is now China," said Andrew Moore, a palaeontologist at Stony Brook University in New York.

"Unless we're willing to believe that we just so happened to discover the largest single individual sauropod that ever existed, our default assumption should always be that there were larger animals out there. We can only hope that some of these titans fossilised and are just waiting to be discovered by palaeontologists."

A long neck was one of the fundamental body features that allowed sauropods to reach such gigantic proportions. It allowed the animals to graze vast areas of vegetation while standing in one spot, meaning they could take in tonnes of food without expending much energy. Having a long neck may also have helped the animals to keep cool by increasing their surface area – a trick elephants achieve with their large ears.

The sauropods' lifestyle was impressively successful, evolving early in dinosaur history and lasting until the final days of their reign during the mass extinction event triggered by an asteroid impact 66 Ma ago. The only dinosaurs that survived are the ancestors of modern birds.

How sauropods evolved such long necks and large bodies without collapsing under their own weight has puzzled scientists since the first fossils of the animals were recovered. But X-

ray scans of the *Mamenchisaurus* fossils show that the vertebrae were light and hollow, with airspaces making up two-thirds to three-quarters of their volume. Similar skeletal features are seen in birds that minimise weight in order to fly. On sauropods, such lightweight skeletons would be prone to fracture, but the animal had rod-like neck ribs – bony extensions of the vertebrae – which stiffened the neck and improved its stability.

"One of the most remarkable facts about enormous sauropods is just how lightly constructed their bones could be," Dr Moore said. "Like their living cousins, birds, sauropods had a lung capable of invading bone and replacing heavy marrow and bone tissue with airspace. Such a lightweight build would have been critical to lightening the gargantuan necks of the largest sauropods."

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Details are published in the *Journal of Systematic Palaeontology*.

<https://www.theguardian.com/science/2023/mar/15/gargantuan-china-fossils-reveal-70-tonne-dinosaur-had-15m-neck-jurassic-sauropod>

Hollow bones that let dinosaurs become giants evolved at least three times independently, shows study

by **André Julião, FAPESP**
7 March 2023

Dinosaurs as big as buses or five-story buildings would not be possible if their bones were dense and heavy like ours. Like present-day birds, **dinosaurs had hollow bones** with inner structures known as air sacs, which made their skeletons lighter and less dense. These structures were apparently so advantageous that they emerged at least three times during the evolution of dinosaurs and pterosaurs (flying reptiles), according to a study described in **Scientific Reports**.

"Less dense bones containing more air gave the dinosaurs and pterosaurs [and still give

birds] more oxygen circulating in their blood, as well as more agility to hunt, flee and fight, or even to fly. They not only used less energy but also kept their bodies cool more efficiently," said Tito Aureliano, first author of the article. The study was part of his Ph.D. research at the State University of Campinas's Institute of Geosciences (IG-UNICAMP).



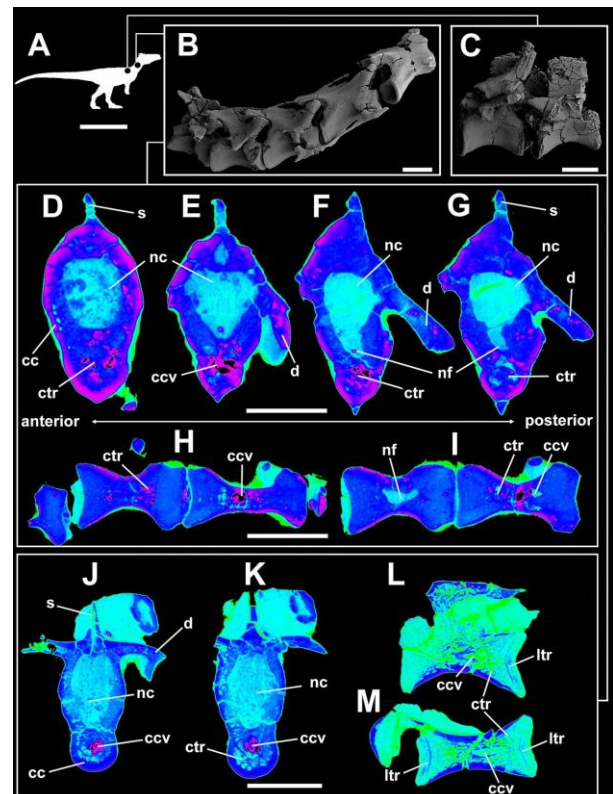
Gnathovorax cabreirai was a herrerasaurid, a lineage that became extinct not long after the period in which it lived. (Credit: illustration: Márcio Castro)

Aureliano analysed fossilized bones from three Brazilian species of the Late Triassic (about 233 Ma ago), the period in which the dinosaurs emerged. All the bones were found in recent decades in Rio Grande do Sul, Brazil's southernmost state.

Detailed knowledge of specimens belonging to different groups and dating from an early stage in their evolution provides a basis for understanding when certain traits were developed. In this case, the researchers were looking for signs of the presence of air sacs, which were commonplace in geologically more recent (and more studied) species, such as tyrannosaurus or velociraptors, and are found in present-day birds, as noted earlier. Air sacs are found in bones throughout the body next to the spinal column.

Computerized tomography was used to visualize the fossils' internal structures. Small spaces in the vertebrae were identified as foramina for veins, arteries and marrow, and attachment points for muscles and tendons could be seen, but none appeared capable of serving as pneumatic chambers through which air might have flowed continuously.

"The Triassic was very warm and dry. What's now Rio Grande do Sul was far from the sea in the heart of the supercontinent Pangea. In that context, more oxygen circulating in the blood would cool the body more efficiently and certainly afford a welcome advantage, so much so that it evolved at least three times independently," said Fresia Ricardi-Branco, penultimate author of the article, a professor at IG-UNICAMP.



Micro-computed tomography of the vertebrae of the basal most sauropodomorph Buriolestes (CAPP/UFMS 0035). (A) silhouette shows the position of the axial elements. Artist: Felipe Elias. (B), three-dimensional reconstruction of the articulated cervical vertebral series and the correspondent high-contrast density slices in (D–I). Diagenetic processes partially compromised the internal structures in these cervicals. (C), 3D reconstruction of the articulated anterior dorsal vertebrae and the correspondent high-contrast density slices in (J–M). Small circumferential chambers occur both ventrally in the dorsal centrum (J) and laterally in the neural arch pedicles (D). All images indicate apneumatic chaotic trabeculae architecture. Some of the latter develop into larger chambers in the centrum (E,J,K).

Nutritional foramina are broader at the bottom of the neural canal in the posterior cervicals (F,G). All slices were taken from the approximate midshaft. Anterior views in (D–H,J,K). Lateral view in (L). Ventral view in (H,I,M). Anterior/posterior orientation was defined based on the axial position, not the anatomical plane. cc circumferential chamber, ccv chamber in the centrum, ctr chaotic trabecula, d diapophysis, ltr layered trabeculae, nc neural canal, nf nutritional foramen, s neural spine. Scale bar in (A) = 500 mm; in (B–M) = 10 mm. Computed tomography data processed with 3D Slicer version 4.10. Figures were generated with Adobe Photoshop CC version 22.5.1 X64. (Credit: Scientific Reports (2022). DOI: 10.1038/s41598-022-25067-8)

Pneumaticity

The fossils analysed were found between 2011 and 2019 by researchers at the Federal University of Santa Maria (UFSM) in an area known as Quarta Colônia near Santa Maria in Rio Grande do Sul. Some of those researchers are co-authors of the article.

The fossils belonged to three species: *Buriolestes schultzi*, *Pampadromaeus barberenai* and *Gnathovorax cabreirai*. The first two were sauropodomorphs, the group of long-necked dinosaurs that became the largest animals to walk the planet. The third was a herrerasaurid, one of the earliest carnivorous dinosaurs. The lineage became extinct shortly after the period in which this specimen lived.

A study published in 2021 by researchers from South Africa, the United Kingdom, the United States and Canada had already shown that another dinosaur lineage, the ornithischians, also lacked structures that could have housed air sacs. This order of dinosaurs probably emerged later, in the Jurassic (between 201 Ma and 145 Ma ago) and included the popular Triceratops.

The data collected on ornithischians, herrerasaurids and sauropods showed that air sacs evolved independently in each group. "We discovered that no common ancestor had this trait. All three groups must have developed air sacs independently," Aureliano said.

The other groups that had air sacs were the pterosaurs (including pterodactyls) and the theropods (including tyrannosaurs and velociraptors, as well as extant birds). Although they descended from *B. schultzi* and *P. barberenai*, in the long-necked lineage, hollow bones only evolved later. Exactly when is not yet known.

"The oldest dinosaurs in the world are in South America and have been discovered only in the past two decades," Ricardi-Branco said. "More of this kind of research needs to be done to show how the dominant organisms of the period coped with a much warmer climate than ours."

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2. Tito Aureliano *et al*, The absence of an invasive air sac system in the earliest dinosaurs suggests multiple origins of vertebral pneumaticity, **Scientific Reports** (2022). DOI: 10.1038/s41598-022-25067-8

UK: Official stats confirm risks of shutting down Scottish oil and gas industry - OEUK

energy-pedia general news
5 March 2023

Official analysis reveals accelerating the decline of Scotland's oil and gas production will increase Scotland's emissions, threaten jobs and ultimately could make Scotland poorer.

The report, commissioned by the Scottish Government, says Scotland will need to 'carefully manage' the decline in oil and gas alongside the growth of the new low carbon sector to 'minimise any negative impacts of the energy transition on society and the economy'.

It also finds the industry was responsible for a total GVA of £16bn to the Northeast, equivalent to 9% of total Scottish GDP in 2019 –

highlighting the importance of the sector to people and jobs in the region.

The independent report was commissioned as part of the draft Energy Strategy and Just Transition Plan (ESJTP) consultation process. The initial draft of the strategy suggested the Northeast should accelerate the decline of oil and gas production.

Scotland gets 79% of its total energy from oil and gas. Across the UK, about 24 million homes (85% of the total) rely on gas boilers, 32 million vehicles run on petrol and diesel, and 42% of electricity comes from gas.

Offshore Energies UK, which represents 400 companies involved in producing energy from gas, oil, wind and hydrogen, says the new analysis reaffirms the ongoing need for domestic production as Scotland transitions to lower carbon forms of energy.

Jenny Stanning, OEUK's external relations director, said: 'All three candidates to be the next First Minister of Scotland should read this report. This new independent analysis shows accelerating the decline of North Sea oil and gas production could increase Scotland's emissions because we'd simply import more. It's why we remain concerned about the Scottish Government's draft plan, which suggested accelerating the decline of Scottish oil and gas production.

'Increasing reliance on imports would be bad for Scottish jobs, the economy, and our climate goals, because as this report shows, imports tend to be associated with a higher carbon footprint.

'More broadly, this independent analysis shows the Scottish economy is set to lose £11 billion per year under existing Scottish Government transition plans. Scotland will be poorer under these plans, and we cannot allow this to happen. Our brilliant skilled people, world class expertise, and unrivalled capabilities mean we are well-placed to realise a successful offshore energy future for Scotland.

'We have to get this right – 25,000 jobs, 98% of which are in the Northeast of Scotland, depend on this. We all know we need to

expand sustainable energy production as fast as possible. Our industry is already working to deliver the UK and Scottish Governments' climate goals through cutting emissions from the production of oil and gas while ramping up investment in renewables.

'In the meantime, and as this report shows, we should continue to support domestic production of oil and gas to meet ongoing demand.

'We are reviewing this paper in full with our members and look forward to responding to the consultation. We continue to make the case that the Scottish Government's energy strategy must both acknowledge the continuing role of oil and gas in Scotland's economy as well as our sector's role in a rapid transition to a low-carbon future.'

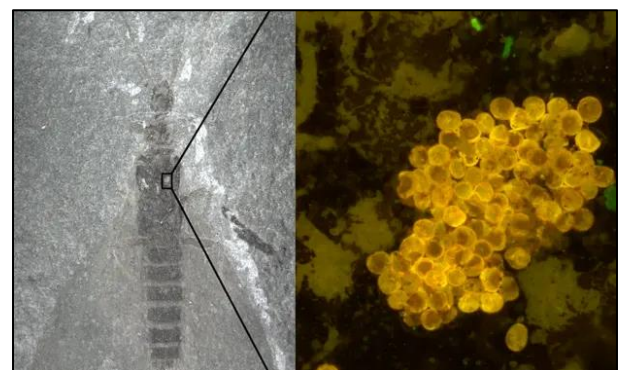
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Scientists discover fossils of oldest known potential pollinators

Remains of earwig-like insects discovered near village of Chekarda, Russia, covered in pollen

*Ian Sample, The Guardian Science editor
1 March 2023*



A tillyardembia fossil with an enlarged area showing pollen attached to its body. (Photograph: Alexander Khramov/Russian Academy of Science/PA)

Nearly 200 Ma before the mosquito in Jurassic Park became trapped in amber, hundreds of ancient insects were encased in sediment along the bank of the Sylva river that flows through the Urals.

