Newsletter of

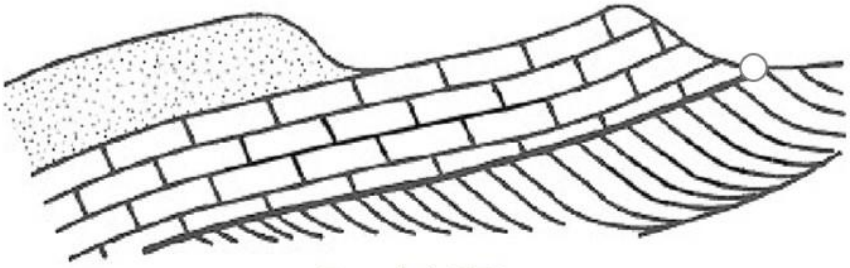
The Farnham Geological Society

Volume 24, Number 2, May 2021

Cover illustration by Audrey Price, December 1983

Farnham Geological Society

Farnhamia farnhamensis



Founded 1970

A local group within the GA

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Contents

Editorial

Welcome to the latest FGS Newsletter. I do hope you are all fit and well and that many of you have had at least your first dose of the vaccine.

What a year it has been. I have had my last 2 birthdays in lockdown, which is not something I expected when the first national lockdown was announced back in March last year!

At the beginning of 2020 the FGS Committee took the obvious but regrettable decision to suspend all face-to-face meetings at The Maltings in Farnham and instead conduct meetings via the online video chatting service, 'Zoom'. The first of these took place on 10 July 2020 when the Society celebrated 50 years since its

inception. Our first external presentation followed on 18 September when Dr. Marina Bercenilla presented a fascinating insight into extremophiles and the search for life beyond the Earth.

We have since enjoyed some excellent and diverse lectures from calcareous nannofossils to the moons of the Solar System and a tremendous amount of credit must go to **Janet Catchpole**, our Programme Secretary, for organising such a varied and extremely interesting programme both for 2020 and 2021. Thanks should also go to our speakers who have embraced the "new" way of delivering their talks.

It seems likely that we will continue with our meetings on Zoom at least until the summer, but the hope is that we may be able to return to The Maltings after the 21 June 2021. Once this has been confirmed we will hope to conduct our meetings both in person, as well as on Zoom, so as to accommodate our members, and other society members, who are unable to travel to Farnham.

Are you planning to holiday in the UK this year? It seems many of us will be unable or unwilling to travel outside of the UK this year. If so you may want to read our Field Trip Secretary, John Williams article on pages 21 to 25 in which he provides us with some ideas for visiting geologically interesting locations, as well as historical buildings dotted across the UK. The article is an excellent starter for planning your "staycation".

On the question of Field Trips, it seems unlikely that we will be able to organise any trips until later this year and they will clearly be dependent on the protocols prevalent at the time.

You will note a change to the front of this Newsletter … I have included a cover illustration by Audrey Price that was used to adorn the cover of our Newsletter in December 1983. During the 1980's a number of our Newsletters had cover illustrations and I thought it would make an interesting cover to this month's edition. I am very keen to continue this idea and would ask if any of our members would be interested in providing a cover illustration that carries a geological or a society theme; I would be very happy to use it in a forthcoming Newsletter. Feel free to send me a copy; my email address is caulfm@hotmail.com.

I would also be very interested in any articles or items of interest that you would like to see included in the Newsletter.

Stay safe.
Mick Caulfield,
Newsletter Editor.

Chair's Report

Update on FGS Introduction to Geology Course … I am delighted to say that we have over 30 students and all attended one or other session of the first talk in March. There were 2 parts to the talk, which was given by Mike Millar, FG Committee Member, entitled "The Big Bang and the Formation of Everything" and "The Formation of the Solar System". On April 13 & 20, Mike also gave a talk on "The Early Earth".

This month on May 11 & 18 the talks will be presented by myself and entitled "The Earth's Vital Statistics".

There is still time to join if you are interested, just contact Sally Pritchard, Membership Secretary, at memsec@farnhamgeosoc.org.uk or me at newsletters.fgs@gmail.com. Further details on page 47.

As far as the Society is concerned, we have had 4 successful meetings this year over the internet using 'Zoom' and have set up a reciprocal arrangement with Reading Geological Society for paid-up members to enjoy the lectures of both societies - RGS and FGS. This has been a success and we have had a number of RGS members at our meetings.

During these Covid / lockdown times, it is sensible, in my opinion, to provide as much interest and distraction to as many people as possible.

I look forward to seeing many of you at this month's lecture on Cambrian arthropods by Dr. Greg Edgecombe.

Liz Aston,
Chair.

Farnham Geological Society

Committee 2021

Chair	**Liz Aston**
Treasurer	**Peter Luckham**
Secretary	**Judith Wilson**
Programme Secretary	**Janet Catchpole**
Membership Secretary	**Sally Pritchard**
Field Trip Secretary	**John Williams**
Newsletter Editor	**Mick Caulfield**
Web Manager	**Michael Hollington**
Advertising	**Peter Crow**
IT / Sound	**Mike Millar**
Without portfolio	**Alan Whitehead**

Meeting Programme 2021

All meetings will be conducted remotely via Zoom until further notice.

Please note the Zoom lecture time: 6.50 pm for 7.00 pm start.

Exceptionally preserved Cambrian arthropods and their role in understanding arthropod evolution
Dr. Greg Edgecombe Fri, 14 May
Merit Researcher, NHM

Ammonite Extinction and K-Pg Boundary in the Gulf Coastal Plain, USA
Dr. James Witts Fri, 11 June
Postdoctoral Fellow, University of New Mexico

Is It a Meteorite, Precious Gem or Dinosaur Claw? Behind the scenes at the Natural History Museum's Identification and Advisory Service
Dr. Christina Fisher & Ben Dixon Fri, 9 July
Identification & Advisory Officers, NHM

No meeting Fri, 13 August

Tales from the Offshore: Random stories of working in the oil industry
Liz Aston, Mike Millar & Mick Caulfield
FGS Fri, 10 September

Colours in the NHM
Robin Hansen Fri, 8 October
Curator, Minerals, NHM

Exploring Life at Deep-sea Hydrothermal Vents: Patterns in Space and Time
Dr. Jon Copley Fri, 12 November
Associate Professor in Ocean Exploration & Public Engagement, NOC, Southampton

Lost Worlds of the Solar System
Professor Hilary Downes Fri, 10 December
Birkbeck College, University of London

Field Trip Programme 2021

Update 6 May 2021

Our Field Trip Secretary, John Williams, is reviewing the potential for Field Trips to recommence in late Summer 2021.

It is likely that these will initially be day trips conducted under any COVID-19 restrictions prevalent at the time.

Geologists' Association Lecture Programme 2021

Updated 6 May 2021

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

All meetings will be conducted remotely via Zoom until further notice.

Zoom lecture time: 6.00 pm start.

AGM and Presidential Address. Shallow geohazards and environmental change
Dr. Vanessa Banks Fri, 7 May
BGS

The pterodactyls of the Sahara Desert

Professor David Martill Fri, 4 June
University of Portsmouth

Geothermal Resources of the UK
Dr. Catherine Hirst Fri, 2 July
COWI, University of Glasgow

"Pills and Politics"; a new look at George Bellas Greenough and his Geological Map of 1820
Professor Hugh Torrens Fri, 1 October
Keele University

Virtual Festival of Geology
Sat, 6 November

From bones to pixels – using computer technology to understand the behaviour of fossil animals
Dr. Stephan Lautenschlager Fri, 3 December
University of Birmingham

Reading Geological Society
Lecture Programme 2021

Updated 6 May 2021

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

Time: 7:45pm for 8:00pm (subject to change)
Venue: Zoom talks

Sarsen Stones: a geological conundrum reassessed
Professor Peter Worsley Mon, 10 May
University of Reading

Geological History of Africa
Dr. Duncan MacGregor Mon, 7 June
MacGeology

Understanding Large Igneous Provinces and Volcanic Rifted Margins
Dr. Dougal A Jerram Mon, 5 July
DougalEARTH Ltd.

Evening Geological Ramble
Mon, 2 August

Evolution of flowering plants, especially in relation to Darwin's "abominable mystery"
Professor Richard Buggs Mon, 6 September
Queen Mary College,
University of London

Cambrian explosion
Dr. Luke Parry Mon, 4 October
St. Edmund Hall, University of Oxford

Mole Valley Geological Society
Lecture Programme 2021

Updated 6 May 2021

https://www.mvgs.org.uk/current-programme

Time: 7:45pm for 8:00pm (subject to change)
Venue: Zoom talks

Fossilised Quicksand's: Key to Fossilised Earthquakes?
Professor Joe Cartwright Thu, 13 May
University of Oxford

West Sussex Geological Society

http://www.wsgs.org.uk/index.html

The WSGS was founded in 1977 and currently has around 80 members. It is organised for and by enthusiastic amateurs. Meetings are normally held in Worthing on the third Friday of each month, except for July and August.

Harrow & Hillingdon Geological Society
Lecture Programme 2021

Updated 6 May 2021

http://www.hhgs.org.uk/index.html

AGM Wed, 12 May

Platinum Group Metals - their Geological Occurrence, Extraction and Applications
Bruce Rimmer Wed, 9 June
Amateur Geological Society

Salt from the frozen wastes: An introduction to the global potash industry
Humphrey Knight Wed, 14 July
CRU Group

Quiz Question

Q: What do ***Alexander the Great*** and ***Winnie the Pooh*** have in common?

A: They both have the same **middle** name, "**the**".

It Happened in May

1 May 1707 GB formed

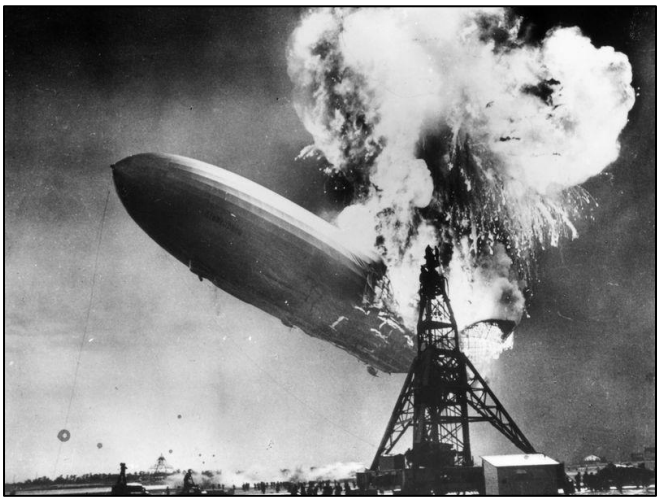
Great Britain was formed from a union between England and Scotland. The union included Wales which had already been part of England since the 1500's. The United Kingdom today consists of Great Britain and Northern Ireland.

5 May 1961 First American in space

Alan Shepard became the first American in space. He piloted the spacecraft *Freedom 7* during a 15-minute 28-second suborbital flight that reached an altitude of 186 km above the earth. Shepard's success occurred 23 days after the Russians had launched the first-ever human in space, cosmonaut Yuri Gagarin, during an era of intense technological competition between the Russians and Americans called the *Space Race*.

6 May 1937 The Hindenburg disaster

The German airship Hindenburg burst into flames at 19:20 as it neared the mooring mast at Lakehurst, New Jersey, following a trans-Atlantic voyage. Thirty six of the 97 passengers and crew were killed. The inferno was caught on film and also witnessed by a commentator who broke down amid the emotional impact and exclaimed, "Oh, the humanity!" The accident effectively ended commercial airship traffic.



The Hindenburg disaster marked the end of the era of passenger-carrying airships.
(Photo by Sam Shere/Getty Images)

6 May 1954 Bannister runs mile under 4 mins

Roger Bannister was the first man to run a mile in under 4 minutes, at the Iffley Road Sports Ground, Oxford, England.

12 May 1937 George VI crowned

George VI was crowned at Westminster Abbey in London, following the abdication of his brother, Edward VIII. King George reigned until his death in 1952. He was succeeded by his daughter Elizabeth, the current reigning monarch.

18 May 1980 Mount St. Helens eruption

Mount St. Helens is an active stratovolcano located in Washington state, in the Pacific Northwest region of the United States. It is 80 km northeast of Portland, Oregon, and 154 km south of Seattle.

Mount St. Helens takes its English name from the British diplomat Lord St. Helens, a friend of explorer George Vancouver who made a survey of the area in the late 18th century. The volcano is located in the Cascade Range and is part of the Cascade Volcanic Arc, a segment of the "Pacific Ring of Fire" that includes over 160 active volcanoes. It is well known for its ash explosions and pyroclastic flows.

Mount St. Helens, the day before the 1980 eruption. (Image USGS)

Plumes of steam, gas, and ash often occurred at Mount St. Helens in the early 1980s.
(Lyn Topinka, CVO Photo Archive)

Mount St. Helens is most notorious for its major eruption on May 18, 1980, the deadliest and most economically destructive volcanic event in U.S. history. Fifty-seven people were killed; 250 homes, 47 bridges, 24 km of railways, and 298 km of highway were destroyed. A massive debris avalanche, triggered by an earthquake of magnitude 5.1, caused a lateral eruption that reduced the elevation of the mountain's summit from 2,950 m to 2,549 m, leaving a 1.6 km wide horseshoe-shaped crater.

18-19 May 363 Galilee earthquake

The Galilee earthquake of 363 was a pair of severe earthquakes that shook the Galilee and nearby regions on May 18 and 19. The maximum perceived intensity for the events was estimated to be VII (Very Strong) on the Medvedev–Sponheuer–Karnik scale. The earthquakes occurred on the portion of the Dead Sea Transform fault system between the Dead Sea and the Gulf of Aqaba.

20-29 May 526 Antioch earthquake

The Antioch earthquake hit Syria and Antioch in the Byzantine Empire in 526. It struck during late May, probably between 20–29 May, at mid-morning, killing approximately 250,000 people. The earthquake was followed by a fire that destroyed most of the buildings left standing by the earthquake. The maximum intensity in Antioch is estimated to be between VIII (Severe) and IX (Violent) on the Mercalli intensity scale.