Now, scientists inspecting the flattened creatures have found a handful that appear to mark a moment in history: they are the oldest known insects to be covered in pollen, and perhaps some of the world's first plant pollinators.

Rare fossils of the earwig-like insects were discovered when palaeontologists cracked open rocks along the riverbank near the half-derelict village of Chekarda in Russia. At 280 Ma old, the specimens predate what were previously the earliest known pollen-covered insects by about 120 Ma.

Known as *tillyardembiids*, the fossilised insects had clumps of pollen on their heads, bodies and legs, which under a fluorescent microscope looked like Christmas baubles. The pollen was found to come from a narrow range of seed-producing, non-flowering plants called gymnosperms. Flowering plants evolved 250 to 150 Ma ago but became far more common 100 Ma ago as the rise in pollinators helped transform the diversity of terrestrial life on Earth.

Writing in *Biology Letters*, the team from Russia and Poland concede it is impossible to know whether their ancient insects contributed to pollination in the Permian period but suggest that by eating pollen – and covering themselves in the grains – the creatures were an “evolutionary precursor” to the mutually-beneficial arrangement.

“It was like touching the past,” said Alexander Khramov, a senior researcher at the Paleontological Institute, Russian Academy of Science in Moscow, on seeing the fossils. “This discovery sheds light on the early evolution of insect pollination. It provides direct, smoking-gun evidence of pollen dispersion by Palaeozoic insects. And we could say that *tillyardembiids* were picky eaters, specialised on a rather narrow range of host plants.”

The Permian period covers the last 47 Ma of the Palaeozoic era, which spans 540 to 250 Ma ago. Many insects preserved in amber date to 100 Ma ago.

Tillyardembiids had wings and so were potentially highly effective at dispersing pollen, but whether the insects co-evolved with gymnosperms as the plants' pollinators is likely to remain a mystery.

“We cannot go back in a time machine to observe whether these insects did pollination work or not. Even if they pollinated ancient gymnosperms all day round, there are no ways to prove it with certainty by means of palaeontology,” Khramov said.

“Who knows, maybe they simply gobbled up pollen, and plants did not benefit from it? Anyway, what we could say for sure is that *tillyardembiids* visited quite a narrow range of plants and carried their pollen in large amounts. So, I do not see why they could not have been pollinators,” he added.

Charles Wellman, professor of palaeobiology at the University of Sheffield, said the majority of modern plants are insect pollinated. “How and when insect pollination began is a compelling question. This new fossil discovery suggests that insects had begun to steal plant pollen to eat millions of years before the process of pollination evolved. However, this eventually became an association of mutual benefit, as plants developed mechanisms to ensure that the thieves left with pollen attached, that fertilised neighbouring plants as they fed on them.”

Barry Lomax, Professor of plant palaeobiology at the University of Nottingham, said plant-insect interactions define the modern world, with pollinator services proving the backbone for much of our food production. The study, he said, provided evidence for the antiquity of the relationship, one that became established well before the evolution of flowers which likely occurred in the Cretaceous period about 135 Ma ago.

“By examining the type of pollen, the authors showed that it comes from just a handful of plant species, suggesting close association

between the plants and these insects,” Lomax said.

“The exciting thing about this discovery is the fact that there appears to be a degree of specialisation in plant-insect interactions and that this specialisation predates flowering plants, and it suggests the possibility that insect pollination predates flowers.”

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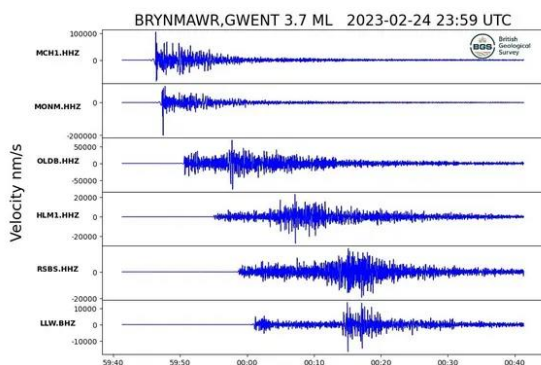
‘My whole bed shook’: south Wales hit by 3.7 magnitude earthquake

Epicentre of quake, which hit just before midnight on Friday, was north of Brynmawr and west of Crickhowell

*Sophie Zeldin-O'Neill, The Guardian
25 February 2023*

An earthquake has shaken parts of south Wales. The British Geological Survey (BGS) said the **3.7 magnitude quake** happened at 23:59 GMT on Friday. The epicentre was just north of Brynmawr, Blaenau Gwent and west of Crickhowell, Powys.

It was felt by residents across the region, including Abergavenny, Crickhowell, Llangynidr, Llanover and Llanfoist, with many saying that furniture and windows shook.



Seismogram on the British Geological Survey website showing the activity in Brynmawr. (Photograph: British Geological Survey/PA)

Gwent police said it had received “multiple calls” overnight, but it was “business as usual” for the force.

“My whole bed shook,” one person tweeted. Others described it as a “scary” experience, and some said it “felt as though their property had been hit by a car”. Others described objects such as bookshelves and desks moving, and claimed the quake was reminiscent of “a bomb going off”.

Shelly Organ was among many residents who shared her experience on social media: “Being in Troedryhiw we honestly thought someone had crashed into a wall, so we checked the children were still sleeping and went out to check and there were a few in the street thinking the same.”

Katy Alexandra Jack tweeted: “Imagine, I just felt this all the way in Dudley, West Midlands.”

The BGS said the earthquake was 1.8 miles under the Earth’s surface. The largest earthquake ever recorded in the UK was in the North Sea on 7 June 1931, with a magnitude of 6.1. The epicentre was in the Dogger Bank area, 75 miles north-east of Great Yarmouth, Norfolk.

Wales’s most powerful quake was on the Llŷn Peninsula, Gwynedd, in 1984 – measuring 5.4, it began at a depth of more than 12 miles. The BGS said smaller quakes were not unusual in Wales, which has had 70 measuring more than 3.5 between 1727 and 1984.

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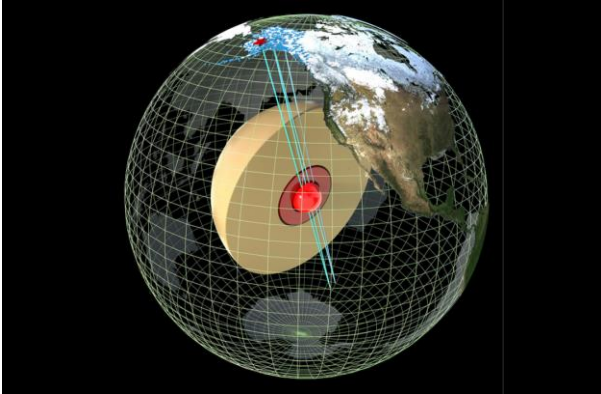
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Bouncing Seismic Waves Reveal A Distinct Layer In Earth’s Inner Core

*By Keith Cowing
Press Release, Australian National University*

21 February 2023

Data captured from seismic waves caused by earthquakes has shed new light on the deepest parts of Earth's inner core, according to seismologists from The Australian National University (ANU).



An earthquake in Alaska causing seismic waves to penetrate the Earth's innermost inner core. (Credit: Drew Whitehouse, Son Phạm and Hrvoje Tkalčić)

By measuring the different speeds at which these waves penetrate and pass through the Earth's inner core, the researchers believe they've documented evidence of a distinct layer inside Earth known as the innermost inner core — a solid "metallic ball" that sits within the centre of the inner core.

Not long ago it was thought Earth's structure was comprised of four distinct layers: the crust, the mantle, the outer core and the inner core. The findings, published in ***Nature Communications***, confirm there is a fifth layer.

"The existence of an internal metallic ball within the inner core, the innermost inner core, was hypothesized about 20 years ago. We now provide another line of evidence to prove the hypothesis," Dr Thanh-Son Phạm, from the ANU Research School of Earth Sciences, said.

Professor Hrvoje Tkalčić, also from ANU, said studying the deep interior of Earth's inner core can tell us more about our planet's past and evolution.

"This inner core is like a time capsule of Earth's evolutionary history – it's a fossilised record that serves as a gateway into the events of our planet's past. Events that happened on Earth

hundreds of millions to billions of years ago," he said.

The researchers analysed seismic waves that travel directly through the Earth's centre and "spit out" at the opposite side of the globe to where the earthquake was triggered, also known as **the antipode**. The waves then travel back to the source of the quake.

The ANU scientists describe this process as similar to a ping pong ball bouncing back and forth.

"By developing a technique to boost the signals recorded by densely populated seismograph networks, we observed, for the first time, seismic waves that bounce back-and-forth up to five times along the Earth's diameter. Previous studies have documented only a single antipodal bounce," Dr Phạm said. "The findings are exciting because they provide a new way to probe the Earth's inner core and its centremost region."

One of the earthquakes the scientists studied originated in Alaska. The seismic waves triggered by this quake "bounced off" somewhere in the south Atlantic, before travelling back to Alaska.

The researchers studied the anisotropy of the iron-nickel alloy that comprises the inside of the Earth's inner core. Anisotropy is used to describe how seismic waves speed up or slow down through the material of the Earth's inner core depending on the direction in which they travel. It could be caused by different arrangement of iron atoms at high temperatures and pressures or preferred alignment of growing crystals.

They found the bouncing seismic waves repeatedly probed spots near the Earth's centre from different angles. By analysing the variation of travel times of seismic waves for different earthquakes, the scientists infer the crystallised structure within the inner core's innermost region is likely different to the outer layer.

They say it might explain why the waves speed up or slow down depending on their angle of entry as they penetrate the innermost inner core.

According to the ANU team, the findings suggest there could have been a major global event at some point during Earth's evolutionary timeline that led to a "significant" change in the crystal structure or texture of the Earth's inner core.

"There are still many unanswered questions about the Earth's innermost inner core, which could hold the secrets to piecing together the mystery of our planet's formation," Professor Tkalčić said.

The researchers analysed data from about 200 magnitude-6 and above earthquakes from the last decade.

Reference:

<https://spaceref.com/earth/bouncing-seismic-waves-reveal-a-distinct-layer-in-earths-inner-core/>

The Dinosaur Footprint Found in England is 166 Million Years Old

ULUKAYIN

18 February 2023

The 166 Ma old carnivorous dinosaur footprint found in Yorkshire represents the largest of its kind ever found in the region.

The discovery was made by local archaeologist Marie Wood on a beach in Scarborough in April of 2021. However, the research paper on the subject was published on February 16, 2023, in the *Proceedings of the Yorkshire Geological Society*.

While spending time on the beach on an April day, Marie Wood saw a three-toed dinosaur footprint by chance. Although similar fossils have been found in that region before, the footprint Marie Wood saw was about 80cm long, making it the largest ever found there.

In an excited rush, Marie Wood informed local fossil experts, and after a while she contacted palaeontologist Dean Lomax.

After the analysis, it was determined that the footprint belonged to a carnivorous theropod that lived about 166 Ma ago. This is interpreted as an important discovery to make predictions

about the behaviour of carnivorous dinosaurs in the region during the Jurassic period.



Dinosaur Footprint. (Photo: Marie Woods / The University of Manchester)

John G. Hudson, lead author of the research paper, thinks the footprint may have belonged to a Megalosaurus-like animal with a hip height of between 250 cm and 300 cm.

It was donated to the museum

The footprint fossil on the coast was at risk of being damaged by natural factors such as erosion and tides, as well as human factors. Therefore, it was decided to remove it from the beach through a team of experts, and the fossil was donated to the **Scarborough Museum and Galleries** to prevent damage.

According to the University of Manchester, the footprint fossil will be exhibited at the Rotunda Museum.

Theropods

A clade of dinosaurs that arose in the Triassic period, about 230 Ma ago, and is characterized by three-toed limbs. There are both insectivorous, herbivorous and carnivorous theropod species. The nine-ton *Tyrannosaurus rex* is a theropod. In addition, modern birds also descend from theropods.

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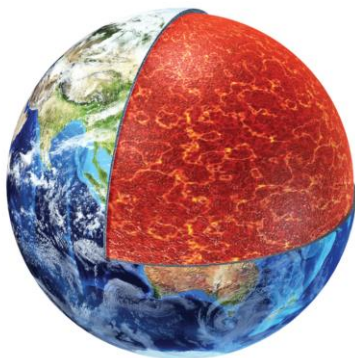
A Molten Rock Layer Is Hidden Under Earth's Tectonic Plates

By Keith Cowing, *Space.com*
Press Release, University of Texas
6 February 2023

Scientists have discovered a new layer of partly molten rock under the Earth's crust that might help settle a long-standing debate about how tectonic plates move.

Researchers had previously identified patches of melt at a similar depth. But a new study led by **The University of Texas** at Austin revealed for the first time the layer's global extent and its part in plate tectonics.

The research was published Feb. 6, 2023, in the journal **Nature Geoscience**.



The Earth with the upper mantle revealed. Researchers at The University of Texas at Austin have discovered a previously unknown layer of partly molten rock in a key region just below the tectonic plates. (CREDIT Leonello Calvetti/Dreamstime)

The molten layer is located about 100 miles from the surface and is part of the asthenosphere, which sits under the Earth's tectonic plates in the upper mantle. The asthenosphere is important for plate tectonics because it forms a relatively soft boundary that lets tectonic plates move through the mantle.

The reasons why it is soft, however, are not well understood. Scientists previously thought that molten rocks might be a factor. But this study shows that melt, in fact, does not appear to notably influence the flow of mantle rocks.

"When we think about something melting, we intuitively think that the melt must play a big role in the material's viscosity," said Junlin Hua, a postdoctoral fellow at UT's Jackson School of Geosciences who led the research. "But what we found is that even where the melt fraction is quite high, its effect on mantle flow is very minor."

According to the research, which Hua began as a graduate student at Brown University, the convection of heat and rock in the mantle are the prevailing influence on the motion of the plates. Although the Earth's interior is largely solid, over long periods of time, rocks can shift and flow like honey.

Showing that the melt layer has no influence on plate tectonics means one less tricky variable for computer models of the Earth, said co-author Thorsten Becker, a professor at the Jackson School.

"We can't rule out that locally melt doesn't matter," said Becker, who designs geodynamic models of the Earth at the Jackson School's University of Texas Institute for Geophysics. "But I think it drives us to see these observations of melt as a marker of what's going on in the Earth, and not necessarily an active contribution to anything."

The idea to look for a new layer in Earth's interior came to Hua while studying seismic images of the mantle beneath Turkey during his doctoral research.

Intrigued by signs of partly molten rock under the crust, Hua compiled similar images from other seismic stations until he had a global map of the asthenosphere. What he and others had taken to be an anomaly was in fact commonplace around the world, appearing on seismic readings wherever the asthenosphere was hottest.

The next surprise came when he compared his melt map with seismic measurements of tectonic movement and found no correlation, despite the molten layer encompassing almost half the Earth.

"This work is important because understanding the properties of the asthenosphere and the origins of why it's weak, is fundamental to

understanding plate tectonics,” said co-author Karen Fischer, a seismologist and professor at Brown University who was Hua’s Ph.D. advisor when he began the research.

The research was funded by the U.S. National Science Foundation. Collaborating institutions included the UT Oden Institute for Computational Engineering and Sciences and Cornell University.

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<https://spaceref.com/earth/a-molten-rock-layer-is-hidden-under-earths-tectonic-plates/>

Asthenospheric low-velocity zone consistent with globally prevalent partial melting, *Nature Geoscience*

OEUK: Calls for UK windfall tax on oil & gas player’s global profits ‘deliberately misleading’

by *Melisa Cavcic*
7 February 2023

The release of BP and Shell’s profits announcements gave rise to calls for windfall taxes on energy producers’ global profits from opposition politicians and union leaders. In response to this, the UK’s representative body for the offshore energy industry, Offshore Energies UK (OEUK), has warned that these calls for new windfall taxes on global profits are misleading.

Energy companies have recorded **all-time high profits in 2022** due to high energy prices, increased demand for oil and gas production and tight supply. This was also seen in the profits announcements from Shell and BP. These announcements caused outrage among those who opted to call for a new windfall tax.

Shell recorded the highest-ever profit on a year-on-year basis last year, reaching **\$39.9 billion (£32.7 billion)**, which is more than double the firm’s full-year 2021 profit of \$19.3 billion. After releasing its results, the oil major’s headquarters were targeted by Greenpeace activists, who set up a huge, mock petrol

station price board outside the company’s London HQ.

At the time, Greenpeace said that Shell had funnelled billions back into shareholder pockets in the form of buybacks, instead of investing its profits back into “clean, cheap renewable power which could alleviate bills, shore up UK energy security, and ease the climate crisis.”

On the other hand, **BP more than doubled its annual profit in 2022 to \$27.7 billion (£22.7 billion)**, which put the oil major firmly on environmentalists’ hit list. Global Witness, an international NGO, says that BP’s record 2022 profit, which represents a 116 per cent jump over 2021 profits, could pay this year’s energy bills for a full third of all UK households.

In addition, the NGO further adds that BP’s profits could cover £10 billion that the government claims would be needed to give NHS nurses – who today have continued their efforts on the picket lines – the pay raises they demand, and still leave the company nearly £13 billion.

In response to the calls for a new windfall tax on energy producers’ global profits, **Offshore Energies UK** – former Oil & Gas UK (OGUK) – said such a levy risked breaching global tax agreements and so could never be implemented. For global oil and gas producers, UK operations will typically be just a fraction of their overall portfolio – **probably less than 10 per cent** for the UK majors.

Commenting on this, Mike Tholen, OEUK’s director of sustainability, said it was wrong to offer false hopes to hard-pressed consumers, adding: “These calls for an increase in the UK windfall tax, linked to the global profits of energy producers, are deliberately misleading. The UK is subject to global tax agreements which say that it cannot tax profits made by companies outside of the UK. That means such a tax could never be implemented. It is irresponsible to pretend otherwise.

“Companies operating within the UK already face a **75 per cent windfall tax** on profits made in UK waters – the highest for any industry. That means the UK government is

actually the biggest beneficiary of the high prices generated by the Ukraine conflict.”

Tholen further emphasises that the “rate of UK tax is already so high it risks driving companies out of UK waters. All parties have acknowledged that we will need oil and gas for decades to come, so why risk damaging our own secure supplies from the North Sea?”

“That will reduce production, undermine the UK’s energy security, destroy jobs and ironically, drive down tax revenues. It will also damage the skilled workforce needed to drive the transition to low carbon energies.”

In a bid to address a common confusion regarding the relationship between global profits and UK taxation, which arises from the assumption that profits from global operations are subject to UK taxes, OEUK clarified that this assumption is incorrect and explained that the relevant UK taxes – Corporation Tax, Supplementary Charge and the EPL – apply only to energy producers profits made on oil and gas extracted in UK waters.

The combined rate of these taxes is 75 per cent, which, according to OEUK, is the highest rate for any UK sector. These UK taxes will apply to profit earned by foreign-owned companies operating in UK waters, however, they will not apply to profit earned by subsidiaries of UK companies operating overseas.

“The key point here is that multinationals like Shell and BP are not single companies but groups, with multiple overseas subsidiaries. Most of their profits are made in other countries which is also where those profits are taxed. The UK cannot then impose a second tax just because the group has its headquarters in the UK. If we did, they would all leave,” added Tholen.

“It would also be invidious for the UK to tax profits made in other countries. The taxes on those revenues belong to the countries where they were generated. It would be wrong for another country’s revenues to be effectively seized by the UK. Our industry wants to work with politicians of all parties to build the UK’s low-carbon energy future. We need long-term

energy policy plus fiscal and regulatory stability if we are to achieve net zero,” concluded Tholen.

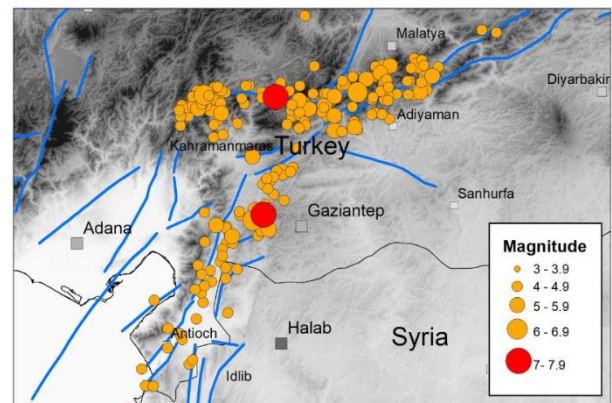
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The Kahraman Maraş earthquake sequence, Turkey/Syria

Two large earthquakes occurred within hours of each other on 6 February 2023

*Dr Brian Baptie,
Seismologist, BGS Edinburgh
14 February 2023*



Evolution of the southern Turkey earthquake sequence along with mapped active faults (blue lines). BGS © UKRI.

Earthquake information: ANSS Comprehensive Earthquake Catalog (USGS ComCat).

Topography: Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010).

Mapped faults: GEM Global Active Faults Database.

The devastating **Kahraman Maraş earthquake** sequence has caused widespread destruction and terrible loss of life across a large part of southern Turkey and northern Syria, with the collapse of thousands of buildings in populated areas throughout the region.

The earthquake sequence

The sequence started with a magnitude **7.8 earthquake** at 01:17 UTC on 6 February 2023, rupturing a 200 km section of the north-east to south-west trending fault system that forms the boundary between the Anatolian and the Arabian tectonic plates. These plates are moving horizontally relative to each other at a speed of around 13mm per year.

The earthquake took about 30 seconds to reach a maximum slip of around 3m and resulted in intense shaking that lasted over a minute. Recorded ground accelerations at some sites close to the fault rupture exceeded 1.0 g. A few hours later, a magnitude 7.5 event occurred on a nearby branch of the fault system that trends east to west. This caused further strong ground shaking and destruction.

Previous seismicity in the area

The magnitude 7.8 earthquake was approximately 2.5 times bigger than the magnitude 7.4 Izmit earthquake in Turkey in 1999, which killed over 17,000 people, and was the same size as the magnitude 7.8 Erzincan earthquake in north-east Turkey in 1939, which killed over 32,000 people. The latter is considered the deadliest natural disaster in Turkey in the 20th century.

Although the earthquake risk in this part of southern Turkey was generally considered to be less than along the well-known Northern Anatolian Fault in northern Turkey, large and damaging earthquakes have struck here in the past. The city of Aleppo in northern Syria has been destroyed by several earthquakes in the last thousand years, including an earthquake in 1822 with over 20,000 fatalities.

The continuing hazard

Aftershocks are expected to cause moderate to severe ground shaking over a 300 to 500km region for months to come. Some of these earthquakes may be several hundred kilometres away from other aftershocks and may be large enough to cause further damage, particularly to buildings that have already been weakened.

There have already been several aftershocks with a magnitude larger than 6.0. Our current understanding of the statistics of the aftershock process suggests that there may be several tens of earthquakes of this size or greater.

Over a period of months to years, the frequency of triggered seismicity (aftershocks) will reduce, with earthquake activity gradually returning to previous levels. Until then, earthquake hazard and risk in the region will remain heightened. This means that increased seismic hazard in the region where the two large earthquakes occurred is transient in nature, whilst longer seismic hazard estimates continue to be relevant.

Earthquake cascades

It is well established that large earthquakes can trigger seismicity on other nearby faults as the Earth's Crust adjusts to the sudden change in stress. Both the permanent deformation caused by the initial earthquake and the passage of seismic waves through the Earth can trigger these subsequent earthquakes.

Other recent examples of this triggering process include the Kumamoto sequence on the island of Kyushu, Japan, in 2016, when a magnitude 6.5 earthquake was followed almost a day later by a magnitude 7.3 event. In Europe, the magnitude 6.0 Amatrice earthquake that occurred in Italy in 2016 was followed by the magnitude 6.5 Norcia earthquake two months later.

Although such cascading sequences of large-magnitude earthquake within short periods of time are relatively rare, investigation and analysis of these may promote a new understanding of the earthquake process.

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Turkey earthquake fault lines mapped from space

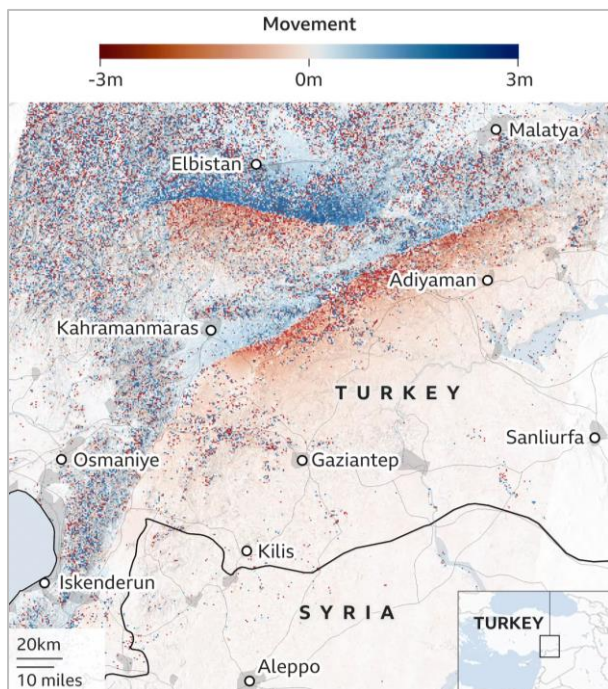
*By Jonathan Amos,
BBC Science Correspondent
11 February 2023*

It seems almost insensitive to start to have a deep dive into the science behind Monday's earthquake events in Turkey.

More than 22,000 people are already confirmed dead and an unknown number still lie trapped, with the window for their rescue closing rapidly.

And yet the science will go on. The insights gleaned from this event will save lives in the future.

Take a look at the map below. It is the most precise yet produced of how the ground lurched in response to the enormous energies that were unleashed.



EU satellite precisely maps earthquake faults: ground movement measured closer to or further away from passing satellite. (Source: Copernicus data, Esa, Comet 2023/BBC)

The data behind it was acquired in the early hours of Friday, 10 February by the European Union's Sentinel-1A satellite as it traversed north to south over Turkey at an altitude of 700km (435 miles).