21 May 1382 Dover Straits earthquake

The Dover Straits earthquake occurred at 15:00 on 21 May 1382. It had an estimated magnitude of 6.0 Ms and a maximum felt intensity of VII-VIII on the Mercalli intensity scale. Based on contemporary reports of damage, the epicentre is thought to have been in the Straits of Dover. The earthquake caused widespread damage in south-eastern England and in the Low Countries. The earthquake interrupted a synod convened in part to examine the religious writings of John Wycliffe, which became known as the Earthquake Synod.

22 May 1927 Gulang earthquake

The 1927 Gulang earthquake occurred at 06:32 on 22 May. This 7.6 magnitude event had an epicentre near Gulang, Gansu in the Republic of China. There were more than 40,900 casualties.

26 May 1940 Dunkirk evacuation began

The Dunkirk evacuation began in order to save the British Expeditionary Force trapped by advancing German armies on the northern coast of France. Boats and vessels of all shapes and sizes ferried 200,000 British and 140,000 French and Belgian soldiers across the English Channel by June 2nd.

Troops on the beach at Dunkirk awaiting evacuation. (Topical Press Agency/Getty Images)

31 May 1935 Quetta earthquake

The Quetta earthquake occurred on 31 May 1935 in Quetta, Balochistan, British India (now part of Pakistan). The earthquake had a magnitude of 7.7 Mw and between 30,000 and 60,000 people died.

31 May 1970 Ancash earthquake

The Ancash earthquake (also known as the Great Peruvian earthquake) occurred on 31 May off the coast of Peru in the Pacific Ocean at 15:23 local time. Combined with a resultant landslide, it is the most catastrophic natural disaster in the history of Peru. Due to the large amounts of snow and ice included in the landslide that caused an estimate of 66,794 to 70,000 casualties, it is also considered to be the world's deadliest avalanche.

References:

1. https://www.historyplace.com/
2. https://en.wikipedia.org/wiki

Notable Quotes

"You wait two years for a Mars mission, and then three come along at once!"

A global pandemic is hardly the best time to set off on an interplanetary trip, but last year offered an irresistible opportunity, notes *Nature's* Alexandra Witze (10 February 2021). Earth and Mars lined up in a way that made it much easier to fly a vehicle from one planet to the other — which happens only every 2.2 years.

Next Lecture

Friday, 14 May 2021

Zoom: 6.50 pm for 7.00 pm start

Exceptionally preserved Cambrian arthropods and their role in understanding arthropod evolution

Dr. Greg Edgecombe
Merit Researcher, NHM

Abstract

Cambrian fossils, with soft-part preservation, shed unique light on the origin of arthropods as well as the early history of some of the major living arthropod groups. Evidence from the fossil record can be integrated with data from molecular biology and development to elucidate how arthropods evolved key adaptations over 520 Ma.

Biography

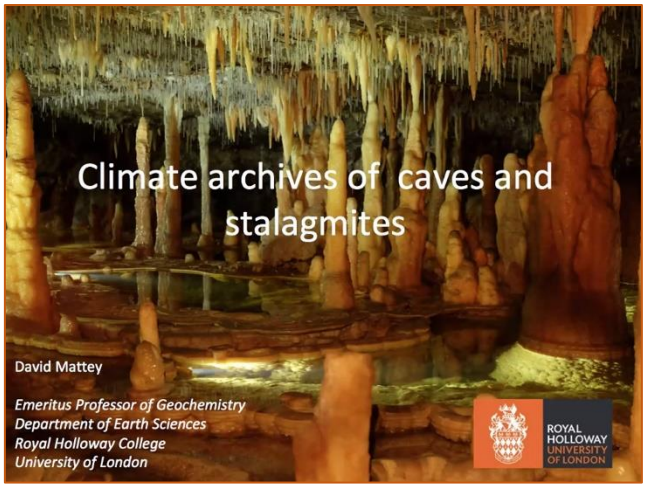
Dr Greg Edgecombe has been a Researcher at the Natural History Museum in London since 2007. His research focus is about 50% fossil arthropods (often from the Cambrian) and 50% living ones (especially centipedes). Before joining the NHM he worked as a Research Scientist at the Australian Museum in Sydney for 14 years. He received his PhD from Columbia University in New York City in 1991, working at the American Museum of Natural History on the systematics of trilobites. He was elected a Fellow of the Royal Society in 2018.

Lecture Summary

9 April 2021

On Friday, 9 April 2021 our Chair Liz Aston and 45+ attendees from the FGS, together with GA and Reading Geological Society members welcomed Professor Dave Mattey to present our external lecture via Zoom.

Climate archives of Caves and Stalagmites

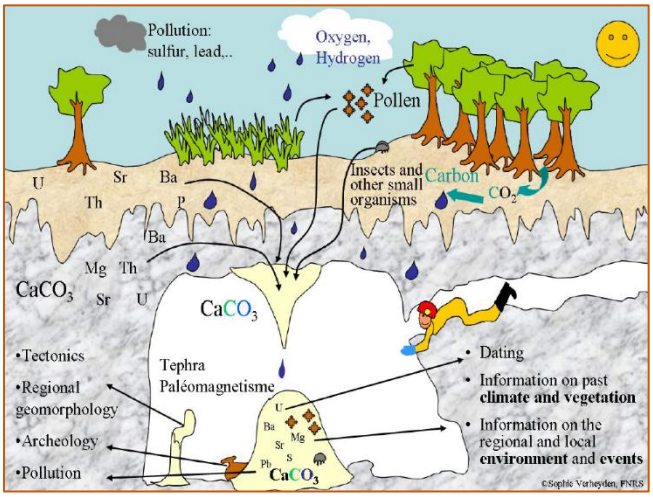


Professor Dave Mattey
Emeritus Professor (Earth Sciences), RHUL

Summary of the lecture is kindly provided by Helen Hacker, FGS Member.

Introduction

Weather patterns can be recorded as chemical 'proxies' in carbonate deposits formed in cave environments. Proxies are biological, physical or chemical measurements stored in deposits or remains of organisms such as stalagmites, ice cores, marine sediment cores, lake sediments, tree rings, shells, corals and forams, all of which can be used in the study of paleoclimatology.



The diversity of chemical proxies in stalagmites reveal a wealth of other environmental changes. (Image Copyright: Sophie Verheyden, FNRS)

Stalagmites preserve long, continuous records of rainfall and the surface environment which can provide a detailed picture of climate change in the past. Research on the (chemical and isotopic content of) carbonate deposits in stalagmites is clarifying the understanding of climate patterns across Europe during the last glacial period. Studies of the carbon deposited in stalagmites can yield useful meteorological data (rainfall and

temperature) for climate modellers, because they can be accurately dated using U-Th isotope geotechnology. Very usefully, cave deposits or speleothems* can be found all over the world, from Cheddar Gorge, Skye, Gibraltar, India and Vietnam to exotic outposts in the Pacific such as Fiji and the Cook Islands.

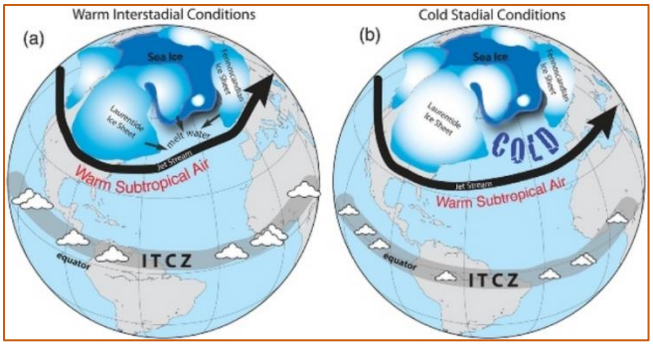
**Speleothems are secondary cave mineral deposits of limestone or dolomite, being derived by a physicochemical reaction from a primary mineral in bedrock, detritus or vegetation and deposited in the cave due to the unique cave environment (Ref 1).*

The source of carbon deposited as speleothems from precipitation via the atmosphere is linked to vegetation and soil microbial activity which all add to the carbon isotope signature. Thus, both carbon and oxygen isotopes are affected by vegetation and rainfall with direct links to climate.

The layers of calcite within stalagmites record changes in the surface environment and local weather variations as variations in the natural isotopes of O and C and trace elements. Thus, stalagmite archives yield unique paleoclimate records from globally diverse continental settings and over a period spanning thousands of years. The abundances of ^{16}O and ^{18}O are related to temperature, evaporation, and condensation; however, the relationships are complicated and affected by many other variables.

Prof Mattey focused the talk on the Gibraltar Cave Science Projects (2004-2020), the objective of which was to construct a reference record of rainfall isotopes from the speleothem samples taken from caves deep within the Rock of Gibraltar and use this as a record of environmental change over the past 500,000 years. The point of this is to gather data which it is hoped can be used to test and guide computer climate models used to predict the amount and rate of change in the future. To this end, there has been continuous logging and monthly sampling in caves within the Rock of Gibraltar since 2004. The challenge is identifying which climatic features drive changes in stalagmite proxies. So, work now focuses on applying what is known about how these caves respond to passing weather and use this to enhance and understand stalagmite climate proxy records.

The main causes of climate instability such as variation in solar radiation and effects of orbital changes i.e., Milankovitch cycles, over the last 5 million years was discussed along with tectonic landmass arrangement and ocean current changes altering surface albedo and heat transport via ocean circulation. Changes in the polar jet stream behaviour are influenced by ice, as icefields and sea ice, which in turn affects weather, such as rainfall, which in turn affect speleothem deposits.



The polar jet stream separates cold, sub-polar air masses from warm, sub-tropical air masses. (Image: Prof Mattey)

Evidence and data in the form of graphs were shown indicating the climate instability during the last glacial period dating from 90,000 years BP to 10,000 years BP. Oxygen isotopes in Greenland ice core records show 25 dramatic events ("*Dansgaard – Oeschger*") occurred through the last glacial – rapid warming followed by gradual cooling – transitioning between the two preferred states.

Summary

Speleothems provide a unique opportunity for reconstructing climate drivers and change on various spatial and temporal scales. These reconstructions are now testing state-of-the-art climate change models that explicitly simulate atmospheric circulation, water, and C isotopes.

Stalagmite records provide unprecedented insight into temperature, rainfall, recharge, vegetation activity and wind fields. There is powerful new evidence that the position and behaviour of the polar jet stream plays a crucial role in rapid climate transitions and rainfall patterns. Stalagmites will provide long records to test and improve evolving climate models. Thus, the past is providing a key to the future.

References:

1. Wikipedia [en.m.wikipedia.org accessed 15 April 2021]

I have relied heavily upon the slides provided by Prof Mattey and quoted directly from these in numerous places. My thanks and appreciation go

to Prof Mattey for illuminating this very complex topic and tangled web of interactions with his superbly illustrated slides. It is clearly a lifetime's work to fully understand the complexity and usefulness of this whole, fascinating, and timely topic.
Helen Hacker

Biography

Professor Mattey has over 40 years research and teaching experience in geology, petrology, geochemistry, planetary science and palaeoclimatology.

His experience ranges from shipboard scientist on the Ocean Drilling Program, Research Fellowships at Birmingham, Hawaii Institute of Geophysics, Cambridge, and the Open University, and, since 1989, Royal Holloway, where among other things he set up and directed the stable isotope facilities and was Head of Department.

He has published over 150 research articles on a wide range of topics and current research interests include palaeoclimate reconstruction, cave environmental monitoring or any projects involving isotope geochemistry, sailing or opportunities to sit in on Irish music sessions.

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12 March 2021

On Friday, 12 March 2021 our Chair Liz Aston and 45+ attendees from the FGS, together with GA and Reading Geological Society members welcomed Thomas Vandyk to present our external lecture via Zoom.

Investigating Precambrian Glaciations from Bottom Up, Subglacial Geomorphology from China and USA.

Thomas Vandyk
Postgraduate Research Student at RHUL

A full summary of the lecture will be included in our next Newsletter due to be issued at the beginning of August 2021.

Abstract

During the Cryogenian Period (ca. 720 to 635 Ma), glacial ice reached sea level at equatorial latitudes, implying extreme global cold and the possibility of a "Snowball Earth".

However, global glacial dynamics and the extent of ice cover during this period remain poorly understood. Likewise, the global character of glaciation during the subsequent Ediacaran Period (ca. 635 to 541 Ma), which set the stage for the Cambrian explosion, is poorly understood.

Striated bedrock surfaces (pavements) abraded beneath glacial ice provide high confidence evidence for grounded ice, ice flow direction and a warm based thermal regime. These attributes are of fundamental importance to reconstructions of Cryogenian to Ediacaran ice dynamics and extent.

Precambrian pavements are, however, globally rare and known examples typically only exist as metre scale fragments. This is in unexplained contrast to pavements of the subsequent Late Palaeozoic Ice Age, which are so numerous that subglacial landscapes may be traced for hundreds of square kilometres from space.

The talk presented some of findings from three Precambrian glaciogenic formations associated with rare examples of striated pavements on three separate palaeocontinents:
(1) The Ediacaran Luoquan Formation of the North China Craton,
(2) the Yuermeinak Formation of the Tarim Craton,
(3) the Mineral Fork Formation from the Laurentian Palaeocontinent.

Biography

Tom Vandyk is a final year PhD student, funded by the London Nerc DTP. He is supervised by Bethan Davies (Royal Holloway), Graham Shields (UCL) and Daniel Le Heron (Vienna).

Prior to his current studies he obtained a BSc from the Open University followed by an MSc by research in Earth Sciences from Royal Holloway.

Tom lives near Farnham and is always happy to answer questions relating to his work.

Please feel free to contact him on thomas.vandyk.2018@live.rhul.ac.uk.

Or if you wish to read some of his publications they are listed on the RHUL website: https://pure.royalholloway.ac.uk/portal/en/persons/thomas-vandyk(e30e8b84-e0f4-4997-883d-7d1768e03f08)/publications.html.