The Sentinel carries a **radar instrument** that is able to sense the ground in all weathers, day and night.

It is routinely scanning this earthquake-prone region of the world, tracing the often very subtle changes in elevation at the Earth's surface.

Except, of course, the changes on Monday were not subtle at all; they were dramatic. The ground bent, buckled and in places ripped apart.

Researchers use the technique of **interferometry** to compare "before" and "after" views. But you do not really need to be an expert to see the consequences for Turkey in the latest Sentinel map.

The red colours here describe movement towards the satellite since it last flew over the country; the blue colours record the movement away from the spacecraft.

It is abundantly clear how the ground has been deformed along and near the East Anatolian Fault line.

For both the Magnitude 7.8 quake that struck first on Monday at 01:17 GMT and the Magnitude 7.5 event at 10:24, the motion is "left-lateral". That is to say: whichever side of the fault you are on, the other side has moved to the left. And by several metres in places.

The shocking thing is that the lines of rupture have gone right through settlements; in lots of places, they will have gone right through buildings.

The Sentinel map will help scientists understand exactly what happened on Monday, and this knowledge will feed into their models for how earthquakes work in the region, and then ultimately into the risk assessments that the Turkish authorities will use as they plan the recovery.

There is sure to be a lot of discussion about how the two major tremors were related and what that could mean for further instability.

The map was processed by the UK Centre for Observation and Modelling of Earthquakes, Volcanoes and Tectonics (Comet). Its director, Prof. Tim Wright, said the Sentinel observations vividly brought home the scale of the forces involved.

"News outlets always show earthquakes as 'the epicentre', as if it is a single point source (like a bomb). Actually, all earthquakes are caused by slip on extended faults, and the

bigger the quake the bigger the fault that ruptured," he told BBC News.

"We can map those ruptures with satellites because the ground around them is displaced, in this case by up to 5m or 6m. The rupture of the first event was 300km or so long and the second big event ruptured another 140km or so of a different fault. To put those distances in context, London to Paris is roughly 345km.

"Damage will be highest near the fault but of course spreads over a wide region either side of the fault, too. It's absolutely horrific."

In the era before satellites, geologists would map earthquake faults by walking the lines of rupture. It was a laborious process that naturally also missed a lot of detail. **Radar interferometry** from space was developed in the 1990s, and in recent years it has become a particularly compelling tool.

In part that is down to the quality of the sensors now in orbit, but it is also the result of more powerful computers and smarter algorithms.

It is possible today to get a data product on to the computers of experts, ready for analysis, within hours of a satellite making an overhead pass. Comet, unfortunately, had to wait several days for Sentinel-1A to be in the right part of the sky to get an optimal view of Turkey. But this will improve as more and more radar satellites are launched.

"By the end of the decade, we should be able to do this kind of analysis within a day of most damaging earthquakes, and then we would be more useful for the relief effort. As things stand, we are of course outside the 72-hour window for search and rescue," Prof. Wright said.

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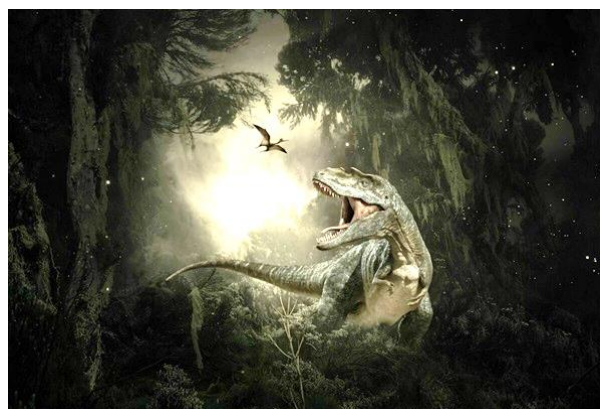
<https://www.bbc.com/news/science-environment-64603521>

Asteroid dust found at Chicxulub Crater confirms cause of dinosaurs' extinction

Although an asteroid impact has long been the suspected cause of the mass extinction

66 million years ago, researchers think new evidence finally closes the case.

**By Jake Parks, Astronomy
12 March 2021**



An asteroid smashed into the Yucatán Peninsula 66 Ma ago, killing some 75 percent of life on Earth, including all non-avian dinosaurs. (Credit: Willgard Krause/Pixabay)

Some 66 Ma ago, a city-size asteroid barrelled through Earth's atmosphere and slammed into the shallow waters off the Yucatán Peninsula in the Gulf of Mexico. The cosmic artillery strike gouged a 200km-wide crater in the Earth's surface, lofting plumes of vaporized rock and debris into the air that globally blocked out views of the Sun for years or decades. After the initial blast, the reduced sunlight caused Earth's surface temperature to plummet by as much as 28 degrees Celsius, aiding in a mass extinction that killed 75 percent of life on Earth. But eventually, the dust settled.

Fast forward to the 1980s, and scientists uncovered traces of asteroid dust, finding it scattered around the globe within the same geological layer that corresponds to the dinosaurs' extinction. In the following decade, **Chicxulub Crater** was discovered in the Gulf of Mexico. And because the crater appeared to be the same age as the global rock layer enriched with asteroid dust, researchers were fairly certain they had the story of the dinosaurs' demise figured out.

Now, a new study seems to have officially closed the case for good.

The latest evidence comes from rock core samples plucked from Chicxulub Crater itself, which is buried beneath the seafloor in the Gulf

of Mexico. In the most recent study based on these samples, which were collected during a 2016 mission co-led by the University of Texas at Austin, researchers say they've found a tell-tale sign of asteroid dust. It comes in the form of **iridium**, which is common in some types of asteroids, yet rare in Earth's crust.



Named after a nearby town, Chicxulub crater is located just offshore. New evidence confirms the site is almost undoubtedly the epicentre of the dinosaurs' demise. (Credit: The University of Texas at Austin/Jackson School of Geosciences/Google Maps)

The researchers found the highest concentration of iridium-peppered rock, which also contains a mixture of ash from the impact and ocean sediment, within a sample taken from the crater's peak ring. This sample likewise shows elevated levels of other elements commonly associated with asteroids, resulting in a chemical fingerprint that resembles the asteroid dust found around the globe in the 1980s, and precisely matches the geological location of the impact itself.

"We combined the results from four independent laboratories around the world to make sure we got this right," said lead author Steven Goderis, a geochemistry professor at Vrije Universiteit Brussel, in a press release.

"We are now at the level of coincidence that geologically doesn't happen without causation," added Sean Gulick, a professor at

UT Jackson School of Geoscience and co-author of the study.



Seen here is the section of rock core from Chicxulub Crater in which researchers found a concentration of iridium, a tracer for asteroid material, mixed with ash from the impact and ocean sediment. (Credit: The International Ocean Discovery Program)

Details on the asteroid dust found in Chicxulub Crater were published February 24 in **Science Advances**.

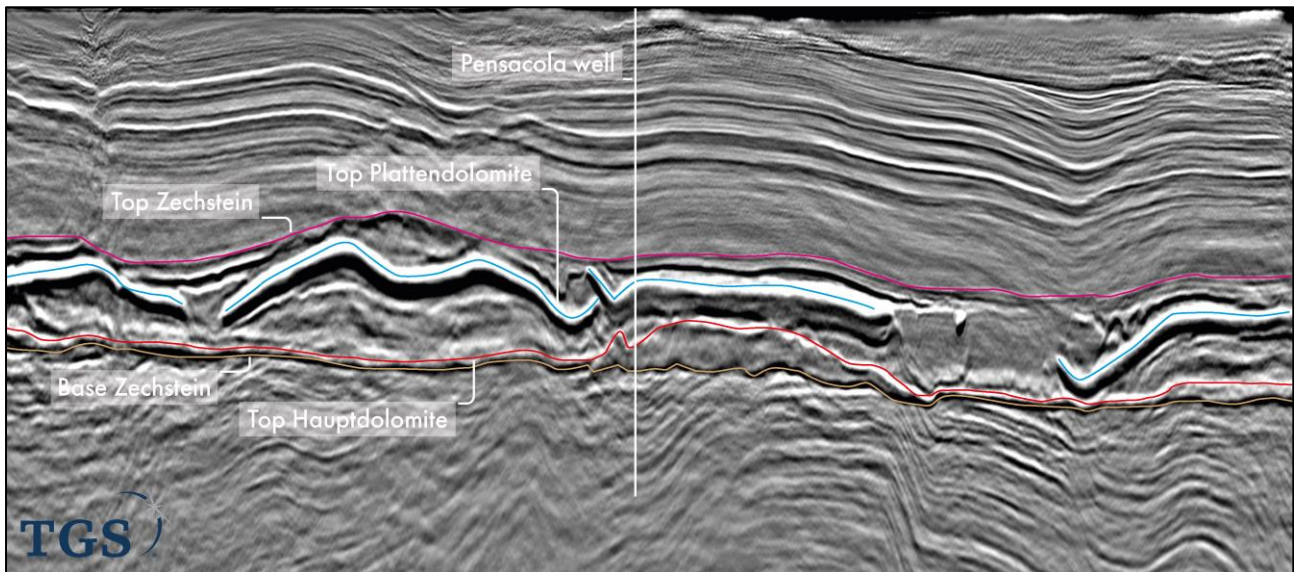
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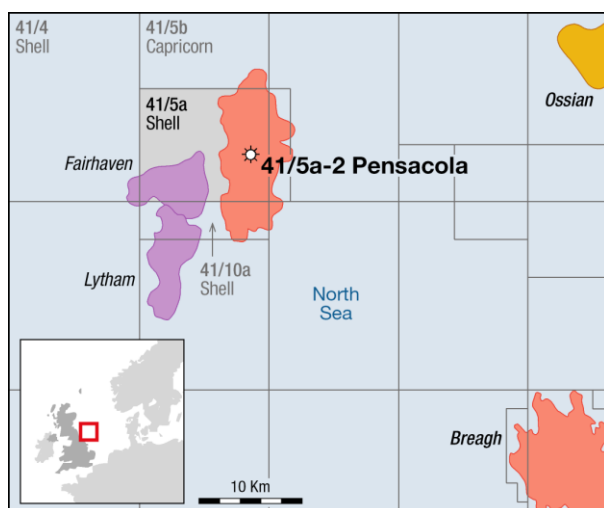
Pensacola discovery could be one of the largest natural gas discoveries in the SNS in over a decade

Even though test results showed a rapid decline in gas flow, the location of the well in a downdip position and the nature of the carbonate reservoir mean that with the right development strategy Pensacola could be developed.

Henk Kombrink, GeoExpro
8 February 2023



Seismic line across the Pensacola gas discovery, showing the top of the Hauptdolomite (top reservoir, red) as well as the overlying Plattendolomite (blue). The top and base of the Zechstein succession are indicated too. (Image: GeoExpro. Seismic line kindly provided by TGS)



Map supplied by: NVentures

The Southern North Sea Pensacola well – 41/05a-2 – was spudded in November 2022. Deltic Energy worked up this **Zechstein Hauptdolomite prospect**, but with operator Shell farming-in in 2019, drilling Pensacola became a lot more of a reality. The gas

discovery was announced in January 2023, followed by a positive test result today that proved 302 Bcf (8.5 Bcm, P50) of recoverable gas. The well proved an average of 16% porosity carbonates of 18.8m thickness. Some light oil was found too.

Pensacola is part of a series of isolated carbonate platforms that developed onto the southern margin of the Mid North Sea High in latest Permian times. The Pensacola platform has an elevation of more than 200m above the time-equivalent basinal facies on either side, which is illustrated by the seismic line above kindly provided by TGS.

Two source rocks?

The recently drilled Ossian Darach well (42/04-1Z) is another example of a discovery in this geological setting. However, Darach flowed oil while Pensacola contains mostly gas. It is likely that the underlying Carboniferous section is the

main source for the gas. However, the Westphalian coals that are widely believed to be the main Carboniferous source interval are absent in the immediate vicinity of Pensacola, so long-distance migration needs to be assumed in that case. At the same time, a deeper Carboniferous succession may have been the dominant source, which then does not require long-distance migration. The oil source, as Mike Cooper from *1st Subsurface – Trove* explained in a recently released video on the Pensacola discovery, could be within the Zechstein itself.

The well test results, which showed a peak of c. 4.75 mmscf/day declining to 1.75 mmscf/day after 12 hours, are in line with expected results according to a Deltic press release. The company states that the flow rates are not representative of potential future production because the well is located at a down dip location of the structure (*see seismic line*). Future production wells will likely target the central part of the discovery.

These test findings are in line with what Mike Cooper further explained in his video, in which he explained that Zechstein carbonates are sometimes showing high initial flow rates, followed by a rapid decline and pressure depletion. Limited connected GIIP is the most likely explanation for this, and it is against this background that the test results from the vertical well may not be too representative. Long horizontal wells with multi-fracs are probably the solution to really tap into the full potential of the Pensacola reservoir.