12 February 2021

On Friday, 12 February 2021 our Chair Liz Aston and 61+ attendees from the FGS, together with GA, OU, Mole Valley, Harrow & Hillingdon and Reading Geological Society members welcomed Dr. Stuart Archer to present our external lecture via Zoom.

Summary by Mick Caulfield, FGS Newsletter Editor

Bearreraig Sandstone Formation on Skye and Raasay and correlation to North Sea formations

Dr. Stuart Archer
Chief Geoscientist, RPS Energy

Figure 1: Cliff face at Screapadal of the Bearreraig Sandstone Formation showing channel sandstones and soft sediment deformation.

The Hebridean Basins of NW Scotland provide the last vestige of Mesozoic outcrop data before the Atlantic Margin and so have a uniquely important place in the geology of NW Europe.

The central theme of Dr. Archer's research has been to explore the interaction between active tectonism and shallow marine sedimentation in Middle Jurassic (Aalenian & Bajocian) strata located on Skye and Raasay that are time equivalent to the Brent Group of the Northern North Sea.

During the Jurassic, Scotland lay around 40° north of the equator (where Spain lies today) and the climate was humid and sub-tropical. Precipitation and therefore run-off is likely to have been perennial but seasonally variable.

Fluvial systems would have fed westwards off the Scottish massif to a coastline positioned somewhere east of the Hebridean study area.

Dr. Archer began by describing the principal outcrops studied, which includes data from the Upper Glen 1 exploration well drilled on Skye in 1989.

The Bearreraig Sandstone Formation represents sediments deposited during the Middle Jurassic from 168 Ma to 178 Ma and comprise alternating fine grained (shale & mudstone) and coarser grained (sandstone) units representing low and high energy depositional environments respectively in a shallow marine sequence.

Detailed sedimentary logging at Bearreraig Bay in the northeastern part of Skye and at Screapadal on the Isle of Raasay (fig. 1), when correlated with the interpretation of samples and electric logs obtained from the Upper Glen 1, indicate a general thickening of the sequence to the northwest (fig 2). Structural interpretation of the northeast to southwest trending faults, together with the outcrop data indicate these faults were active at the time of deposition, the half grabens showing their thickest deposits in the northwest.

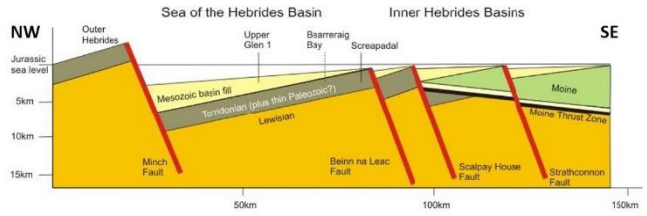


Figure 2: Structural setting: cross section through Skye at the time of Bearreraig Sandstone Fm deposition.

Excellent outcrop photographs were obtained at the almost vertical cliff faces at Screapadal (fig. 1) on the Isle of Raasay by "Droney MacDroneface" … it should be noted that drone photography and drone remote sensing have, over the last few years, been used more and more to help field geologists in their understanding of difficult-to-reach outcrops.

Dr. Archer made direct comparisons of the sedimentary structures observed in Skye and Raasay with well core data obtained from the Brent Group in the Northern North Sea which were, for the most part, well matched. Distributary mouth bars, trough cross-bedding and very large sand-filled channels were among the depositional forms recognised. Some excellent large scale soft sediment deformation "ball and pillow structures" were also seen.

The final outcrop at Glasnakille in the southern part of Skye on the Strathaird Peninsula is interpreted

as a sequence of strongly influenced tidal sediments deposited in a structurally confined half graben with a strong palaeo-flow direction to the south/southwest.

The geomorphology is generated by rotating fault blocks and the emergence of footwall islands. Some 500 m of Bearreraig Sandstone Formation are preserved at this location, suggesting high subsidence rates and high sediment supply (fig. 3).

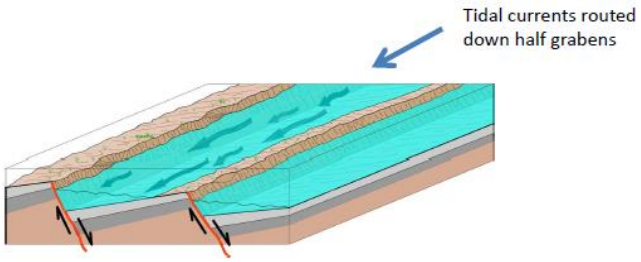


Figure 3: Tidal straight development in a narrow half-graben (Glasnakille location model).

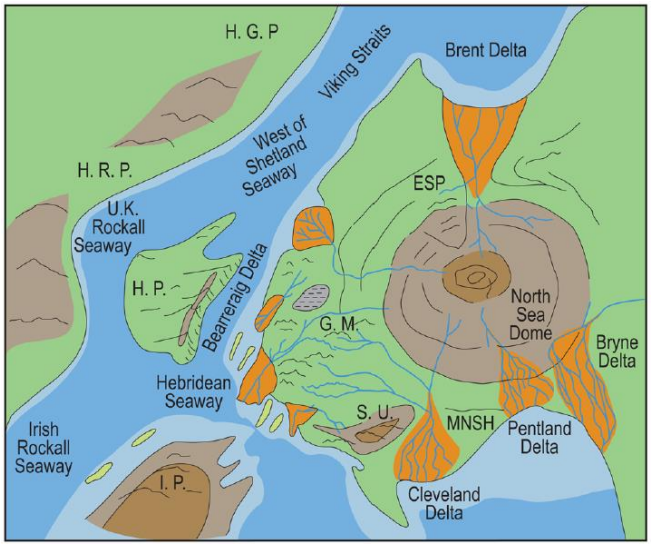


Figure 4: A mega-regional 'source to sink' palaeogeographical sketch reconstruction of the Hebridean seaway and the Bearreraig Delta in the context of other major Middle Jurassic deltas. Huge volumes of sediment dispersed radially from the mid North Sea thermal Dome during the Middle Jurassic.

Dr. Archer concluded the talk by proposing a mega-regional model which linked the Middle Jurassic Brent delta in the Northern North Sea, the Pentland, Cleveland and Bryne delta's in and around the Mid North Sea and onshore Yorkshire, and the Bearreraig delta of Skye and Raasay with the emergence of the Central North Sea volcanic dome. Thermal doming initiated in the Early Jurassic was at its most prominent during the Middle Jurassic, deflating during the early part of the Late Jurassic, causing radial sediment flow (fig. 4).

A comparison between the individual units of the Bearreraig Sandstone Formation and the individual Members of the Brent Group show many similarities in both sediment type and depositional processes. Differences are evident but the outcrops in the Hebrides should be considered as excellent analogues for the one of the major hydrocarbon reservoirs of the Northern North Sea.

Dr. Archer provided the FGS with an extremely informative, very well presented, and entertaining presentation.

Reference:

Archer SG, Steel RJ, Mellere D, Blackwood S & Cullen B, Response of Middle Jurassic shallow-marine environments to syn-depositional block tilting: Isles of Skye and Raasay, NW Scotland. SJG, 2019, Vol 55, pp 35-68. https://doi.org/10.1144/sjg2018-014

Dr. Stuart Archer

Stuart was employed by ConocoPhillips from 1996 to 2008 in Aberdeen and Houston. He held positions as an exploration and a production geologist.

In 2009, he took up the position of Director of exploHUB at the University of Aberdeen, which was a ground-breaking training centre for hydrocarbon exploration with a teaching philosophy of 'learning by doing'.

Since 2014, Stuart has held various exploration assurance positions with Dana Petroleum, Maersk Oil and Total, most recently in Copenhagen, Denmark. He currently works for RPS where he is responsible for the geoscientific content in the RPS Training portfolio.

Stuart holds a BSc from Glasgow University and an MSc and PhD from Aberdeen University and his research interests are in the area of clastic sequence stratigraphy and emphasising its key role in the exploration and development of natural resources.

Lecture Summary

11 December 2020

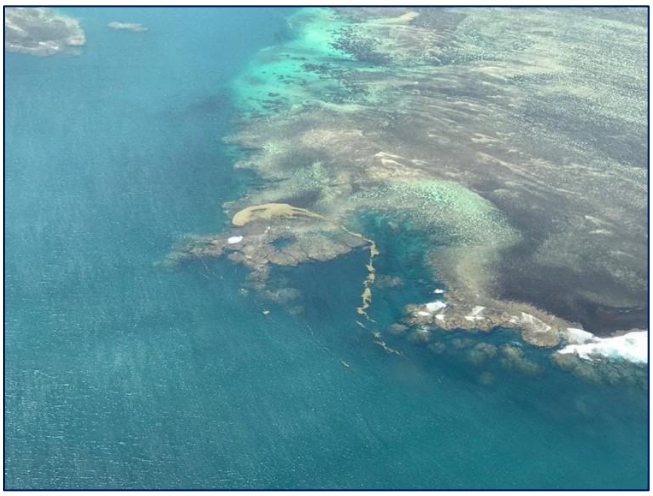
On Friday, 11 December 2020 our Chair Liz Aston and 49+ FGS members, together with GA and

Reading Geological Society members welcomed Dr. Isobel Yeo to present our external lecture via Zoom.

The Tongan Pumice Raft

Dr. Isobel Yeo
NOC, Southampton

The 2019 pumice-forming eruption of volcano 0403-091, Tonga



On the 15 August 2019 yachts sailing in the South Pacific began to report encountering large volumes of floating volcanic rock approximately 75 km west of Late Island, Tonga. The bubbly rock, called pumice, had been formed by an explosive volcanic eruption between the 6th and the 8th of August from an unnamed submarine volcano and was now drifting westward, where it would wash up on Island shores across Fiji and, eventually, Australia.

Very few submarine volcanoes are actively monitored and as a result it is hard to know how often pumice rafts occur in the oceans. However, they can pose a range of hazards to vessels, marine infrastructure, and wildlife, so if we can better understand the process that control pumice raft formation it is will be easier to forecast and mitigate future events.

In February 2020 a team of scientists from the UK, Japan and Australia set out to study the volcanic eruption that produced the August 2019 pumice raft and to visit the Fijian communities that were cut off when it washed up on their beaches. The team worked with Tonga and Fijian scientists to locate and sample the volcanic vent and to collect samples of the pumice that formed the raft.

These samples are now being analysed at the National Oceanography Centre Southampton (UK), The Queensland University of Technology (Australia) and the Japan Agency for Marine-Earth Science and Technology (Japan) to unravel the processes that control pumice raft formation and evolution.

***Dr. Isobel Yeo** completed her undergraduate degree in Geology at the University of Edinburgh in 2008 and then moved to Durham University to study for a PhD in Submarine Volcanology and Marine Geophysics.*

Since completing her education, she has worked in the USA and Germany, and in 2016 returned to the UK to take up a position at the National Oceanography Centre (NOC), Southampton.

Her research interests are focussed on submarine volcanic and magmatic processes, marine geohazards and blue resources and energy. She currently leads the NERC funded Tonga RAFTS project, investigating shallow submarine volcanic processes in the Tofua Arc, and contributes to others looking at seafloor resources and hazards.

Interesting Places 1

Colima Fire Volcano

This impressive photograph of the Colima Fire Volcano (3850 m high) was captured by Mexican photographer Sergio Tapiro Velasco on the night of 13 December 2015 after a long wait. Tapiro began taking the first shots from 19:30 at night and obtained this image four hours later from a safe position located 12 km from the volcano.

The image shows the volcano expelling incandescent material and a large ash column. One of the most conspicuous elements is the 600 m long bright beam that forms from the right side. Lightning is part of the phenomenon known as a dirty storm that occurs when mineral particles expelled by the volcano collide with each other causing electrical discharges. The photographer captured his image with a Canon EOS 6D camera, at a shutter speed of 8, a 2.8 aperture and an ISO (sensitivity to light) of 3200. The same volcano contributed to the success of the photo, says Tapiro, as “the beam worked like a giant flash”.

The Power of Nature: Volcán de Colima, Mexico. (Image: Sergio Tapiro Fotografía / Photography)

Etna's Fiery Fountain

The eruption of Sicily's Mount Etna — Europe's most active volcano — led to some spectacular views as fountains of hot lava lit up the landscape. Etna began spewing ash, smoke, and lava in mid-February, but volcanologists say this period of activity is unlikely to cause serious damage or injury.

In this night-time shot of a church in Catania, Italy, forked rivers of lava can be seen pouring out of the crater more than 25 km away. (Credit: Fabrizio Villa/Getty)

Mount Hood

Mount Hood is a potentially active stratovolcano in the Cascade Volcanic Arc. It was formed by a subduction zone on the Pacific coast and rests in the Pacific Northwest region of the United States. Mt. Hood is Oregon's highest mountain at 3,429 m.

Full Moon over Mt. Hood, Oregon, USA. (Photograph by Autumn Schrock Photography + Design)

Jezero Crater

The NASA Perseverance rover was put down on Mars in a near-equatorial crater called Jezero, to search for evidence of past life. This will involve roving some 15 km over the coming Martian year (roughly two Earth years).

An early target for study could be the layered rocks in this mound. (Image: NASA/JPL-CALTECH)

Article

UNESCO Geoparks

In this article Liz Aston describes the geology of the Geoparks recognised by UNESCO on Mainland Spain.

UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with an holistic concept of protection, education, and sustainable development. At present, there are 161 UNESCO Global Geoparks in 44 countries.

UNESCO's work with geoparks began in 2001. In 2015, the 195 Member States ratified the UNESCO Global Geoparks.

SPAIN

By Liz Aston

GEOLOGY OF THE IBERIAN PENINSULA

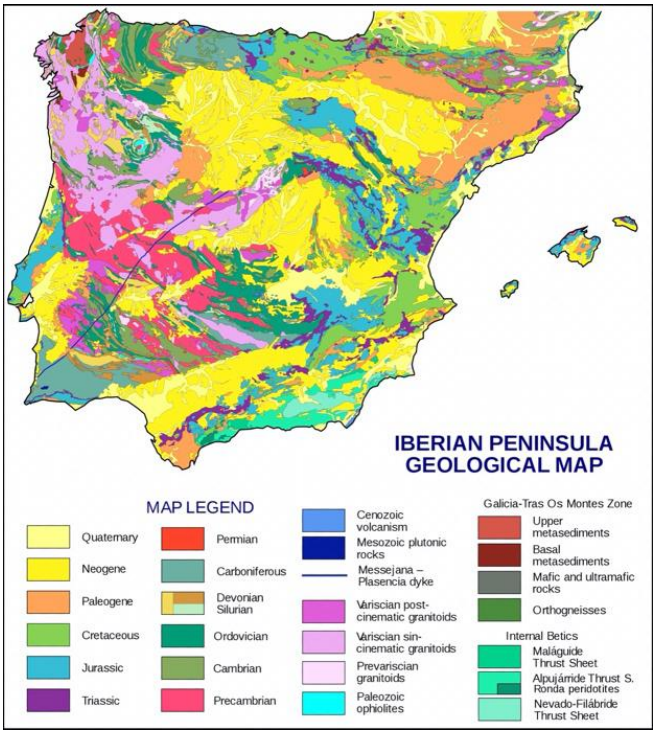


Figure 1: Geological Map of the Iberian Peninsula (Licensed under Wikipedia's Creative Commons Attribution-Share Alike 3.0 Unported license)

The Iberian Peninsula comprises Spain, Portugal, Andorra, and Gibraltar. The peninsula contains rocks from the Ediacaran (late Precambrian) to the Quaternary (Fig. 1). The core is a Hercynian cratonic block known as the Iberian Massif, which is bound to NE by the Pyrenean fold belt, and to SE by the Baetic Fold belt; both chains are part of the Alpine mountain system.

Iberian Massif

The massif comprises a Late Precambrian basement and Palaeozoic terranes which united to form the massif c.310 Ma ago (base of the Upper Carboniferous). These individual blocks are (Fig. 3):

- Cantabrian Zone (in NW corner of Spain).
- W Asturian-Leonese Zone, Catalan Coast.
- Central Iberian Zone, N Portugal, central Spain.

These comprise a single structural terrane.

- The Galicia-Trás-os-Montes Zone "Nappe Stack"
- The Ossa-Morena Zone - E of Lisbon (+ Precambrian rocks)
- South-Portuguese Zone (was part of Laurentia).

Figure 2: Political Map showing Iberian Geoparks (in red)
(Image: https://www.onestopmap.com/iberian-peninsula-733/).

The Variscan Orogeny occurred in the Carboniferous (354–305 Ma) when the European Hunic Terrane, EHT, split from Gondwana & collided with the Laurentia-Baltica continent.

The Cantabrian Zone was part of the external orogenic zone & deformed in the upper crust; the W Asturian Leonese & Central Iberian Zones were also part of the external orogenic zone, but they were deformed, metamorphosed, and intruded deep in the crust. These 3 zones are part of one terrane.

The Ossa-Morena Zone and South Portuguese Zone are two separate and very different terranes.

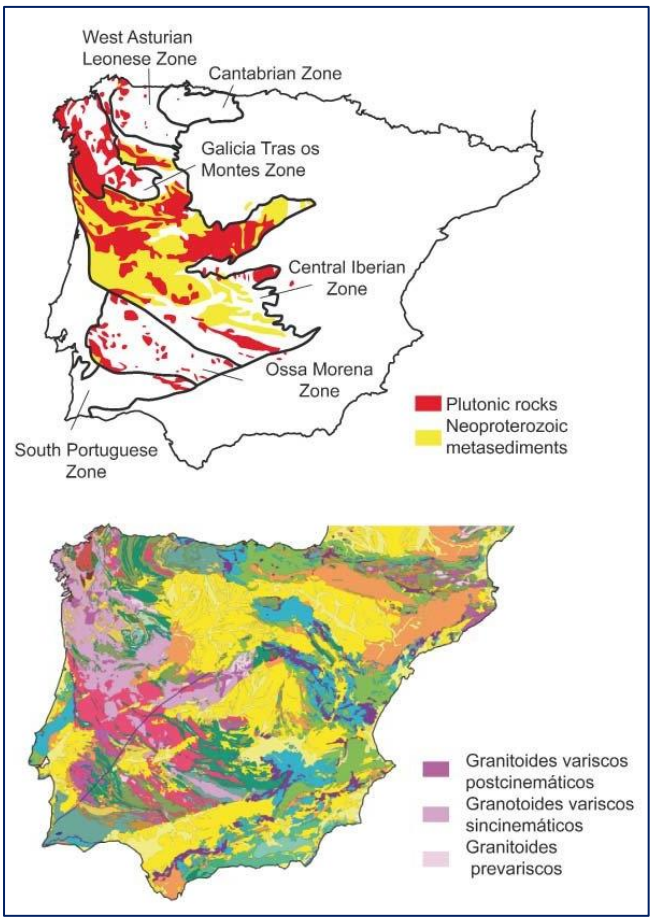


Figure 3: Geological map of the Iberian Peninsula (https://www.researchgate.net/publication/320775817. Rey, B. C., et al, October 2017, Tinworking Landscape of Dartmoor Conference in a European Context - Prehistory to 20th Century (adapted from Ribeiro and Sanderson 1996; Vera 2004)).

The Cantabrian Zone (CAN)

The Cantabrian Zone comprises Palaeozoic unmetamorphosed rocks, bound on W & SW by an arc of Precambrian rocks. Cambrian shales, sandstones & conglomerate (1-1.5 km thick) pass up into shallow marine limestones, then trilobite shales & sandstones. The overlying Ordovician quartzite (500 m) is part of a full Ordovician succession of graptolitic black shales & iron bearing sandstones >400 m thick.

Devonian dolomites, limestones & shales are 600 m thick. There is a Central Coal Basin where red sandstones, shales and coral rich limestones occur, thickest in the W.

Carboniferous deposition started with black shales, cherts, red limestone, red shale and radiolarites (sediment composed of mainly radiolarian ooze). Lower Carboniferous 'Mountain Limestone' is thick, black & lifeless; turbidites with olistoliths from Hercynian (Variscan) tectonic events (~320 Ma ago) are also present.

Variscan compression in the W created a mountain range and proceeded E with a turbidite subduction zone and a carbonate platform further offshore. In Middle to Upper Carboniferous times the trough infilled with detritus from the Hercynian mountain chain (i.e., from W & S) until terrestrial material filled the Central Coal Basin Unit (5000 m coal bearing sediments). Further E, a shallow sea & carbonate platform remained. Elsewhere conglomerates, turbidites and slump deposits from deeper offshore areas are present.

At the end of the Carboniferous, older Palaeozoic rocks were thrust over younger sediments forming nappes and thrust sheets. This zone comprises several thrust units which moved in Upper Carboniferous times. The Ponga Nappe Province is E of the Central Coal Basin. Further uplift occurred forming land locked basins in the mountains and across the nappes.

During the Permian and into the Mesozoic, there was extension, rift basins were created, then infilled by limestone, conglomerate, shale, gypsum and alkaline volcanics. It became part of central Pangaea and an arid, continental environment with desert sandstone, conglomerate through to end Triassic but a marine transgression in the Jurassic and Cretaceous Periods left marine deposits, now mostly eroded.

See the Las Loras Geopark (LL) (FGS Newsletter, August 2021).

The West Asturian Leonese Zone (WAL)

The West Asturian Leonese Zone comprises a Palaeozoic sequence which is much the same as in the Cantabrian Zone; they are now metamorphosed to greenschist or low-grade amphibolite, with folds facing into the centre of an arc. In the W the folds are recumbent, overthrust and large, while in the E folds are asymmetrical. All these structures formed between Lower Devonian and upper Carboniferous times.

See the Courel Mountains Geopark (C) (FGS Newsletter, August 2021).

The Central Iberian Zone (CIZ)

The Central Iberian Zone covers the middle part of the W side of the peninsula, including N & central Portugal. The NW area comprises deformed Proterozoic meta-sediments involved in the Cadomian (Late Precambrian) Orogeny. There are

volcanic and sedimentary sequences from late Ediacaran and Cambrian periods. Overlying these unconformably are reddish sandstone, shale and conglomerate of Lower Ordovician age ~1 km thick, younger sequences are similar to those of the Cantabrian Zone. Devonian terrigenous deposits ~2 km thick occur in the S. The lower Carboniferous has a flysch facies in S and around the Massifs. There was NE thrusting with folds and granite intrusions during the Variscan Orogeny.

See the Portuguese Geoparks of Arouca (A), Naturtejo da Meseta Meridional (NM) (FGS Newsletter, August 2020) and the Spanish Geoparks of The Villuercas Ibores Jara Geopark (J) (FGS Newsletter, August 2021).

The Galicia-Trás-os-Montes Zone (GTMZ)

The GTMZ is a tectonic unit in the NE corner of Portugal comprising a stack of 5 highly metamorphosed nappes (exotic, allochthonous complexes) formed by the collision of the Iberian Plate with a thinned piece of crust from another continent called the Meguma terrane. They are part of the Variscan (Hercynian) Orogeny.

The lowest nappe comprises HPLT (high pressure, low temperature) metamorphosed rocks; then an ophiolite; 3rd is HPHT (high pressure, high temperature) lower continental crust; then sediments with low-grade metamorphism; finally, the top one has HPHT schists.

Metamorphism of the nappes is dated 390–380 Ma ago (Middle Devonian). The underlying (basement) is a Late Precambrian (Ediacaran) / early Palaeozoic autochthonous (*in situ*) unit.

These nappes are interpreted to be part of the internal Variscan belt and to represent terranes from the outer edge of the N Gondwana margin with oceanic Cambro-Ordovician/Early Devonian ophiolites. Early Variscan, subduction-related HPHT metamorphism characterizes many of the allochthonous units, with ages younging from the structurally upper to the lower units from 400–385 Ma to 370–360 Ma, respectively.

It is concluded that the Upper Allochthon was a unique peri-Gondwanan terrane, whereas the Middle Allochthon represents units of the same peri-Gondwanan ocean, opened at the Cambro-Ordovician boundary, and having recorded localized renewed activity in the Silurian–Early Devonian. No other oceans separated the lower autochthons.

The ophiolite sequence forms 5 oval masses of mafic-ultramafic rocks, each in a syncline surrounded by Silurian metamorphic rocks with an inward-dipping bounding thrust plane. Metamorphism (~385 Ma) of these mafic rocks has formed schist, gneiss, amphibolite, metagabbro, granulite, eclogite & serpentine and represents part of an accretionary wedge from the Rheno-Hercynian Ocean.

A shear zone runs N-S along the W side of this Zone; it is 275 km long and associated with intrusions of granodiorite. There is >10 km of vertical offset along the shear zone.

See the Portuguese Geopark of Terras de Cavaleiros Geopark (TC) (FGS Newsletter, August 2020).

The Ossa Morena Zone (OMZ)

The OMZ forms a terrane in S Portugal/SW corner of Spain. It is a section of NW Gondwana which was involved in the Neoproterozoic Cadomian orogeny.

Cadomian Orogeny

The Cadomian Orogeny, which takes its name from Cadomus (Caen) in Normandy, occurred in Europe between 650-550 Ma (late Precambrian) and was the last in the sequence of events that formed the crystalline basement rocks of Gondwana, Iberia and much of Europe. The Caledonian and Hercynian basement complexes of W and central Europe, not to mention some basement inliers within the Alpine-Carpathian orogen, contain several continental crustal blocks derived during the Cadomian Orogeny. These include the Irish Sea Horst, the London Platform, the Armorican and Bohemian cratons, the E Silesian block, and the Malopolska Massif of SE Poland. Cadomian crustal elements are also recognised in the Alpine fold belt, based on their geology and radiometric age dating.

Following the Cadomian orogeny, deep sedimentary rift basins developed across Proterozoic Europe, and the wide ocean known as the Tornquist Sea opened. At the end of the Proterozoic, Europe drifted N towards the Equator and reached high S latitudes, where the Gondwana continent was assembling (650-550 Ma). It remained in these high latitudes during Cambrian times.

By the Early Ordovician those parts that now constitute the Fennoscandian Shield, and the

basement of the E European Platform, had broken off and drifted away as an independent tectonic plate, 'Baltica', which eventually became a nucleus for the future Caledonian terrain of N Europe.

Other parts of the former Proterozoic Europe, which had become attached to Gondwana, and were strongly influenced by the Cadomian Orogeny, were left behind for the time being.

Later, there was a period of rifting that led to the formation of the EHT micro-continent and the opening of the Rheic Ocean (early Palaeozoic) (Figs 4 and 5). Gondwana's N continental edge split into several micro-blocks (the European Hunic Terrane, EHT) with major faults which reactivated forming accretionary units as it drifted towards Laurussia. The drift of Gondwana (+EHT) towards Laurussia during the Devonian and the Carboniferous caused the Variscan Orogeny. This collision was associated with high level crustal granite intrusions and HP metamorphic rocks typical of Cordilleran-type orogens. The magmatic-metamorphic suites in the OMZ are akin to those along the N margin of West Gondwana.

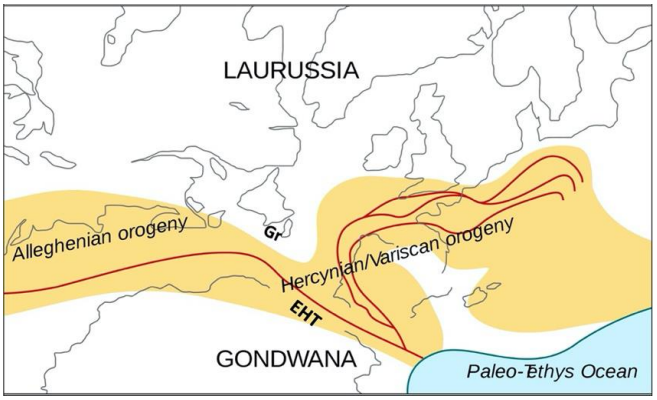


Figure 4: Hercynian/Variscan mountain chains in the Middle Carboniferous. Present day coastlines are shown for reference. Red lines are sutures, capitalized names are the different continents that joined during these orogenies. Bay of Biscay had not opened. EHT: European Hunic Terrane

The Precambrian rocks in the OMZ occur in two elongated anticlines between Córdoba and Abrantes. The Cambrian rocks start with conglomerate, then shallow water clastic rocks and limestones. The Ordovician sequence comprises shales. Late Ordovician granite intrusions rose along the Córdoba Abrantes belt. The Silurian has acid and basic volcanic rocks and shales. The Lower Devonian was formed in shallow water while the turbiditic Upper Devonian rocks follow after a break.