Glossary

<i>Bcf</i>	Billion cubic feet
<i>Bcm</i>	Billion cubic metres
<i>mmscf/day</i>	Million standard cubic feet per day

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‘Charmouth crocodile’ identified as new genus of croc-like creature

Remains of 2-metre-long animal discovered in 2017 by two fossil hunters

Steven Morris
31 January 2023

Scientists have identified a new genus of a fearsome crocodile-like creature that once hunted off what is now Dorset’s Jurassic Coast.

The remains of the 2-metre-long animal were discovered by fossil hunters after a series of landslips on to a beach in 2017, and the newly recognised beast has been named *Turnersuchus hingleyae* in honour of the finders, Paul Turner and Lizzie Hingley.

The “**Charmouth crocodile**”, as it is known in Dorset, is on display at Lyme Regis Museum, and the new research is likely to lead to an increase in visitors keen to come face to face with it.



An artist's impression of Turnersuchus hingleyae, named after the two fossil hunters who found it. (Photograph: Júlia d'Oliveira / SWNS)

Though it would have looked like a crocodile and is colloquially known as a “marine crocodile”, the animal is a type of **thalattosuchian**, often described as a sister species to modern crocodiles’ ancestors and would have been at large in the early Jurassic period.

Paul Davis, a geology curator at Lyme Regis Museum, said the original discovery – and now

the pinpointing of its origins – were thrilling. “It’s very exciting they have named a new genus of the marine crocodile. It’s so special for us.”

Davis said there were some good remains of more modern versions of the animal and a few older ones, but none from the age of the specimen found in Dorset.

Because of its relatively long, slender snout, *Turnersuchus hingleyae* would have looked similar to modern gharial crocodiles, found in major river systems in the north of India. The region of the skull that housed jaw muscles was particularly large, possibly suggesting the ability to take fast bites, meaning it could grab fast-moving fish, octopus or squid.

Hingley was delighted that what she and Turner found turned out to be so special. “I think it’s fantastic – we didn’t expect to find anything so rare. It’s unbelievable it’s turned out to be something that nobody has found before,” she said.

It was a hot May day when they made the find. “Paul found the first block and said there’s bone everywhere on this. We chucked it in a bag and carried on.” She put it on a fossil collectors’ Facebook page. “Within 10 minutes, the Natural History Museum was messaging me.”

Helped by a representative from the **Charmouth Heritage Coast Centre**, Hingley and Turner revisited the site every day for weeks to make sure they recovered every possible piece as it was washed out of a landslip, before it could be destroyed by the sea. Body parts including the head, backbone and limbs were found.

Remarkably, once the finds had been made, other local people came forward to reveal they had parts of the “crocodile”, and these have been collected with those found by Hingley and Turner.

The new findings are described in the ***Journal of Vertebrate Paleontology***.

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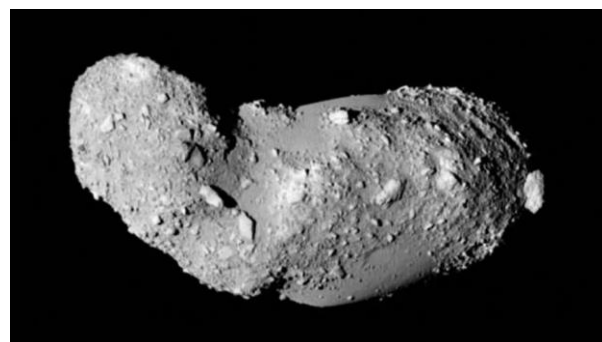
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Rubble-pile asteroids are 'giant space cushions' that live forever

Sharmila Kuthunur, Space.com
26 January 2023

The **asteroid Itokawa** is a pile of rocky debris 500 meters long. Itokawa, new research suggests, has remained pristinely intact — despite incessant asteroid bombardment in the inner solar system — since it formed more than 4.2 Ga ago. The finding may be crucial for any future mission designed to protect Earth from a rubble-pile asteroid, the researchers argue.



An image from the spacecraft Hayabusa of the asteroid Itokawa. (Image credit: JAXA)

"In short, we found that Itokawa is like a giant space cushion, and very hard to destroy," Fred Jourdan, an astronomer at Curtin University in Australia and the lead author of the new paper, said in a statement.

The team calculated Itokawa's age using specks of asteroid dust that were scooped by the Japanese Hayabusa spacecraft and brought back to Earth in 2010. By analysing the dust particles, Jourdan's team found that Itokawa is almost as old as the solar system itself. In the new paper, the team explains how Itokawa has survived countless asteroid collisions over 4.2 billion long years.

Although researchers already knew that a catastrophic collision destroyed Itokawa's parent body, this is the first time that Itokawa's

precise age and resilience have been directly studied.

A "giant space cushion"

The team behind the new research studied the texture and composition of three tiny dust particles collected from Itokawa's surface. The scientists used a radioactive dating method called **argon-argon dating** to measure Itokawa's age, which they clocked at 4.2 Ga.

As part of the study, the team also measured how much the dust particles, and by extension Itokawa, had been affected by shocks from asteroid collisions. For this, the researchers used another method called **electron backscatter diffraction** to measure the structures and orientations of crystals embedded inside the dust particles.

The team found that the dust particles were mostly pristine, suggesting that they were excavated from deep within the parent asteroid, likely when it broke apart during the catastrophic collision. The scientists concluded that Itokawa is extremely resilient to collisions, thanks to the asteroid's highly porous nature.

As an amalgamation of remnants from asteroid collisions, Itokawa hosts boulders of different shapes and sizes that have blended under gravity. The rubble pile is "entirely made of loose boulders and rocks, with almost half of it being empty space," Jourdan said in the statement.

When asteroids impact Itokawa, large cavities or pores between these boulders absorb much of the resulting energy surge, protecting the asteroid's structure from fractures. In this way, the pores help rubble piles like Itokawa survive asteroid collisions for at least 10 times longer than conventional, single-body asteroids, also known as monoliths, the researchers found.

The case for deflecting rubble-pile asteroids

The new research will help planetary defence experts, who discover near-Earth asteroids, track their paths and determine whether any threaten to collide with Earth.

The scientists say their analysis of Itokawa suggests that thanks to their resilience in the

face of impacts, rubble-pile asteroids may be more common, both in the asteroid belt and near-Earth, than previously expected.

"There is more chance that if a big asteroid is hurtling toward Earth, it will be a rubble pile," Nick Timms, also an astronomer at Curtin University, said in the same statement.

And the structure of an asteroid may make a difference if humans need to choose a strategy for deflecting a threat. For example, NASA's Double Asteroid Redirection Test (DART) mission rammed into *Dimorphos*, a similar rubble pile that was not on a collision course with Earth, but that was a convenient target to test how humans might respond to a future threatening asteroid. The impact shortened *Dimorphos*' orbit around the larger asteroid *Didymos* by 33 minutes, a major success for the mission.

When it collided with *Dimorphos*, DART transferred its energy and momentum to the asteroid. Although this method, called **kinetic impact**, was successful with DART, the authors of the new study warn it may be less efficient at deflecting shock-absorbent porous asteroids.

The kinetic impactor method is also most effective when we spot asteroids on collision courses with Earth well in advance, leaving enough time for a small change in orbit to build up. If a threatening asteroid is spotted too late for the kinetic impactor approach, "we can then potentially use a more aggressive approach like using the shockwave of a close-by nuclear blast to push a rubble-pile asteroid off course without destroying it," Timms said.

*The research is described in a paper published Monday (Jan. 23) in the journal **Proceedings of the National Academy of Sciences (PNAS)**.*

Reference:

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Suggested by Liz Aston.

Dark matter particle that may finally shed light on cosmic mystery the 'best of both worlds,' scientists say

Robert Lea, Space.com
27 January 2023

A new dark matter model suggests a new candidate for the constituent particles of this mysterious form of matter that could mean it is detectable by future experiments.

Despite making up 85% of the matter in the universe, dark matter has remained frustratingly undetectable thanks to the fact that it doesn't seem to interact with light as does the "normal" everyday matter that makes up stars, planets, and us. The only way dark matter can be inferred currently is through its interaction with gravity, with this gravitational influence literally keeping galaxies from ripping apart as they spin.

The new model suggests that dark matter could be composed of what its authors call **HighLY Interactive Particle Relics**, or **HYPERS**. This new model suggests that after the formation of dark matter in the early universe, the strength with which it interacts with everyday baryonic matter would have increased abruptly. This HYPERS model would have the consequence of making dark matter detectable in the current epoch of the universe while also offering an explanation of why dark matter is so abundant.

"The HYPERS model of dark matter asks and answers the question: How 'hyperactive' can light dark matter be?" McGehee told *Space.com*. "More technically, how frequently might we find light dark matter scattering off nuclei in near-future direct detection experiments that are sensitive to dark matter lighter than even a proton."

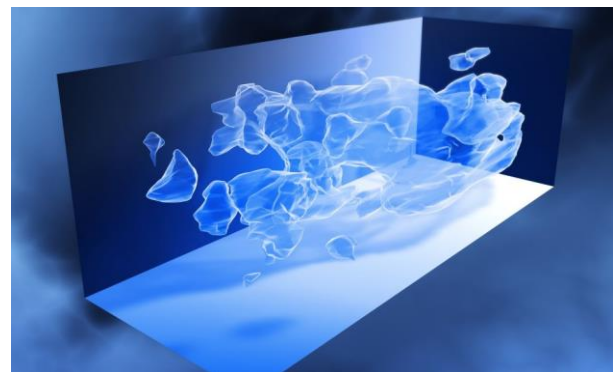
One of the current leading suspects in the hunt for dark matter candidates, are so-called **"Weakly Interacting Massive Particles"** or **"WIMPs."** The fact the search for these and other massive particles has been fruitless has led researchers to start proposing lighter

particles like HYPERS as dark matter candidates.

Additionally, current dark matter investigations tend to neglect the idea of phase transitions, the change of one physical state to another such as the shift from a solid to a liquid, which are common in everyday matter.

The HYPERS model instead hinges on a phase transition, demanding a transition in the early universe that changes how dark matter and everyday matter interact. The team behind the HYPERS model thinks that this change of state could mean dark matter may actually be detectable in the universe as it is today.

"We found that concrete models of such dark matter may be realized if a special, new phase transition occurred in the early universe," McGehee said.



This 3D map illustrates the large-scale distribution of dark matter, reconstructed from measurements of weak gravitational lensing by using the Hubble Space Telescope. (Image credit: Lawrence Livermore National Laboratory)

The "best of both worlds" for dark matter

The challenge faced by potential dark matter models currently is that if they suggest dark matter interacts strongly with baryonic matter, then the amount of dark matter formed in the early universe would be too small to conform with our observations of the universe. Conversely, models that produce the right amount of dark matter suggest interactions with baryonic matter that are too weak to be detected experimentally today.

The HYPERS model with its phase transition suggests one single abrupt change in the interaction between dark matter and baryonic

matter. This allows for what McGehee called "the best of both worlds" - both the right amount of dark matter to be created and a large enough interaction with everyday matter to be detectable.

Interactions in particle physics require a "mediator," a specific messenger particle, usually force-carrying bosons such as photons, which are messenger particles of electromagnetic force, to proceed.

Interactions between dark matter and ordinary matter would also require a mediator. The strength of the interaction would depend on the mass of the mediator particle with a larger mass meaning a weaker interaction. So, the mediator in this case must be heavy enough for the correct amount of dark matter to form, while still being light enough to grant a detectable interaction with matter.

The aforementioned phase transition in the HYPER model sees the mass of the mediator particle suddenly decrease with this change occurring after the formation of dark matter. This allows for the inferred amount to be created, while simultaneously allowing for a boosted interaction with ordinary matter that leads to scattering events that could allow dark matter to be directly detectable.

While the HYPER model may address some of the challenges associated with developing a dark matter model, creating it was anything but easy.

"One thing that shocked me about this research was how hard it was to circumvent the usual constraints on dark matter," McGehee said. "When I first thought about how a phase transition could circumvent stringent cosmological constraints and provide a serious dark matter benchmark, I was extremely excited and naively expected to write a paper within a few-month time period.

"Years later, my collaborators and I had found that even the assumption of this phase transition was not enough to guarantee protection from the many serious bounds that any new model of dark matter must face and overcome."

McGehee pointed out that should a future dark matter detection experiment see what appears to be quite light dark matter scattering off nuclei frequently, the HYPER model may be the only model available to physicists to explain this observation.

"That would be an extremely exciting circumstance for myself and my co-authors," he concluded.

Robert Lea, science journalist in U.K. whose articles have been published in Physics World, New Scientist, Astronomy Magazine, All About Space, Newsweek and ZME Science.

Baryonic matter, of which the Earth, other planets, and stars are made consists of atoms and their parts - protons, neutrons, and electrons.

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Suggested by Liz Aston.

Rare Antarctic meteorite is one of the largest ever found

Antarctica is the perfect place to go meteorite hunting, as space rocks stand out on the wide fields of ice, and researchers have found a new crop

**By Alex Wilkins
SPACE 24 January 2023**

Researchers in Antarctica have recovered a rare large meteorite on the ice. Weighing in at 7.6 kilograms, it is one of the largest space rocks ever discovered on the continent.