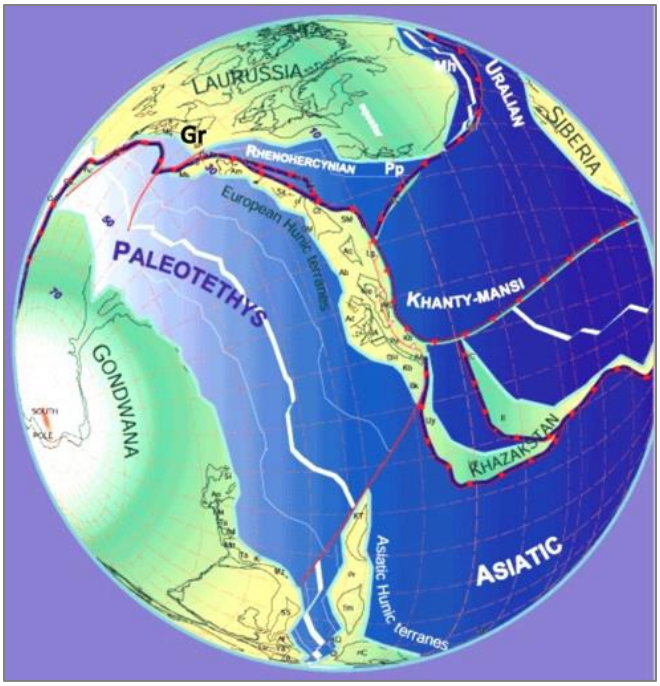


Figure 5: Palaeogeographic Image of European Hunic Terrane and Rheic Ocean at 380 Ma, Lower Carboniferous. This image comes from the Tethyan Plate Tectonic working group of the Institut de Mineralogie et Petrographie, Université de Lausanne. Note: Rheno-Hercynian or Rheic Ocean; Gr: Grand Banks, Newfoundland

The Carboniferous starts with a turbidite/basic lava sequence, ~200 m thick, passing up into terrestrial, coal bearing, strata. Hercynian mountain building occurred at this point and in the Upper Carboniferous, sediments accumulated in lakes between the mountain ranges, with molasse deposits in intermontane basins.

The OMZ was faulted against the Central Iberian Zone. The fault zone is 350 km long and 2-15 km wide; the OMZ slid sinistrally to SE (200 km horizontally + 10 km vertically) during Lower Carboniferous times, forming the Peñarroya Basin, which is ~50 km long and 1 km wide. The shearing and movements occurred from end Devonian to Carboniferous.

Cambrian and Ordovician granites, metamorphosed to orthogneiss, with migmatites and metasediments and local bodies of eclogite and garnet amphibolite occur (UHP (Ultra High Pressure) HT zone rocks). The boundary or suture between the OMZ and the SPZ is formed by an ophiolite complex, made up of UHP eclogite and blueschist (associated with subduction). These have been thrust SW over the SPZ rocks.

The South Portuguese Zone (SPZ)

The SPZ is an exotic terrane from Laurentia (offshore Newfoundland "Grand Banks"). Laurentia was N of Iberia, which was part of the European Hunic Terrane (EHT) on N Gondwana. At ~380 Ma SPZ impacted the EHT between the Galicia-Tras-Os-Montes Zone and the Meseta. At ~320 Ma, the SPZ again headed S sliding past the W side of the OMZ.

The SPZ now forms a thin triangle on the S end of Portugal. The only strata to occur are Upper Devonian phyllites & quartzites to Lower Carboniferous lavas containing Mn, Zn & Fe sulphide ores (the Iberian Pyrite Belt) which represent the remains of seafloor hydrothermal vents. The majority of the zone is covered by younger turbidite sequences several kms thick.

Hercynian Intrusions

During the Hercynian (Variscan) Orogeny, some plutons formed in the peninsula. Gabbro in NW Galicia & at Beja in Portugal. Granodiorites and 2-mica granites were intruded into the middle crust ~340 Ma to ~319 Ma; younger calc-alkaline biotite and hornblende granodiorites were intruded later at ~300 Ma into the lower crust.

Mesozoic

In the Late Triassic and Early Jurassic there were 2 stages of rifting on the W margin of Iberia. The Iberian Abyssal Plain, W coast of Portugal/Spain, formed at 126 Ma separating Newfoundland's 'Grand Banks', with Galica Bank and Flemish Cap being split from Laurentia at 118 Ma.

Iberia was joined to Armorica (N France) and by Early Cretaceous, 110 Ma, rifting occurred on W & NW edges, the Bay of Biscay opened from ~126 Ma to 85 Ma, creating the Biscay Abyssal Plain, while Iberia rotated anticlockwise relative to Eurasia. This caused the Ligurian Basin to subduct below the E side of Iberia forming the Baetic nappe stack.

After 85 Ma, the Atlantic Ocean opened between Ireland & Greenland leaving the Bay of Biscay a failed rift. Atlantic spreading caused Eurasia to rotate clockwise causing underthrusting and subduction on the E side of N Iberia, forming the Pyrenees.

In Late Jurassic times, Africa started moving E opening the Alpine Tethys (the far W end of the Tethys Ocean, close to the Adriatic). Subsistence, associated with this, caused the thick deposition of deep-water sediments on the E and sedimentation in rift basins in the central parts of Spain.

Two stages of rifting occurred in E Iberia, first Late Permian-Triassic, then Late Jurassic-early Cretaceous. On the S side, carbonates & clastic sediments formed a shelf in shallow water during late Triassic to Liassic times and rifted in the Jurassic (190-160 Ma). Thermal subsidence occurred until the end of the Cretaceous, while rifting separated North America from Africa.

The Iberian Basin of E Spain

Rifts formed in the Variscan basement from Permian to Late Cretaceous, stretching it by 35 km - initially small continental basins formed with internal drainage. Later, in Early Neogene, the Iberian Basin was inverted in the Pyrenean Orogeny, part of the Alpine orogeny and formed the Iberian Range.

The Mesozoic basins filled with siliciclastic & carbonate sequences, suffered low grade metamorphism before being folded and thrust to form the Iberian Range; 30 km of shortening occurred during a series of compressions.

- The Iberian Range trends NW-SE. In the NW the ranges are buried under the Duero Basin.
- Sierra de Altomira is a N-S oriented range separated from the Iberian Range by the Tajo Basin. This was formed from a thrust sheet that split through Triassic evaporite beds.
- From 170 to 120 Ma more than 200 km of left-lateral slip occurred between Europe and Iberia as it was rifted from the Newfoundland Grand Banks.
- From 120 to 83 Ma there was 115 km of convergence in Sardinia and Corsica.
- From 83 to 67.7 Ma Africa converged with Europe.
- In the Eocene, 55 to 46 Ma, there was right lateral slip.
- Then convergence again from the Eocene to early Oligocene.

The Spanish Central System

The Spanish Central System is a mountain range separating the Tajo and Duero basins. The land was compressed and elevated as a result of the Alpine Orogeny.

The Pyrenees

The Pyrenees were formed as the Iberian Plate impacted the European plate and was partly subducted. Initial compression started in Upper Cretaceous times with thin crust subducted. Thrusts were formed to the S resulting in inversion of the Mesozoic basins. The Central Pyrenees had the greatest shortening, with smaller amounts to W. Shortening continued for 40 Ma. There are several Permian sedimentary basins, up to 1 km deep. At the end of the Cretaceous there was about 15 km separation between Iberia & France.

The Baetic Cordillera, S & SE Spain

This region stretches ENE-WSW from the Gulf of Cádiz to the Cabo de la Nao. It formed from complex interaction between Africa and Iberia, as part of the Alpine Orogeny. It has 4 parts: the internal Baetics along the coast; the external Baetics inland; flysch units of S Spain (& Gibraltar); and the foreland basin (the Guadalquivir River Basin). There was 250 km of N-S convergence from mid-Oligocene to late Miocene and a minimum of 50 km WNW transvergence.

The Baetics are part of the Gibraltar Arc to the Rif in Morocco. During Triassic and Jurassic times, the Baetic (S Spain-Gibraltar) and Maghrebian (N Africa) margins were opposite each other.

The Internal Baetics comprise 3 thrusts, the lower one suffered UHP metamorphism. They are metamorphosed basement rocks of pre-Miocene age and occur along the coast. Within the Internal Baetics there are many sediment-filled depressions, of which some are forming now.

The Maláguide thrust sheet (N & E of Málaga) forms a strip along the border between the internal and external Baetics. The Silurian rocks, deformed by the Variscan Orogeny, show low grade metamorphism with phyllites, meta-greywackes, limestone, meta-conglomerates. The Devonian and Early Carboniferous is represented by grey slates and conglomerate, with smaller amounts of limestone, chert, and radiolarite. Permian-Triassic desert red beds (conglomerate, sandstone, mudstone) pass up to Oligocene strata.

The Alpujárride Thrust Sheet (W Málaga to Cartagena in E) is more metamorphosed than the Maláguide thrust having been buried to 35-50 km with mica schist, gneiss & migmatite formed from pre-Permian sediments. Above this is a blue grey schist and then carbonate of Middle to Late Triassic age. The Rock of Gibraltar is a monolithic limestone promontory and was created during the Jurassic period some 200 Ma ago and uplifted during the Baetic Orogeny.

The Baetics were compressed ~300 km in the Cenozoic. In Late Miocene a land bridge formed in the Gibraltar arc, blocking the Mediterranean-Atlantic Ocean connection several times, causing the evaporation of the entire Mediterranean Sea.

The Alboran Basin, offshore, S of Spain & Gibraltar

The basin formed in the early Miocene by extending & thinning of continental crust (now just 12-15 km thick). It is infilling with sediment (8 km have so far accumulated). Numerous volcanic flows occur across its floor.

The Trans Alboran Shear Zone

This is a NE trending major sinistral fault zone extending from Alicante in Spain, along the coast of Murcia through the Baetic range, across the Alboran Sea to the Tidiquin Mountains in Morocco.

Cenozoic

In the Cenozoic, compression spread to the W along the N margin of Iberia narrowing the Bay of Biscay; subduction under the N coast of Iberia formed the Cantabrian Mountains, from end Cretaceous into early Eocene. The subduction ceased at 54 Ma.

Africa's movement towards Eurasia changed from NNW to NW in the Late Miocene. This change in compression formed the Baetics on the Mediterranean coast (Middle Miocene), basins were inverted and raised up in the Iberian Central System & the Alboran Basin.

The crust has continued to fold in these areas since the Pliocene. Some coastal areas have been uplifted x00 m. Also new shear zones have appeared in the Alboran Basin.

Holocene

In the Holocene, the Valencia Trough (offshore) between NE coast of Spain, near Barcelona, and the Balearic Islands, forms a NE-SW oriented depression between the continental slope of the Iberian Peninsula and the slope off the shelf around the Balearic Islands. It opened between Late Oligocene and early Miocene, at the same time as the Provençal Basin.

The continental shelf off the Catalan coast is 6-30 km wide. Several V-shaped canyons cut deeply into the shelf. The Ebro margin, a shallow coastal

shelf 70 km wide, is fed by the Ebro River. The shelves on the Balearic margin are <20 km wide; they have a low influx of sediments, so are dominated by carbonates. At the base of the Valencia Trough is the Valencia Channel, a gully that carries sediment NE to the Provençal Basin.

The Valencia Trough comprises extended continental crust <8 km deep, whereas under the mainland it is 32 km; beneath the Balearics it is 23–25 km; at other places, the Trough axis has the Moho at 10-15 km. The lithosphere is ~50-80 km thick. The crust in the Trough had a history similar to that of the mainland - it was compressed in the Variscan Orogeny, extended in the Mesozoic so that resulting basins filled with sediment, compressed back and lifted up in the Cretaceous, then eroded. In the Eocene and late Oligocene there were a couple of basins filled with terrestrial deposits.

In the uppermost Oligocene and lower Miocene rifting started, and continental sediments were deposited, followed by marine deposits on a shallow shelf; the trough grew by extension to its present dimensions. In the Middle and Upper Miocene marine clastic sediments were deposited but then the level of the Mediterranean evaporated, during this Messinian salinity crisis gullies were cut deeply into the sediments and salt deposits evaporated onto the deeper parts.

In the Pliocene and Holocene deltas were formed over the shallow parts and deep-sea fans in the deeper parts. The slopes around the trough were the sites of many underwater landslides; mainly small, <100 km2 in area, but one "the Big '95" debris flow, is a large landslide off the coast from Castellón de la Plana, beyond the Columbretes Islands. This slide covers 2,200 km2, containing 26 km3 of sediment. It is 110 km long, has an average thickness of 13 m, ranging from 600-1800 m below sea level. A 14C date indicates the slide occurred before 9,500 BC. It is believed to have been triggered by a volcanic dome, the same one that raised the Columbretes Islands above sea level.

The Balearic Abyssal Plain lies E of the Balearic Islands. A large undersea deposit of unknown origin called the Balearic megaturbidite covers 77,000 km2, and contains 600 km3 of sediment, at 10 m thick. The slip happened at the last lowstand. Pleistocene-aged raised sandy or pebbly beaches along the coasts which have been partially cemented. One found in the Basque Country has the largest cavern (La Grand Sala del GEV) in Europe with an area of 76,620 m2, or 245 x 520 m.