Antarctica's dry, cold weather carefully preserves any meteorites that land, while a uniform white background and active glaciers churn up ancient space rocks buried beneath the ice, making it one of the best places to find

meteorites. In the past hundred years, more than 45,000 meteorites have been found in Antarctica, the majority of which have been micrometeorites, which range from tens to hundreds of grams.



The meteorite probably originated from the asteroid belt between Mars and Jupiter. (Image: Maria Valdes)

Maria Schönbachler at ETH Zurich in Switzerland and her colleagues discovered five new meteorites during an expedition near the Princess Elisabeth Antarctica research station in December last year. This was during Antarctica's summer, when temperatures were at a relatively warm -10°C (14°F).

To find the meteorite, Schönbachler and her team combed through satellite imagery using a machine learning model and identified five icy regions that were relatively free of snow, which might have otherwise covered up meteorites. They explored all five regions systematically by snowmobile, but only one contained any meteorites. "To find such a big one – this is kind of luck to be honest," says Schönbachler.

While the meteorite has yet to be analysed, it appears to be an **ordinary chondrite**, says Schönbachler, which is the most common type. These objects contain the oldest material in the solar system and probably originated from the asteroid belt between Mars and Jupiter.

The team will now send the meteorite to Belgium, in a cool box to prevent thawing that could damage its delicate chemical structure, for further analysis.

"We don't tend to find too many meteorites in Antarctica that are as big as this," says Ashley King at the Natural History Museum in London. "The more meteorite we have, the more

sample that we have available for us to study and learn about the early solar system."

Reference:

<https://www.newscientist.com/article/2356082-rare-antarctic-meteorite-is-one-of-the-largest-ever-found/>

Fossilised nests of the world's largest dinosaur discovered in India

*By James Ashworth, NHM
18 January 2023*

More than 250 titanosaur eggs have been uncovered in India, revealing more about the lives of some of the largest animals which ever lived.

Among the eggs was one containing the remains of a second egg inside it which suggests that these mighty sauropods may have reproduced similarly to modern birds.

There could have been more titanosaurs in India than previously thought.



An unhatched sauropod egg (left) and the outline of a fossilised shell in the ground (right). (Image © Dhiman et al., 2023, licensed under CC-BY 4.0 via PLOS ONE)

A new study, published in the journal **PLOS ONE**, found evidence of six different types of fossilised egg across the Lameta Formation in central India. They date to the Late Cretaceous and are thought to have been buried by lava during the eruption of a volcanic area known as the Deccan Traps.

While these eggs don't necessarily all come from different dinosaur species, it adds weight

to theories that there could have been more titanosaurs living in India than the three types that are currently known.

Professor Guntupalli V.R. Prasad, co-author and leader of the research team, says, "Together with dinosaur nests from Jabalpur in the east and Balasinor in the west, the new nesting sites from Madhya Pradesh's Dhar District cover an east-west stretch of about 1000 kilometres. This constitutes one of the largest dinosaur hatcheries in the world."

Titanosaur reproduction

Titanosaurs are among the largest animals which have ever walked the Earth. While they had a similar appearance to other sauropods, such as *Diplodocus*, they were much bigger.

One of the largest species, *Patagotitan mayorum*, is believed to have measured over 37m long, or the same length as two bowling lanes.

While titanosaur remains are found all over the world, they are most species rich in South America. Around 75% of all titanosaur species are known from Patagonia, with the Auca Mahuevo site having been particularly important for understanding how these dinosaurs reproduced.

Spectacularly preserved sites such as these have revealed exquisite fossils, such as a preserved titanosaur embryo. Described in 2020, this fossil revealed that, like modern birds, titanosaurs developed an egg tooth they used to break open the shell when they were ready to hatch.

But because preserved eggs are very rare, it is difficult for researchers to directly link a type of egg to a type of dinosaur.

Dr. Susannah Maidment, a Principal Researcher and Curator of Dinosaurs at the Museum, explains, "Dinosaur eggs aren't very common in the fossil record, and this may be because of how they evolved. A recent paper suggested that some ornithischians, a group of dinosaurs containing ankylosaurs, stegosaurs and Triceratops, may have had soft shelled eggs."

"It's possible that the ancestors of this group, and perhaps even dinosaurs as a whole, didn't have hard eggshells. However, it's hard to tell if ornithischians lost their ability to make hard eggs, or if other dinosaurs such as the sauropods and theropods gained it."

The newly discovered nesting sites in India help to add further evidence for researchers investigating the process of dinosaur reproduction.

Inside a titanosaur nesting colony

Across the Dhar District, the researchers excavated 92 nests as part of the study. These mounds of earth were likely dug from the soft sediment of a floodplain environment over 66 Ma ago.

The nests were packed closely together, suggesting that while the dinosaurs may have laid their eggs together in colonies, the parents may not have stuck around to look after them.

"We think that sauropods like the titanosaurs lived in herds because of their preserved footprints and trackways, and it seems that they also nested together as well, like some birds," Susie says. "Their strategy of laying a lot of eggs packed densely together is not one commonly associated with parental care."

"While there are fossils of some dinosaurs, such as the meat-eating theropods, where parents are preserved sitting on a nest, there is no evidence of that kind of behaviour in the sauropods. It looks like sauropods laid their eggs and then left their offspring to fend for themselves."

Though the parents may have left, the eggs would still need to be kept warm during their incubation period. Whether this was by burying them under sand like turtles, or under rotting plant material like crocodiles, is still debated by scientists.

A lack of preserved plant material and the pattern of fragmented eggshell at the Indian nests have led the researchers to suggest that burial under sand may have been more likely, at least in titanosaur species such as *Jainosaurus* and *Isisaurus* which once lived on the subcontinent.

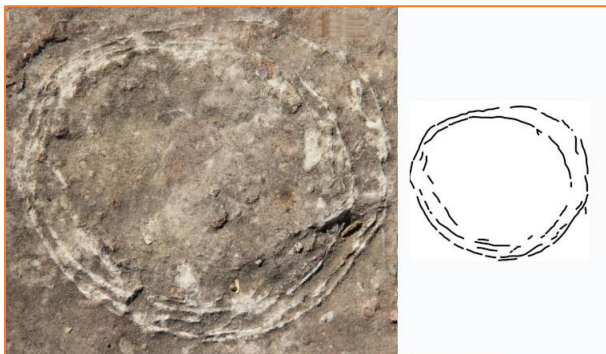
While the results seem to suggest that these eggs were part of a nesting colony, other explanations can't be completely ruled out. More research will be needed to confirm whether the different nests were made at the same time.

A unique dinosaur egg

Among the 256 eggs found at the site, one in particular caught the researchers' attention. It appears to show a layer of eggshell inside another egg, with its shape suggesting that it had always been this way.

While multi-shelled eggs, where an egg can have more than one external layer, are not uncommon in birds, reptiles and dinosaurs, the researchers believed this fossil was something different.

They think it is an ovum-in-ovo egg, where one egg is found inside another. If confirmed, it would be the first example of an ovum-in-ovo egg not only in dinosaurs, but reptiles as a whole.



A photo of the ovum-in-ovo dinosaur egg with a diagram to its right. The ovum-in-ovo egg is the first of its kind to be found in dinosaurs, and reptiles more widely. (Image adapted from © James St. John, licensed under CC-BY 4.0 via Scientific Reports)

Currently these eggs are only known of in birds, where they form under stressful conditions such as disease, lack of food or abnormal temperatures. This causes a developing egg to be pushed back into the mother's body after its shell has started forming.

When this egg meets a less developed egg, it can be covered in another layer of yolk and albumen before being shelled again. This is

possible because different sections of a bird's oviduct carry out different roles, causing the egg to repeat certain stages of its formation.

As birds are descended from dinosaurs, it suggests that titanosaurs and their ancestors may have had a similar reproductive system. Discovering exactly when this ability evolved would help to support or refute this theory and tell us more about how dinosaurs might have behaved.

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https://www.nhm.ac.uk/discover/news/2023/january/fossilised-nests-worlds-largest-dinosaur-discovered-india.html?utm_content=pod6-cta&utm_campaign=news&utm_medium=email&utm_source=2283152_ma-enews-whatson-20230126&dm_i=2XEG,1CXOW,6L3SCQ,5BMLU,1

Dozens of bids to drill new oil and gas fields

BBC Scotland
17 January 2023

More than 100 applications have been submitted to drill for new oil and gas in the North Sea.

The UK government opened a fresh round of licensing after a three-year hiatus while it hosted the UN climate change conference in Glasgow. But UK ministers said more licences would be made available because of the energy security crisis.

A total of 115 bids have been received and the successful applicants will be announced later this year.

Licensing new oil and gas developments is reserved to Westminster. But the Scottish government last week announced a presumption against new oil and gas exploration as part of its new energy strategy.

Scottish ministers say they can no longer support the previous position of "maximising economic recovery" of fossil fuel reserves.

The North Sea Transition Authority (NSTA), which regulates the sector, said a total of 115 bids have been received from 76 companies, covering 258 "blocks" of the sea.

The NSTA said the bids will now be studied and those that go ahead could begin production in as little as 18 months.

Several different consents are needed after licences are granted but before production can begin - including ensuring it is in line with climate commitments.

Dr. Nick Richardson, the NSTA's head of exploration, said: "We have seen a strong response from industry to the [licensing] round, which has exceeded application levels compared to previous rounds. We will now be working hard to analyse the applications with a view to awarding the first licences from the second quarter of 2023."



Environmentalists argue new fossil fuel projects such as oil fields are incompatible with climate change action. (Image Source: Getty Images)

'Security of supply'

The decision to increase oil and gas exploration is at odds with international climate scientists who say fossil fuel projects should be closed down, not expanded, if there is to be a chance of keeping global temperature rises under 1.5C.

Both the Intergovernmental Panel on Climate Change, the global body for climate science, and the International Energy Agency have expressed such a view.

But UK Climate Minister Graham Stuart said: "Putin's illegal invasion of Ukraine has led to volatile global energy markets.

"It's fantastic to see such interest from industry in this round, with the awarded licences set to play an important role in boosting domestic energy production and securing the UK's long-term energy security of supply."

Reference:

<https://www.bbc.com/news/uk-scotland-64297563>

Meteorite that crashed onto UK driveway contains the building blocks of life

The Winchcombe meteorite contains amino acids that potentially led to life on Earth.

**By Elizabeth Rayne
17 January 2023**

The Winchcombe meteorite, which crashed onto a driveway in England in 2021 and is pristine enough to rival asteroid samples taken directly from space, contains amino acids that potentially led to the spawning of life on Earth.

When scientists analysed fragments of the meteorite, they found that the asteroid it broke off from once had liquid water and that the meteorite itself contains organic compounds, including amino acids, some of which are the precursors to the proteins that make up DNA and are vital for life on Earth.

"Studying the organic inventory of the Winchcombe meteorite provided us with a window into the past, how simple chemistry kickstarted the origin of life at the birth of our solar system," Queenie Chan, a lecturer in Earth sciences at Royal Holloway, University of London who led the research, said in a statement.

Chan and her colleagues think the Winchcombe meteorite might belong to an entirely new category of meteorite. Although the space rock is a carbonaceous chondrite — already considered rare — its extra-terrestrial organic matter sets it apart. Because the Winchcombe fragments were collected so soon after they fell to Earth, there was almost

no chance for terrestrial contamination. Therefore, the organic matter found inside the meteorite is believed to be as it was when the asteroid it came from was hurtling through space.

And there's another characteristic that makes the Winchcombe meteorite a time capsule: evidence of liquid water from the distant past. Among the organic matter the scientists discovered was organic matter that can be dissolved — and probably had been dissolved — in water.

Parts of the meteorite were found to be more chemically altered by water than others. Scientists think water from the space rock's parent asteroid set off chemical reactions that created the meteorite's amino acids, some of which are rare on Earth. Those same types of amino acids eventually formed proteins, from which primitive life-forms would emerge billions of years ago.

What makes the Winchcombe meteorite even more mind-blowing is that its structure should have made it too weak to make it to the surface, the team said.

The Winchcombe meteorite "represents an unusual sample that would not typically survive atmospheric entry," Chan and colleagues wrote in their study.

What, exactly, was needed to kick-start life on Earth remains a mystery. However, organics — especially amino acids — found in meteorites like Winchcombe are taking scientists closer to the origin of living things.

The research is described in a paper published Jan. 9 in the journal ***Meteoritics & Planetary Science***.

Reference:

https://www.space.com/pristine-meteorite-winchcombe-amino-acids?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&utm_campaign=58E4DE65-C57F-4CD3-9A5A-609994E2C5A9&utm_medium=email&utm_content=3297CBAE-F895-408C-9B37-2373B6C8F713&utm_source=SmartBrief

Queensland graziers unearth 100m-year-old plesiosaur remains likened to Rosetta Stone

Amateur fossil hunters find skull connected to body of marine giant Elasmosaurus for the first time in Australia

**Joe Hinchliffe, *The Guardian*
6 December 2022**

A group of female graziers from outback Queensland who hunt fossils in their downtime have uncovered the remains of a 100 Ma old creature that palaeontologists are likening to the **Rosetta Stone** for its potential to unlock the discovery of several new species of prehistoric marine giant.