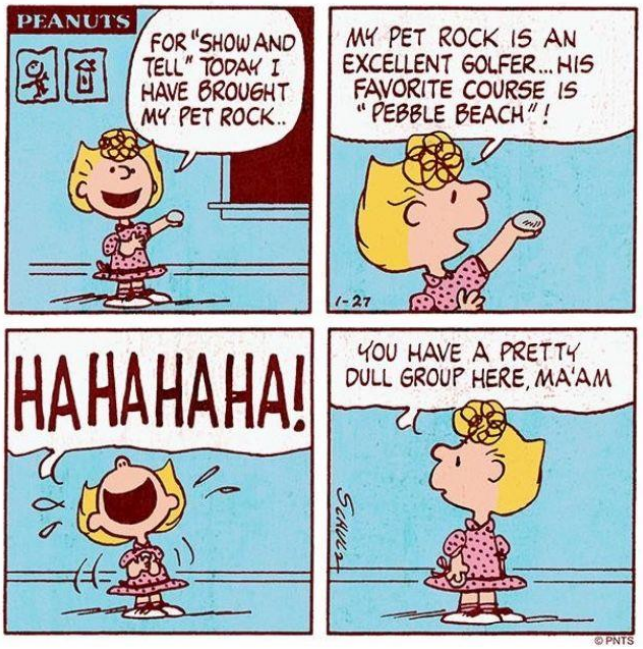
Reference:

1. Global UNESCO Geoparks Spain & Portugal Final 003

Cartoon Corner 1

Courtesy of Janet Catchpole

(Credit: Rigolages, 3 November 2020)



(Image: https://www.peanuts.com/about/sally)

Ga = billions of years

Ma = millions of years

Article

Possible Freedom

By John Williams, Field Trip Secretary
4 March 2021

With the easing of restrictions beginning, you might be thinking of planning a **"Staycation"** this year. To help you satisfy your lack of Geological Field Trips I thought that a list of possible places to visit would be appropriate to whet your appetites.

My **first list** is of **17 Top Geology Sites**; this is subjective, but it will give you a broad experience of various ages and types of rock, together with options for length of visits.

You can search for details of these sites on the web.

Anglesey	**South Stack**	Folded metamorphosed sandstones of the Cambro-Ordovician South Stack Formation.
Berwickshire	**Siccar Point**	Siccar Point is notable in the history of geology as in 1788 geologist James Hutton observed the angular unconformity of the point. He wrote later that the evidence of the rocks provided conclusive proof of the uniformitarian theory of geological development.
Cornwall	**Lizard Kynance Cove**	Two types of ophiolitic serpentinite exposed, together with granite and gneiss pods within the serpentine.
Derbyshire	**Peak District**	Dominated by a series of sedimentary rocks that formed 350 Ma, in the Carboniferous Period.
Dorset	**Jurassic Coast**	The Dorset and East Devon Coast World Heritage Site. The name comes from the best known of the geological periods found within it, but in fact it includes rocks from the Triassic, Jurassic, and Cretaceous periods.
	Swanage Durlston Head	At the southern margin of the Isle of Purbeck lies Durlston Head, composed of Portland Limestone.
Edinburgh	**Arthur's Seat**	An extinct volcano, which forms most of Holyrood Park. Like the rock on which Edinburgh Castle is built, it is early Carboniferous in age.
Hampshire	**Highcliffe**	Highcliffe to Milford Cliffs is a geological *Site of Special Scientific Interest* which stretches along the cliffs of Christchurch Bay. It exposes the fossil rich strata of the Barton Beds and the Headon Beds, dating to the Eocene.
Hertfordshire	**Dunstable Downs**	Part of the Chiltern Hills, in southern Bedfordshire. They are a chalk escarpment forming the north-eastern reaches of the Chilterns.
Isle of White	**Alum Bay**	The location of upper Palaeocene and Eocene beds of soft sands and clays, separated by an unconformity from the underlying Cretaceous Chalk. Due to geological folding of the Alpine orogeny, the strata are near vertical. The sands are coloured due to oxidised iron compounds formed under different conditions.

Leicestershire	**Bradgate Park**	Bradgate Park is a public park in Charnwood Forest, Leicestershire. The visible geology ranges from some of the oldest (Precambrian) fossil bearing rocks in England to the youngest (Quaternary).
Orkney	**Old Man of Hoy**	The Old Man of Hoy is a 137 m high sea stack on the island of Hoy, formed from Old Red Sandstone.
Shetland	**Mavis Grind**	Mavis Grind is a narrow isthmus joining the Northmavine peninsula to the rest of the island of Shetland Mainland.
Snowdonia	**Cwm Idwal**	Cwm Idwal is a spectacular product of glaciation, surrounded by high crags, screes, moraines and rounded rocks, with a lake, Llyn Idwal, on its floor.
Surrey	**Devil's Punch Bowl**	The Devil's Punch Bowl is a 2.82 km2 visitor attraction and biological *Site of Special Scientific Interest* situated just to the east of the village of Hindhead in Surrey. The geology has two layers: an upper layer of sandstone, with clay beneath. This deep depression is believed to be the result of erosion caused by spring water beneath the sandstone, causing the upper level to collapse.
	Newlands Corner	Newlands Corner is a 1.01 km2 nature reserve east of Guildford in Surrey.
Yorkshire	**Malham Cove**	Malham Cove is a spectacular natural early Carboniferous limestone formation which comprises a curved limestone cliff at the head of a valley. The limestone pavement at the top is a superb example of later karst weathering.
	Brimham Rocks	Brimham Rocks is an outcrop of Millstone Grit. Once known as Brimham Crags. It is a 1.84 km2 biological *Site of Special Scientific Interest* and *Geological Conservation Review* site, 13 km northwest of Harrogate, on Brimham Moor in the Nidderdale Area of Outstanding Natural Beauty.

Some of these are possible on a local day trip, others would require longer and could be joined together as a tour.

The Devil's Punch Bowl (Credit: BBC)

Newlands Corner, Albury Downs (Credit: Visit Surrey)

My **second list** is from the *Photographers Resource* website and is a timeline of Britain's buildings.

The architecture of Britain has evolved throughout history and has been influenced by many things, including the occupation of the Roman's, the domination of England on other parts of the world, the design creativity of individuals who picked up on elements of grand design from their trips to Europe and beyond, through to technological advances of today and will no doubt go on evolving into the future.

The table below is ordered by the period in history, looking at the major developments that took place at that time and listing some of the examples of buildings that still survive today and can be visited.

Period	Major Developments	Example Buildings	Stone
Pre-Roman	Community based structures: from excavations carried out it is assumed mainly circular in nature.	Stonehenge, Wiltshire Avebury, Wiltshire Cadbury Castle, Somerset Example Round Houses can be found at Living History museums in England and Wales.	Sarsen; Blue stone Sarsen Limestone
Roman	Built first cities and towns. Road systems, creating streets. Structures built with Brick. Hypocausts supplying hot water. Lavatoriums. Communal Baths.	Roman Baths, Somerset Hadrian's Wall Fishbourne Roman Palace, West Sussex	Bath Stone Whin Sill Dolerite Lower Chalk; limestone
Anglo-Saxon	Mainly made of wood. Use of Ashlar Masonry in combination with reused Roman Brick. Typically, high, and narrow, usually accompanied with a West Tower. Small windows with rounded or triangular tops deeply splayed or in groups divided by squat columns.	Only examples left are churches, although most of those left today are Norman; no major Anglo-Saxon church survives. Earls Barton Church, Northamptonshire Bradford on Avon Church, Wiltshire	Barnack Stone Ham Hill Stone
Norman (Medieval)	Destroyed all of England's existing cathedrals and built Romanesque ones. Rounded arches. Arcades supported by cylindrical piers. Low relief sculpture decoration. Decorative Chevron patterns. Motte and Bailey Castles.	Durham Cathedral St Albans Cathedral, Hertfordshire White Tower, Tower of London Domestic examples include: Haddon Hall, Derbyshire Jews House, Lincoln Oakham Castle, Rutland (a fortified manor house)	Low Main Sandstone Flint, Totternhoe Stone Caen Stone Lincolnshire Limestone Marlstone

Gothic (Medieval)	Influenced by France. Columns composed of multiple shafts. Large windows - often stained glass and subdivided by decorative stone tracery. Pointed arches, rib vaults, flying buttresses and pinnacles. Large gatehouses on castles.	Salisbury Cathedral, Wiltshire Wells Cathedral, Somerset Westminster Hall, London	Chilmark stone; Purbeck Marble Doulting stone Magnesian limestone
Vernacular (Medieval)	Constructed of wood. Wattle and Daub, clay, or Turf. Based around a Great Hall with a bay at each end split into two: one for service rooms, the other for owners.	Ightham Mote, Kent Alfriston Clergy House, Sussex Stokesay Castle, Shropshire	
Tudor	Moved away from defence structures to those for entertaining. Tudor Arch. Increased use of Glass.	Hampton Court Palace Longleat House, Wiltshire Montacute House, Somerset Hatfield House, Hertfordshire Hardwick Hall, Derybshire	Brick Combe Hill stone Ham Hill stone Brick Grenoside Moor Rock
Stuart	Palladian style from Italy influenced by Inigo Jones. Following the Great Fire of London. Sir Christopher Wren. Baroque style - included heavy embellishment and mass.	Queens House, Greenwich St Paul's Cathedral, London Chatsworth House, Derbyshire Castle Howard, Yorkshire Blenheim Palace, Oxfordshire	Portland stone Ashover grit Corallian sandstones Headington limestone; Clypeus grit
Georgian	European Palladianism. Urban development. Introduction of crescents and terraces.	Woburn Abbey, Bedfordshire Kedleston Hall, Derbyshire Georgian Terrace, Bath, Somerset Mayfair, London	Totternhoe stone Hopton Wood limestone (interior) Bath stone
Victorian	Romantic Medieval Gothic. Introduction of steel as a building component.	Palace of Westminster	Clipsham stone

20th Century	Arts and Crafts. Non symmetrical design. Mullioned or Lattice windows. Multiple Gables. Tall chimneys. Art Deco.	Red House, Bexleyheath, Kent Castell Coch, Cardiff Manchester Central Library	Brick Pennant sandstone Portland stone facings
Modernism (20th Century)	Following World War II cost dictated designs; however, it did still evolve with Brutalism - many are now being redeveloped. Re-enforced concrete frames. Prefabricated buildings. Metal frames. Concrete cladding. High Rise housing.	Barbican Arts Centre, London Royal National Theatre, London Bracknell, Berkshire (town centre)	Concrete; granite cladding on some buildings. Concrete Chinese granite paving
High-Tech (20th Century)	Mainly used in non-domestic buildings.	Lloyds Building, London Millennium Dome	
Post Modern (20th Century)	Fashionable in the 1980's with shopping malls and office complexes.	Broadgate, London	
Neo-Classical (20th Century)	n/a		
Contemporary (20th Century)	Sustainability. Glass.	Gateshead Millennium Bridge London Eye The Gherkin, London The Shard	

Stonehenge (Credit: Sky News)

London Eye (Credit: Aneb/iStock.com)

Reference: http://www.photographers-resource.co.uk/

We hope to be able to introduce a limited Field Trip programme for late Summer / Autumn 2021 when we have more freedom announced with definite dates for relaxation.

Cartoon Corner 2

Yorkshire's 'largest ever dinosaur print' discovered on coast

14 April 2021

BBC Science

The print is claimed to be the largest ever found in the county. (Image Copyright: Marie Woods)

A dinosaur footprint belonging to a "real Jurassic giant" has been discovered on the Yorkshire coast.

The print, said to be the largest unearthed in the county, was found by archaeologist Marie Woods.

"I had originally gone to collect shellfish for dinner but got completely distracted by this beast!" she wrote on Twitter.

Experts believe it was left by a large meat-eating dinosaur with a body length of up to 9 m.

Ms Woods said she had been out collecting shellfish and was shocked to stumble across the huge three-toed print. "I didn't collect much after seeing that" she said.

Following her discovery, at an undisclosed location, Ms Woods contacted specialists including palaeontologist Dr. Dean Lomax, author of “Dinosaurs of the British Isles”.

'Fragile state'

He described it as "a real Jurassic giant", adding that it was the "largest theropod footprint ever found in Yorkshire".

It belonged to a large meat-eating dinosaur, possibly a Megalosaurus, which lived between 164 and 175 Ma ago," Dr. Lomax said.

He added that Ms Woods' discovery had actually turned out to be "a rediscovery", as it had been partially spotted by fossil collector Rob Taylor back in November 2020.

However, despite Mr Taylor posting pictures of his find in a Facebook group dedicated to Yorkshire fossils, it had not been fully exposed at the time and its true importance was not realised, Dr. Lomax said.

Plans are now being put in place to recover the print, which according to Ms Woods is in "a fragile state" and is in danger of being "lost to the sea".

If successful, it will go on display at the Rotunda Museum in Scarborough.

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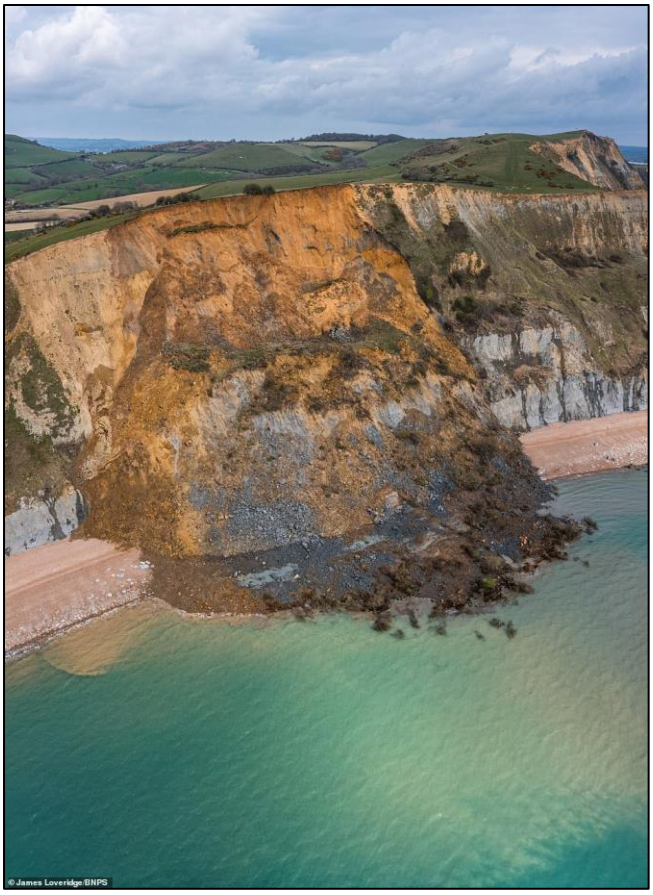
The Jurassic Coast's biggest rockfall in 60 years: 4,000-ton chunk falls off 430ft high cliff sending boulders the size of cars plummeting towards picturesque beach

- ***4,000-ton rockfall has completely blocked off a beach along a stretch of Britain's historic Jurassic Coast***
- ***Huge chunk from sandstone cliff gave way causing boulders the size of cars to plummet near Seatown, Dorset***
- ***Landslip affecting almost 1,000ft of cliffside took place overnight, with whole trees seen floating out to sea***

14 April 2021

By Henry Martin For MailOnLine

An enormous 4,000-ton rockfall from a 430ft cliff has completely blocked off a beach along a stretch of Britain's historic Jurassic Coast.



A huge chunk from the sandstone cliff gave way causing boulders the size of cars to plummet near Seatown in Dorset.
(Image: James Loveridge/BNPS)

A huge chunk, described as the biggest in 60 years, gave way from the sandstone cliff causing boulders the size of cars to plummet near Seatown in Dorset.

Rangers have been assessing the damage throughout the day and Dorset Council is warning people to stay away.

The 'gigantic' landslip affecting almost 1,000ft of cliffside took place overnight, with whole trees seen floating out to sea.

It is believed to have been caused by natural erosion, not helped by recent mixed weather.

The beach before the collapse. It is believed to have been caused by natural erosion, not helped by recent mixed weather. (Image: MailOnLine)

Jake Lanning, from West Bay Coastguard, said: 'We have been aware of this since this morning and it is a very, very substantial fall. The county council are aware of it and I know their rangers have been out assessing the damage. I believe it was caused by substantial cracks around the cliff, which have occurred as part of natural erosion.

'The recent warm days and cold nights probably haven't helped either and we're expecting to see a fair bit of this in the coming weeks. In terms of this one, high tides will eventually see the debris disappear but at the moment the beach is completely cut off.

'We weren't called out to it, as there is not any danger to life, but we did get a lot of calls about debris in the water. The fall was so big that people thought the rocks and trees were vessels and/or people in difficulty.'

Among those to see the debris was walker Nicola Prakash, who came across it while on the beach this morning.

She said: 'The entire beach is blocked, it's very lucky it happened overnight rather than during the

day. It is a huge landslip, certainly the biggest one I've seen in my 40 years in Bridport.

'I was chatting to some of the people who live by the beach and one man who's been here for 60 years said it's the biggest one he's ever seen. By the looks of things there could well be more to come so people need to stay away from that area of the beach.'

Dorset Council has warned that further falls are expected - and urged residents to stay clear of the area.

A spokesman for Dorset Council said: 'There has been substantial rock fall between Seatown and Eype Beach. Further movement is expected with fresh cracks, affecting the fence line but not the Coast Path. We will monitor over the next few weeks to ensure that any further movement does not affect access.

'Now the ground is drying out, there is the possibility of more slips and falls and they can happen very quickly. For your safety keep clear of tops and bases of cliffs when out and about.'

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2. https://www.bridportnews.co.uk/news/19228721.huge-cliff-fall-seatown-beach/
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St Vincent volcano: heavy ashfall clouds evacuation efforts on Caribbean island

10 April 2021

Reuters in Kingstown

Extremely heavy ashfall rained down on parts of the Caribbean island of St Vincent on Saturday and a strong sulphur smell enveloped communities, a day after a powerful explosion at La Soufriere volcano uprooted the lives of thousands who evacuated under government orders.

Caribbean countries including Antigua and Guyana offered help by either shipping emergency supplies or temporarily opening borders to the roughly 16,000 evacuees fleeing ash-covered communities.

La Soufriere volcano. (Photograph: UWI Seismic Research Centre)

The volcano, which last had a sizeable eruption in 1979, kept rumbling and experts warned explosions could continue for days or weeks. An eruption in 1902 killed about 1,600 people.

“The first bang is not necessarily the biggest bang this volcano will give,” Richard Robertson, a geologist with the University of the West Indies’ Seismic Research Centre, said at a news conference.

Conditions worsened overnight in settlements near the volcano as ash covered homes, cars, and streets. Lush green scenery had turned grey and gloomy, with people leaving footprints as they walked through the soot.

The prime minister, Ralph Gonsalves, told NBC Radio, a local station, that officials were trying to figure out how to remove the ash.

“It’s difficult to breathe,” Gonsalves said, adding that while the volcano’s venting had diminished, a big plume of ash and smoke remained. “What goes up must come down.”

He asked people to remain calm and keep protecting themselves from the coronavirus as he

celebrated that no deaths or injuries were reported after the eruption in the northern tip of St Vincent, part of an island chain that includes the Grenadines and is home to more than 100,000 people.

“Agriculture will be badly affected, and we may have some loss of animals and we will have to do repairs to houses, but if we have life and we have strength, we will build it back better, stronger, together,” he said.

Gonsalves has said it could take up to four months for life to return to normal. About 3,200 people were staying in 78 government shelters while four empty cruise ships floated nearby, waiting to take evacuees to nearby islands. Those staying in shelters were tested for Covid-19, and anyone testing positive would be taken to an isolation centre.

Gonsalves said it was unclear how much more ash the volcano would vent out. “All I’m asking of everybody is to be calm,” he told reporters during a visit to a shelter.

The first explosion occurred on Friday morning, a day after the government ordered mandatory evacuations based on warnings from scientists who noted seismic activity before dawn on Thursday that meant magma was on the move close to the surface.

An ash column burst more than 33,000ft into the sky. Lightning crackled through the still-towering cloud late on Friday.

The ash forced the cancellation of flights and poor visibility limited evacuations in some areas. Officials warned that Barbados, St Lucia, and Grenada could see light ashfall as the 4,003ft volcano continued to rumble. The majority of ash was expected to head north-east into the Atlantic Ocean.

La Soufriere had an effusive eruption in December, prompting experts from around the region to analyse the formation of a new volcanic dome and changes to its crater lake, among other things.

The eastern Caribbean has 19 live volcanoes, including two underwater near the island of Grenada. One of those, Kick ’Em Jenny, has been active in recent years. But the most active volcano of all is Soufriere Hills in Montserrat. It has erupted continuously since 1995, razing the capital, Plymouth, and killing at least 19 people in 1997.

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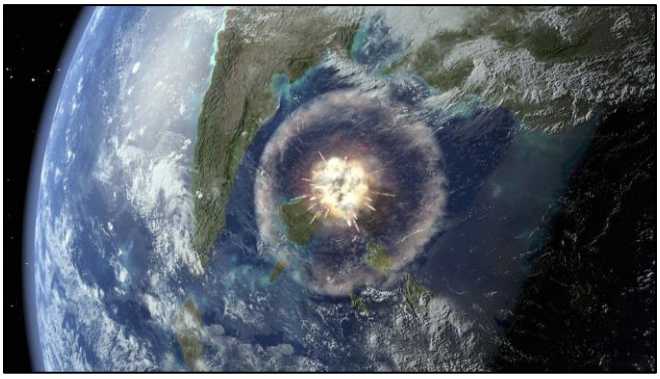
Dinosaur-killing asteroid strike gave rise to Amazon rainforest

3 April 2021

BBC Science



The asteroid impact 66 Ma ago led not just to the extinction of dinosaurs, but other forms of life. (IMAGE COPYRIGHT: SPL)

The asteroid impact that killed off the dinosaurs gave birth to our planet's tropical rainforests, a study suggests.

Researchers used fossil pollen and leaves from Colombia to investigate how the impact changed South American tropical forests.

After the 12 km-wide space rock struck Earth 66 Ma ago, the type of vegetation that made up these forests changed drastically.

The team has outlined its findings in the prestigious journal *Science*.

Co-author Dr. Mónica Carvalho, from the Smithsonian Tropical Research Institution in Panama, said: "Our team examined over 50,000 fossil pollen records and more than 6,000 leaf fossils from before and after the impact."

They found that cone-bearing plants called conifers and ferns were common before the huge asteroid struck what is now the Yucatan Peninsula in Mexico.

But after the devastating impact, plant diversity declined by roughly 45% and extinctions were widespread, particularly among seed-bearing plants.

While the forests recovered over the next six Ma, angiosperms, or flowering plants, came to dominate them.

The structure of tropical forests also changed as a result of this transition. During the late Cretaceous Period, when the dinosaurs were still alive, the trees that made up the forests were widely-spaced. The top parts did not overlap, leaving open sunlit areas on the forest floor.

But post-impact, forests developed a thick canopy that allowed much less light to reach the ground.

So how did the impact transform the sparse, conifer-rich tropical forests of the dinosaur age into the rainforests of today, with their towering trees dotted with multi-coloured blossoms and orchids?

Based on their analysis of the pollen and leaves, the researchers propose three different explanations:

- Firstly, dinosaurs could have kept the forest from growing too dense by feeding on and trampling plants growing in the lower levels of the forest.
- A second explanation is that falling ash from the impact enriched soils throughout the tropics, giving an advantage to faster-growing flowering plants.
- The third explanation is that the preferential extinction of conifer species created an opportunity for flowering plants to take over.

These ideas, say the team, aren't mutually exclusive, and could all have contributed to the outcome we see today.

"The lesson learned here is that under rapid disturbances... tropical ecosystems do not just bounce back; they are replaced, and the process takes a really long time," said Dr. Carvalho.

Reference:

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Skull of dinosaur called 'one who causes fear' found in Patagonia

31 March 2021

BBC Science

Scientists in southern Argentina have found the skull of a large meat-eating dinosaur named "one who causes fear" in the local Mapuche language.

The horned *Llukalkan aliocranianus* was around 5 m long and roamed South America 85 Ma ago.

Researchers found remains nearby of another carnivorous dinosaur, something they said was highly unusual. The findings from Patagonia were published on Tuesday, 30 March.

An artist's impression of Llukalkan aliocranianus. (Image credit: Reuters)

Like the Tyrannosaurus rex, the Llukalkan dinosaur was two-legged with very short arms but was medium-sized compared to the giant T. rex. It also had short horns and tiny fingers. It was estimated to weigh between one and five tonnes, slightly lighter than an adult African elephant.

It was probably a fearsome predator, with a large skull and a strong bite, according to the research published in the *Journal of Vertebrate Paleontology*.

The findings suggest it had better hearing than other dinosaurs in the abelisaurids family which likely made it a better hunter, Federico Gianechini, a palaeontologist at the National University of San Luis Argentina told Reuters news agency.

It lived on earth during the Cretaceous period, the last era before dinosaurs were wiped out.

Close to Llukalkhan's skull, scientist found the fossilised remains of a slightly larger meat-eating dinosaur called *Viavenator exxoni*.

Mr. Gianechini said it is very unusual to find two abelisaurids living close together at the same time.

"Llukalkan was a little smaller than Viavenator, although, if they lived together, they surely shared the same ecological niche and fed on the same prey, so they would have competed with each other and - why not - even eaten each other," he told Reuters.

Reference:

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Vesuvius killed people of Pompeii in 15 minutes, study suggests

Cloud of ash and gas engulfed Roman city within minutes and suffocated inhabitants, research says

22 March 2021

Lorenzo Tondo in Palermo
The Guardian

The peak of Mount Vesuvius is seen from the streets of the archaeological site in Pompeii, Italy, in February. (Photograph: Cesare Abbate/EPA)

A giant cloud of ash and gases released by Vesuvius in 79 AD took about 15 minutes to kill the inhabitants of Pompeii, research suggests.

The estimated 2,000 people who died in the ancient Roman city when they could not escape were not overwhelmed by the lava, but rather asphyxiated by the gases and ashes and later covered in volcanic debris to leave a mark of their physical presence millennia later.

The study by researchers from the Department of Earth and Geo-environmental Sciences of the University of Bari, in collaboration with the National Institute of Geophysics and Volcanology (INGV) and the British Geological Survey in Edinburgh, has revealed the duration of the so-called pyroclastic flow, a dense, fast-moving flow of solidified lava pieces, volcanic ash and hot gases that hit the ancient Roman city minutes after the volcano erupted.

The lethal cloud had "a temperature of over 100 degrees and was composed of CO2, chlorides, particles of incandescent ash and volcanic glass", said Roberto Isaia, senior researcher of the Vesuvius Observatory of the INGV. "The aim of the work was to develop a model to try to understand and quantify the impact of pyroclastic flows on the inhabited area of Pompeii, about 10 km from Vesuvius," he added.

The study confirms that the inhabitants had no escape, and most of those who died suffocated in their homes and beds, or in the streets and squares of the city. Isaia's model estimates the gases, ash and volcanic particles would have engulfed the city for between 10 and 20 minutes.

"It is probable that dozens of people died due to the rain of lapilli that fell on Pompeii after the eruption, but most of them died of asphyxiation," Isaia said, adding the pyroclastic flow would have reached Pompeii a few minutes after the explosion.

"Those 15 minutes inside that infernal cloud must have been interminable. The inhabitants could not have imagined what was happening. The Pompeiians lived with earthquakes, but not with eruptions, so they were taken by surprise and swept away by that incandescent cloud of ash."

The INGV research described pyroclastic flows as "the most devastating impact" of explosive eruptions. "Comparable to avalanches, they are generated by the collapse of the eruptive column. The resulting volcanic ashes run along the slopes of the volcano at speeds of hundreds of kilometres per hour, at high temperatures and with a high concentration of particles."