One of the “Rock Chicks” – as the amateur palaeontologists call themselves – uncovered the fossilised remains of the long-necked plesiosaur, known as an *elasmosaur*, while searching her western Queensland cattle station in August.

This was the first time that an *elasmosaur* skull has been found connected to its body in Australia.

The information that the fossil provides could allow palaeontologists to decipher other fossils held in museums, just as the Rosetta Stone, with its three scripts, allowed philologists to crack ancient Egyptian hieroglyphics.

The trio had already found another plesiosaur among other significant fossil finds in the weeks leading up to the moment when Cassandra Prince saw a head looking up at her from the dry earth.

“I’m like, no, you know, this is not real,” Prince said. “And then I look down again and I’m like, holy hell, I think that’s a skull looking up at me.”

Such a fossil, which has been kept under wraps until now, is globally rare, according to Dr. Espen Knutsen, the senior curator of palaeontology at the Queensland Museum.

Prince was in regular contact with Knutsen at the time of her discovery, sending him pictures of her and sister Cynthia and cousin Sally’s other finds. Instantly, though, the palaeontologist knew this one was special.

The museum already holds the skull of an *elamosaur* its collection, along with several bodies. But a skull connected to a body has proved elusive.

This is largely to do with the distinctive anatomy of *elamosaur*. The marine reptiles probably grew to around eight metres in length and had tiny heads atop very, very long necks.

“A lot of it is neck,” Knutsen said. “At least half, if not two-thirds of the entire body length [of an *elamosaur*] is mostly neck.”



Discovered in outback central Queensland, the skull, neck and front half of the body of the *elamosaur* were found preserved together. (Photograph: The Guardian)



At between five- and seven-metres long the juvenile *elamosaur* was not yet fully grown before it died. (Photograph: The Guardian)

When an *elamosaur* died, its decomposing body would swell with gas that made it rise to the surface, where it would float at the mercy of tides and scavengers. A metres-long gap between body and head meant these body parts would rarely sink to the same spot once the gas dissipated.

This particular *elamosaur* had its skull, neck and front half of the body all preserved together – but the back half of its body is missing.

Knutsen suggested the *elamosaur* may have been “bitten in half” by the apex predator of its day: a 10-metre, 11-tonne *kronosaur*. Such a

puncture, he said, would have caused the rest of the *elamosaur* corpse to sink instantly to the bottom of what was then an inland sea 50m deep.

It is an initial theory Knutsen’s team of palaeontologists will tease out over coming years as they hope to unravel the story of this five- to seven-metre juvenile they’ve called the **Little Prince**, in honour of the person who found it.

But that work is likely to also shed light on many other prehistoric beasts that swam central Queensland during the Cretaceous period, when the now arid grasslands formed part of the supercontinent Gondwanaland and were submerged beneath a vast inland sea upon whose shores dinosaurs roamed.

While only one species can currently be deciphered from the remains already found in Australia, Knutsen is confident that many different kinds of *elamosaurs* shared that prehistoric sea.

A skull is a key to unlocking the difference between those species. Not only was the single skull found in Queensland – prior to the discovery of Little Prince – separated from its body, it had been squashed flat by the weight of earth that covered it.

The skull and body that Prince found, however, is three-dimensionally preserved, allowing a much richer insight into the anatomy and way of life of the *elamosaur*.

Scientists have wondered whether the prehistoric reptiles used their teeth to filter feed crustaceans and bivalves from the ocean floor, and their big flippers to slowly cruise along migration routes as whales do today.

Knutsen hopes Little Prince could shed light on those questions, while enabling palaeontologists to describe several species from the disparate remains already held within the museum. “We will be able to unravel all that taxonomy that has eluded us up until now,” Knutsen said.

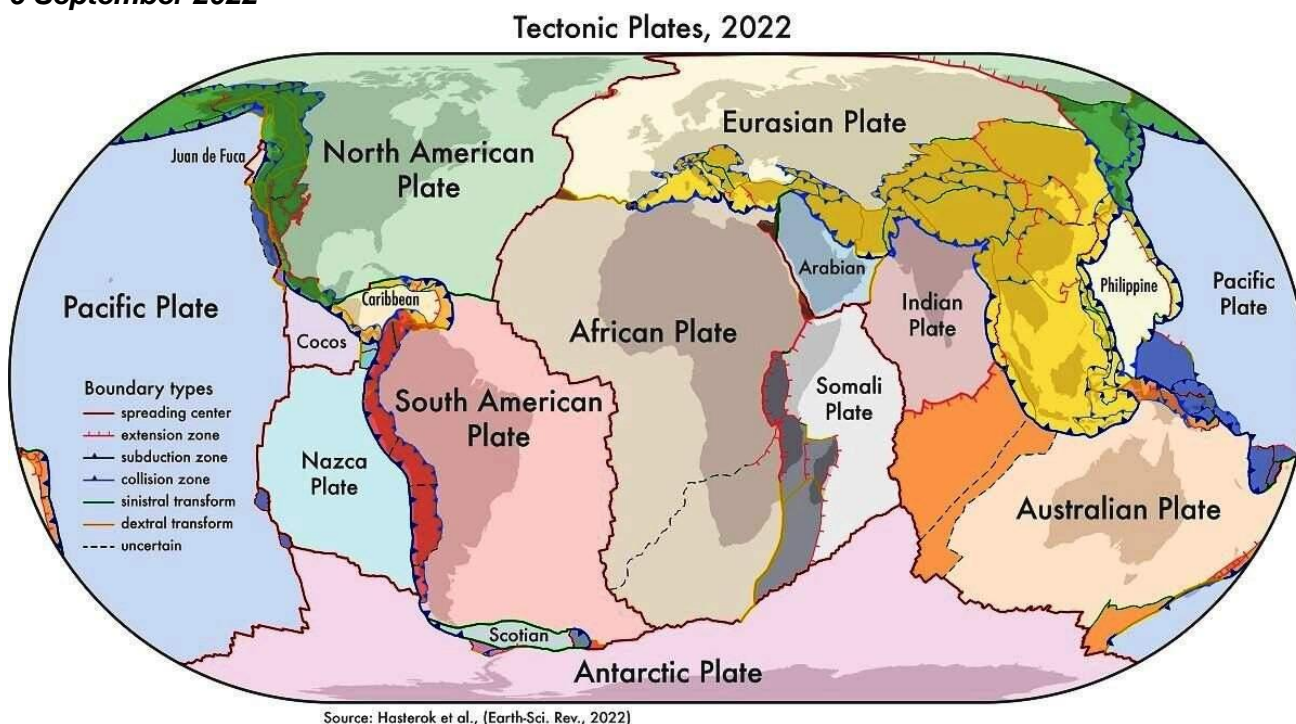
Reference:

<https://www.theguardian.com/science/2022/dec/06/queensland-graziers-unearth-100m-year-old-pleiosaur-remains-likened-to-rosetta-stone>

New Map Shows Earth's Tectonic Plates in Unprecedented Detail

Geology

6 September 2022



New Map Shows Earth's Tectonic Plates in Unprecedented Detail. (Credit: Dr. Derrick Hasterok, University of Adelaide)

New models that show how the continents were assembled are providing fresh insights into the history of the Earth and will help provide a better understanding of natural hazards like earthquakes and volcanoes.

"We looked at the current knowledge of the configuration of plate boundary zones and the past construction of the continental crust," said Dr. Derrick Hasterok, Lecturer, Department of Earth Sciences, University of Adelaide who led the team that produced the new models.

"The continents were assembled a few pieces at a time, a bit like a jigsaw, but each time the puzzle was finished it was cut up and reorganised to produce a new picture. Our study helps illuminate the various components so geologists can piece together the previous images.

"We found that plate boundary zones account for nearly 16 per cent of the Earth's crust and an even higher proportion, 27 per cent, of continents."

The team produced three new geological models: a plate model, a province model and an orogeny model.

"There are 26 orogenies - the process of mountain formation - that have left an imprint on the present-day architecture of the crust. Many of these, but not all, are related to the formation of supercontinents," said Dr. Hasterok.

"Our work allows us to update maps of tectonic plates and the formation of continents that are found in classroom textbooks. These plate models which have been assembled from topographic models and global seismicity, have not been updated since 2003."

The new plate model includes several new microplates including the Macquarie microplate which sits south of Tasmania and the Capricorn microplate that separates the Indian and Australian plates.

"To further enrich the model, we added more accurate information about the boundaries of deformation zones: previous models showed these as discrete areas rather than wide zones," said Dr. Hasterok.

"The biggest changes to the plate model have been in western North America, which often has the boundary with the Pacific Plate drawn as the San Andreas and Queen Charlotte Faults. But the newly delineated boundary is much wider, approximately 1500km, than the previously drawn narrow zone.

"The other large change is in central Asia. The new model now includes all the deformation zones north of India as the plate bulldozes its way into Eurasia."

Published in the journal **Earth-Science Reviews**, the team's work provides a more accurate representation of the Earth's architecture and has other important applications.

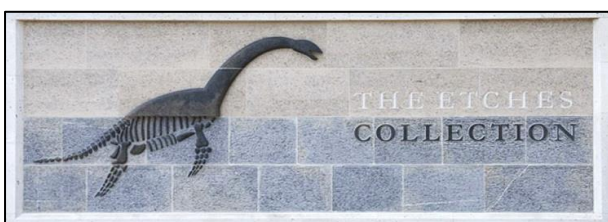
"Our new model for tectonic plates better explains the spatial distribution of 90 per cent of earthquakes and 80 per cent of volcanoes from the past two million years whereas existing models only capture 65 per cent of earthquakes," said Dr. Hasterok.

"The plate model can be used to improve models of risks from geohazards; the orogeny model helps understand the geodynamic systems and better model Earth's evolution and the province model can be used to improve prospecting for minerals."

The above story is based on Materials provided by University of Adelaide. Original written by Crispin Savage.

Reference:

1. <https://www.geologyin.com/2022/06/new-map-shows-earths-tectonic-plates-in.html>
2. FGS Newsletter, August 2022



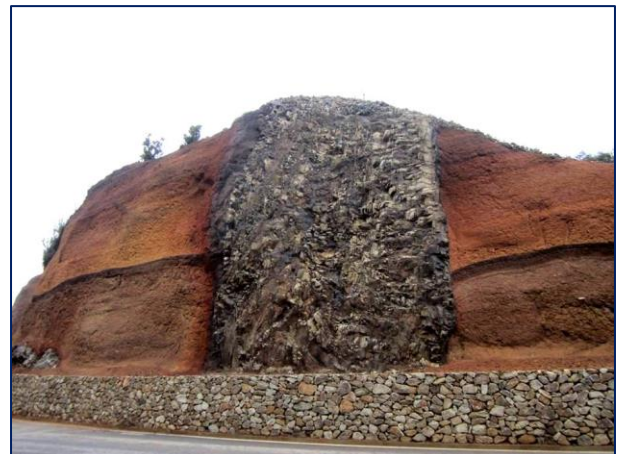
Interesting Topics & Places 2

Gorgeous Dyke Intrusion in Spain

Amazing image of a dyke exposed in a road cutting on La Gomera, Spain's Canary Islands, high up on the "cumbre" above Vallehermoso.

The dyke has been intruded into red layered volcanic ashes and as it has melted its way towards the surface (which must have been much higher than the eroded surface we see today) it has simply gobbled up the ash layers, leaving an incredibly clean contact on either side.

The dyke is made of basalt, and it is about 10m wide. The stone wall marks the edge of the roadway.



Gorgeous Dyke Intrusion in Spain. (Copyright: Miltos Andreadis)

Reference:

<https://www.geologyin.com/2015/11/goergous-dyke-intrusion-in-spain.html?fbclid=IwAR0eiiidJj6usl8rvAuBwn9GPz2dqW1OiNQsB4GGOznKryz3VWEfUeliHVtY>

Jan Meyen

Date: 27 February 2023

Location: Jan Meyen

Credit: European Union, Sentinel-2 imagery

Jan Mayen is a volcanic island located halfway between Iceland and the Svalbard archipelago in the northern Atlantic Ocean.

It is home to the northernmost volcano in the world and the only active volcano in the Norwegian territories.



Image of The Day

Folds in Iraq

Folding in the rocks of the Early Cretaceous in the Kurdistan region of Iraq.



(Credit: @Kamal Haje Karim)

Reference:

<https://www.facebook.com/photo/?fbid=208292065205578&set=a.201267989241319>

West Bay rockfall

The **video** captures the rockfall that happened last Wednesday morning (18 January 2023) at West Bay, Dorset. These natural processes keep this world-famous coastline beautiful and valuable, but they also pose a danger.

Rockfalls like this happen without warning and they are more likely to occur after periods of heavy rain. Stay clear of the cliff edge, keep a good distance from the base of the cliffs and do not linger below them.



(Footage courtesy of the Environment Agency)

Reference:

<https://www.facebook.com/watch/?ref=saved&v=915365666160360>

TV Preview

Secrets of the Jurassic Dinosaurs

Biologist and natural history presenter Liz Bonnin takes us on a journey to prehistoric Wyoming in the western USA in this two-part series for BBC Two.

*By Megan Shersby, BBC Wildlife
16 February 2023*

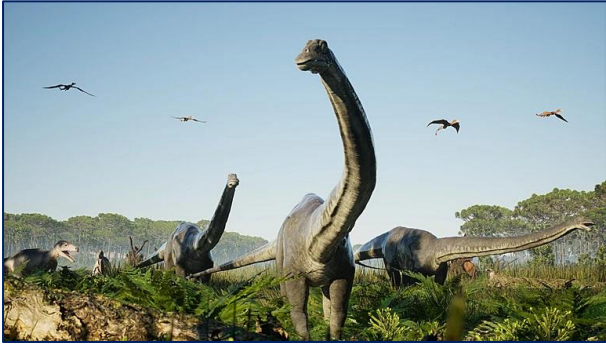
The first episode of **Secrets of the Jurassic Dinosaurs** will air on **Sunday 19th February 2023 on BBC Two**, followed the second episode on **Sunday 26th February 2023**. They will also be available to watch on **BBC iPlayer**.

What is Secrets of the Jurassic Dinosaurs about?

“In these weather-beaten badlands, an ancient secret is hidden,” Liz Bonnin says in the introduction. The secret location is nicknamed the Jurassic Mile for the “extraordinary number of dinosaur fossils ... from 150 million years, making this a unique prehistoric treasure trove.”

An international team of palaeontologists, including scientists from Naturalis Biodiversity Centre in the Netherlands, The Children’s Museum of Indianapolis and the **Natural History Museum**, London, have spent the last

few years uncovering these fossils – and Bonnin gets stuck in to help. The tally so far for this site totals over 3,000 fossils of dinosaurs, non-dinosaur marine reptiles called ichthyosaurs and a variety of plants, such as horsetails – a type of plant that still grows nearby.



The Jurassic of 150 Ma ago was dominated by giant, long-necked sauropods which lived under threat of attack from carnivores like Allosaurus, the apex predator of the time. (© A.A Studios Graphics/BBC Studios)



Fossil preparator Laura Rooney using a compressed-air powered scribe to remove hard rock from a 150 Ma old Allosaurus dinosaur skeleton at the top-secret Jurassic Mile excavation site in Wyoming, USA. (© Paul King/BBC)

These fossils give an insight into what these dinosaurs ate, how they moved and behaved, the environment in which they lived, and what killed them and caused the fifth mass extinction.

Even if you are not the biggest fan of dinosaurs, the enthusiasm of Bonnin and the scientists she speaks to is infectious – shouts go up when a digger reveals the edge of a fossilised limb bone, likely from a sauropod dinosaur, and Bonnin gasps in delight as a brush wipes away some of the dirt, exclaiming “It’s absolutely beautiful!”

Secrets of Jurassic the Dinosaurs is presented by **Liz Bonnin**, who will be familiar face to natural history documentary lovers. She has presented a range of programmes for the BBC including *Animals in Love*, *Big Blue Live*, *Galapagos* and *Wild Alaska Live*.



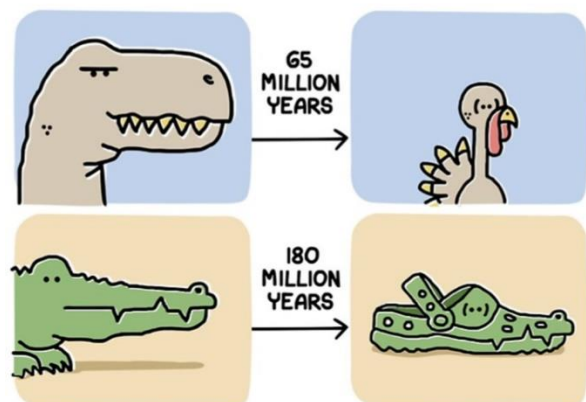
Liz Bonnin with a pair of 150 Ma old leg bones from a gigantic Jurassic dinosaur which are safely wrapped in protective plaster ready for transportation from their secret excavation site in Wyoming, USA. (© Paul King/BBC)

Reference:

https://www.discoverwildlife.com/tv/secrets-of-the-jurassic-dinosaurs/?fbclid=IwAR37VBnSRnhSQyMR5oGePhHRYXigGrft3_jfqOFPsuPDKEhKfe0PEGdpGtl

Cartoon Corner 2

disappointing moments in evolution



© John Atkinson, Wrong Hands • wronghands1.com

Suggested by Janet Catchpole

TV Review

Dinosaur with Stephen Fry review – as enchanting as Jurassic Park

This four-part series uses CGI beasts to make it look like its host has been sent back in time, and it's excellent – full of fascinating insights and gripping experiments

Stuart Jeffries
12 February 2023

The average elephant has to eat 150kg of food a day. I'm no scientist but that's probably one reason elephants have never learned to speak, crochet or read the Booker longlist – they're too busy masticating leaves 24/7. Probably.

The same is true – only more so – with your average diplodocus, which, when it lived around 150 Ma ago, was, as Stephen Fry tells us, taller than a double decker bus and about 14m long from nose to tail tip, which, as you know, is 13m longer than your average metre.

Scaling up from an elephant, suggests Fry, who is also no scientist, we can confidently estimate that the diplodocus ate three-quarters of a tonne of food a day – much of it conifer leaves – to stay alive. "That seems impossible given how small its head was," observes Fry.



Plenty more where that came from ... Stephen Fry tries feeding hay to a diplodocus. (Photograph: Mentorn TV/Tinopolis tv)

Good point: its neck was longer than Stephen Fry's CV, which I'd have thought would have made its teeth to tummy journey prohibitively costly in energy terms. But again: I'm no scientist.

This first episode of a four-part new series really is excellent, with helpful graphics, CGI

dinosaurs, gripping experiments and expert insight. I didn't know, for instance, that an allosaurus, one of the diplodocus's leading foes in the early Jurassic, could open its jaw 79 degrees. Not that it was yawning because there was nothing on TV back then, but rather trying to use its upper jaw to wound diplodocuses, each one of which, as Fry puts it, is "basically 15 tonnes of prime Jurassic steak". We see engineers from University College London build a replica of that jaw and use it to snap through a melon representing a diplodocus flank. I'm sure they should be designing railways or building bridges, but making a metal jaw to destroy fruit in the manner of an extinct dinosaur seems much more fun.

Dinosaur's central conceit is that Fry has travelled back in time – somehow – to the western coast of Pangaea, the land mass that covered a third of the planet 150 Ma ago, and there walks with plant-eating diplodocuses, meat-eating allosauruses and the real-life equivalents of Laura Dern in Jurassic Park. More likely, he and the palaeontologists are in front of a green screen in Elstree, but let's not spoil the illusion. Just before Christmas, Fry was on ITV fronting a nature show called A Year on Planet Earth, now he's presenting a show as enchanting as – but more data-rich than – Spielberg's dinosaur classic. He has impersonated David Attenborough, now he's having a go at brother Richard.

So, how in fact does a diplodocus ingest so many tonnes of greenery? Good question. Like a toddler, it doesn't chew, but swallows its meals whole and a formidable array of enzymes break the meal down while it's already swallowing more leafy input.

But this requirement of endlessly eating makes it a tricky business when, as happens, you give birth to lots of eggs that hatch baby diplodocuses. What do you do then? Like turtles, Fry tells us, mother diplodocuses abandon the eggs to hatch. Childcare and feeding offspring would be too time consuming for diplodocuses, so they let the little poppets fend for themselves.

But we're getting ahead of ourselves. How do diplodocuses mate? They probably reared up on to their hind legs and balanced with their tails before embarking on coitus that, you'd think, sent tremors that could have been

measured on the Richter scale. Plus, argues maverick tech billionaire Nathan Myhrvold – who constructed a robo-tail to prove the point – diplodocuses could create whip-cracking sonic booms. These whip cracks, Myhrvold explains, were also part of the diplodocus's seduction technique. Of course, this is all very controversial: who among us really knows what aroused a diplodocus 150 Ma ago? Apart from Stephen Fry of course, who, as we explained earlier, was sent back in time to the Jurassic by Channel 5 – somehow – to find out.

Fry's documentary takes on a topical relevance, given that later this month **Dippy**, the Natural History Museum's life-size plaster of Paris diplodocus skeleton replica, is to be transported, possibly up the M1 and thus passing the diplodocus's soulmates, the elephants of Whipsnade zoo, to the Herbert Art Gallery and Museum in Coventry. It is confidently expected that Dippy will escape the Herbert to lead the Coventry City frontline as a target man, like Erling Haaland with a much longer neck, ideal for headers though tricky when it comes to beating the offside trap. Stephen Fry has already been signed up to present one of those All or Nothing Amazon series about how Dippy helps the championship side get promotion to the premiership. Probably.

Reference:

<https://www.theguardian.com/tv-and-radio/2023/feb/12/dinosaur-with-stephen-fry-review-as-enchanting-as-jurassic-park>

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2. Fragments of 'Valentine's fireball' meteorite fall in southern Italy

<https://www.theguardian.com/science/2023/feb/19/fragments-of-valentines-fireball-meteorite-fall-in-southern-italy>

3. SwRI Models Explain Canyons on Pluto's Moon Charon

<https://spaceref.com/press-release/swri-models-explain-canyons-on-plutos-moon-charon/>

4. The Geology Behind the Deadly Earthquakes in Turkey and Syria

<https://www.geologyin.com/2023/02/the-geology-behind-deadly-earthquakes.html>

5. Hunga Tonga undersea volcano eruption likely to make ozone hole larger in coming years

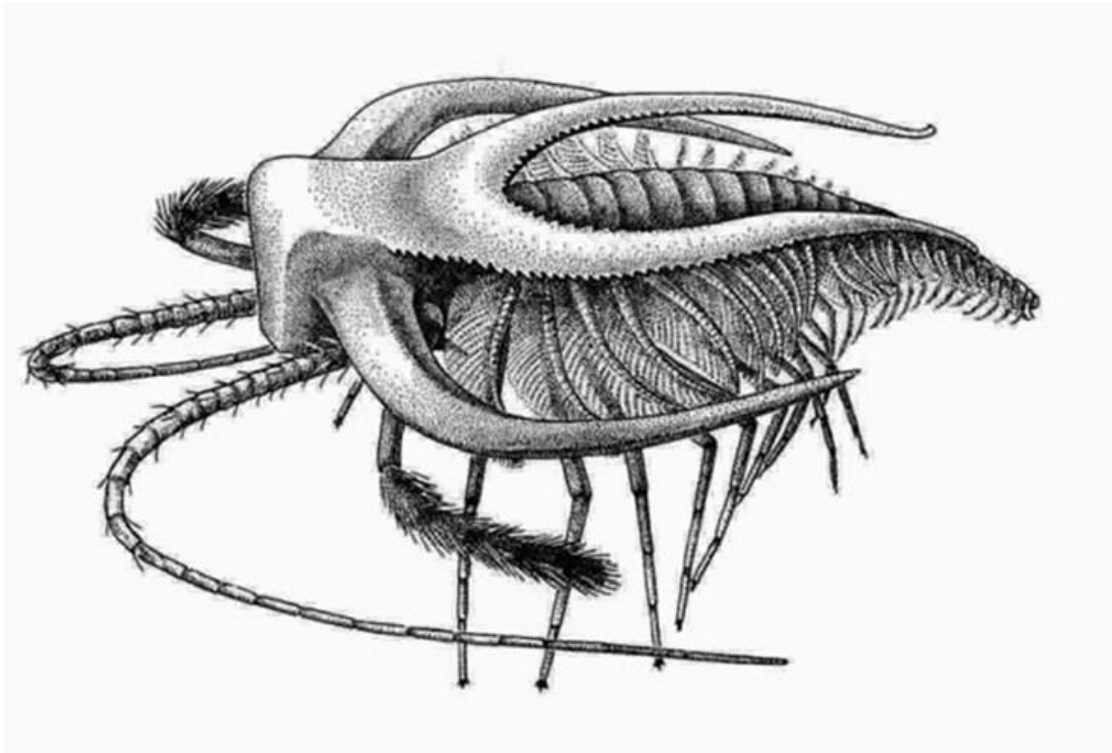
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6. The mystery of North America's missing eastern dinosaurs

[https://www.bbc.com/future/article/20230202-the-weird-dinosaurs-of-americas-lost-continent?xtor=ES-213-\[BBC%20Features%20Newsletter\]-2023February10-\[bbcfeatures_northamericaslostdinosaurcontinent_history\]](https://www.bbc.com/future/article/20230202-the-weird-dinosaurs-of-americas-lost-continent?xtor=ES-213-[BBC%20Features%20Newsletter]-2023February10-[bbcfeatures_northamericaslostdinosaurcontinent_history])

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Credit: <https://woostergeologists.scotblogs.wooster.edu/2012/01/15/wooster%E2%80%99s-fossil-of-the-week-marrella-splendens-burgess-shale-middle-cambrian-british-columbia/> Reconstruction from Stephen Jay Gould's famous Burgess Shale book titled "Wonderful Life".

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