View of Mount Vesuvius from the forum in Pompeii (Credit: M Caulfield 29 July 2008)

Today, the ruins of Pompeii are Italy's second-most visited archaeological site, after the Colosseum in Rome and, last year, attracted about a million tourists.

"It is very important to be able to reconstruct what happened during Vesuvius's past eruptions, starting from the geological record, in order to trace the characteristics of the pyroclastic currents and the impact on population," said Prof Pierfrancesco Dellino of the University of Bari.

"The adopted scientific approach in this study reveals information that is contained in the pyroclastic deposits and that clarifies new aspects of the eruption of Pompeii and provides valuable insights for interpreting the behaviour of Vesuvius, also in terms of civil protection."

Definition:

Lapilli: Pyroclastic fragments or tephra ranging in size from 2 to 64 mm. Lapilli may be composed of primary magmatic material (e.g., pumice), accessory lithic material, accidental lithic material, or accretions of wet ash-size material (accretionary lapilli). The size-term 'lapilli' is usually applied to the lithological clast type to give descriptive terms, e.g., 'pumice lapilli' or 'accessory lithic lapilli'.

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Newfound meteorite could help unlock secrets of the solar system

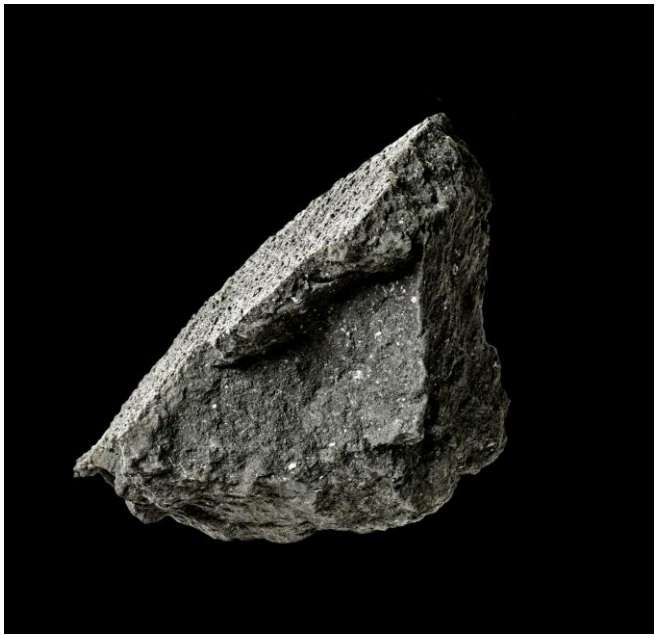
The incredibly rare space rock recovered in the U.K. could help scientists answer questions about how Earth got its water and maybe even how life here got started.

11 March 2021

By Robin George Andrews
National Geographic

On the night of February 28, a rocky shard fell from the sky and lit up the atmosphere above England. The impressive fireball was caught by an international network of meteorite-tracking cameras, and scientists were dispatched to the sleepy town of Winchcombe. A chunk of the meteorite was found on a driveway, while another was discovered in a field full of sheep droppings.

About 18 ounces of space rock have been found so far, all of which was promptly delivered to a select few scientific institutions—chiefly London's Natural History Museum—for preliminary analysis. Speedily transporting the samples to the laboratories was crucial to ensuring that Earth's environment didn't significantly alter the chemistry of these near-pristine materials from space.



A chunk of the meteorite that has been recovered from Winchcombe. (Photograph from Trustees Of The Natural History Museum, London)

It turns out that the meteorite—the first found in the United Kingdom in 30 years—is a rather rare type known as a **carbonaceous chondrite**. These ancient fragments contain not only the building blocks of planets, but also compounds that may help explain how Earth got its water or even provide clues for how life itself got started.

"This is like the magic type of meteorite that lots of people are completely fascinated by," says Katherine Joy, a meteorite expert at the University of Manchester.

Strangely, at first glance, the chemistry, minerals, and textures of the meteorite don't seem to belong to any one type of carbonaceous chondrite. Each of the fragments studied so far appears to be a little different from the others.

"Could it be a new meteorite type, a new meteorite class, something we've never seen before?" asks Luke Daly, a meteorite expert at the University of Glasgow. It's an intriguing possibility, but additional research is needed to say one way or the other.

The scientific work on what will likely become known as the Winchcombe meteorite has only just begun. But the rarity of the meteorite, combined with the speed with which it was recovered, has

caused the meteorite community to explode with jubilation.

“We’ve all just gone bananas,” says Sara Russell, a planetary scientist at London’s Natural History Museum. “For our meteorite group, it’s the most important acquisition, I would say, ever.”

Time capsules from above

Meteorites smash into Earth all the time, but most are not big enough to announce themselves with a fireball. Even when they do, many tumble into the oceans. The vast majority of collected meteorites are found in deserts, particularly the cold desert of Antarctica, a huge expanse where conveyor belt-like ice flows deposit space debris in specific areas, and the continent’s white hues allow black meteorites to easily stand out.

The UK is small, so meteorites don’t strike the islands often, and it is full of cities and vegetation, making meteorites difficult to find. But occasionally space rocks serendipitously fall right in front of people’s noses. On Christmas Eve 1964 a meteorite “bounced off a driveway, through someone’s window, and landed under their Christmas tree,” says Matthew Genge, a meteorite expert at Imperial College London.

In recent years, meteorite hunters in the UK have improved their odds by setting up cameras designed to spy fireballs, which are used to work out where the fragments fall to Earth. Over the past decade, six different networks of sky-facing cameras, run by both amateur and professional researchers, have been integrated into the UK Fireball Alliance.

These cameras “are pointing at the sky the whole time,” always recording, looking out for any notable flashes or objects streaking through the sky, says Jim Rowe, the group’s organiser. During the pandemic, he wrote computer code that ensured these individual networks could communicate with each other to track any objects falling from above.

The system has captured occasional fireballs over the past five years or so, but the impact sites were not convenient for collection. A few years ago, “there was a fireball that dropped a meteorite directly into the North Sea,” Daly says, missing the surrounding lands of the UK, northern Europe, or Norway where it could have been recovered.

Welcome to Winchcombe

At the end of February, after years of watching and waiting, a six-second fireball was caught throwing meteorite fragments across Gloucestershire, a county in southwest England. The trajectory was immediately analysed by a team of international researchers working with the UK Fireball Alliance, the likely impact zone was determined, and experts from across England descended upon the town of Winchcombe and the surrounding region.

After a few days of looking around, scientists notified the local press and asked the public to help them find any odd-looking rock fragments. People from across the country sent experts countless photographs of possible fragments.

One family awoke to find black rock fragments and soot-like spatter on their driveway. After hearing about reports of a fireball, they quickly figured out the debris was meteoritic, and they contacted the UK Meteor Observation Network. Just 12 hours after impact, a large chunk of the meteorite had already been bagged up, ready to be collected by the experts.

“What a generous thing, to recognise how important this is for science and want to contribute to that,” Joy says.

Daly and his girlfriend Mira Ihasz joined a group combing through a nearby field riddled with sheep droppings. As a rock streaks through Earth’s atmosphere, material melts and then hardens into a black shell, and the dark hues of the sheep dung inconveniently resembled the scorched crust of meteorites.

“Another promising poo, as we started to call them,” Daly says. But after five days of searching, Ihasz stumbled upon the real deal.

The chunk was found within 400m of where the models said fragments should have landed—a remarkable degree of accuracy, but not precise enough for the modellers, who according to Daly expressed some disappointment that their prediction was not more accurate.

‘A mud ball from the beginning’

Preliminary work determined that the meteorite was a carbonaceous chondrite: rocky objects as old as the solar system that are named for their carbon-rich compositions. Such space rocks are rare. Out of the 65,209 meteorites catalogued, just 2,639 are carbonaceous chondrites.

Most meteorites’ precise origins remain a mystery. But thanks to the Winchcombe meteorite’s well-documented Earthbound trajectory, it was traced

back to the outer rim of the asteroid belt, between Mars and Jupiter.

“Knowing where this thing came from, and what it is, is very special,” Joy says. This knowledge makes it easier to work out what type of asteroid the meteorite broke away from, and it also helps scientists better understand the sorts of disturbances in space that can send rocks hurtling our way.

Although the Winchcombe meteorite shows characteristics of multiple types of carbonaceous chondrites, which means this could be something entirely novel, the initial chemical analysis pegged it as a CM-type. These meteorites contain (among other things) abundant water-containing minerals.

“It’s a mud ball from the beginning,” says Genge of Imperial College London. Only 652 of them have ever been found.

Compared to most other types of meteorites, CM chondrites “are incredibly delicate,” Daly says. The minerals inside degrade quickly in Earth’s wet atmosphere, so if left exposed to the elements for long, “these things just turn to dust.”

“The fact that it is so fragile and delicate, and the fact that it was collected so quickly, was critical,” Joy says. “This one was bagged and back at the museum within 36, 48 hours of it falling, which just doesn’t happen very often.” The quick recovery means its ingredients have been nearly perfectly preserved—and they will have plenty to reveal about the early solar system and the lush planet we live on today.

Secrets of Earth and space

One secret hidden in rocks like the Winchcombe meteorite has to do with how Earth got such vast quantities of water. The giant impact with our planet that led to the formation of the moon some 4.5 Ga ago likely stripped away much of the water that Earth started with.

Whether the surface water we have today mostly came from within the planet and escaped through volcanic eruptions, or whether it was primarily delivered by soggy asteroids is a matter of debate. By studying the hydrated minerals in carbonaceous chondrites, Russell says, we may discover which process filled the oceans of our modern world.

CM chondrites also generally contain many different organic molecules, including amino acids and sugars, and this meteorite is expected to be no different. Asteroids bombarding the early Earth would have brought this organic matter with them, perhaps depositing the materials needed for the first living organisms to form.

“That organic chemistry may well have accelerated the origins of life on Earth,” Genge says.

Meteorites can also tell us about the time before Earth formed. The Winchcombe meteorite contains features known as calcium-aluminium-rich inclusions, or CAIs. “They’re the oldest solids in the solar system, which of course is the most amazing, cool thing,” Russell says.

The chemistry of CAIs suggests they all formed at the same time and place, 4.56 Ga ago, right next to the sun, before ending up wedged in rocky material that clumped together in the cold recesses of the outer solar system. The dramatic, outward journey of this material isn’t easy to explain, but gathering more CAIs will help unravel how matter moved and mixed as planets were forming and the solar system was evolving to its modern form.

CM chondrites also often contain substances like graphite and diamond grains that are, rather remarkably, older than solar system itself. Their chemistry is so distinct from anything found within our solar system that scientists believe they came from the atmospheres of giant stars or formed in supernovae explosions before drifting to our still-forming cosmic neighbourhood.

Such grains were “blown out into the universe, floating around for hundreds of millions of years, and then collapsing inwards to form our solar system” Genge says. While these primordial gems have not yet been identified in the Winchcombe meteorite, scientists fully expect that, like other CM chondrites, it contains grains that pre-date the solar system.

The Winchcombe meteorite could therefore hold not only clues to the history of our neighbourhood around the sun, but also the ghosts of other planetary systems lost to time—and the international effort to decode its many secrets has only just begun.

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A month on Mars: what NASA's Perseverance rover has found so far

No signs of past life have emerged yet, but rocks at the landing site show signs of having been shaped by wind and water.

16 March 2021

Alexandra Witze
Nature News

NASA's Perseverance rover has had a busy first month on Mars' surface. From Jezero Crater, where Perseverance landed on 18 February, it has been doing as much geology as it can — snapping pictures of its surroundings and analysing the rocks nearby. Already, team scientists have determined that several of the rocks are chemically similar to volcanic rocks on Earth, and that wind and water have eroded some of them.

"Everything is going great so far," said Kenneth Farley, a geochemist at the California Institute of Technology in Pasadena and the mission's project scientist. He and others described Perseverance's progress on 16 March at a virtual meeting of the Lunar and Planetary Science Conference.

As planned, the rover's main science experiments will have to wait a few more months, while engineers continue to test its scientific instruments and prepare for the first helicopter flight on another world. Eventually, Perseverance will deploy an arsenal of tools, including a drill bit, a close-up camera and multiple chemical sensors to hunt for signs of past life in Martian rocks.

Perseverance took its first drive on Martian soil on 4 March. (Credit: NASA/JPL-Caltech)

In the meantime, team scientists are plotting how the rover might travel from its landing site — recently named after the late science-fiction writer Octavia Butler — to the 40-metre-high cliffs of the ancient river delta that was the reason for Jezero's choice as landing site in the first place. The delta, deposited billions of years ago by a river flowing on Mars, would have been an ideal landscape for ancient microbial life, had such life existed. But a treacherous dune field, which the rover cannot cross, lies between Perseverance and the delta. Researchers are discussing whether to drive the rover clockwise or counter-clockwise around the dune field; the latter would make for a shorter trip, but the former would take Perseverance past a greater variety of interesting rocks.

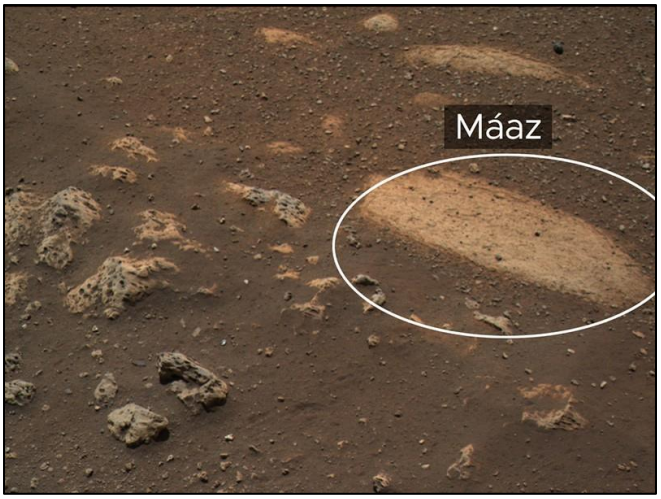
None of this is likely to happen, however, until June at the earliest. First, Perseverance must drive to a suitable spot for it to test Ingenuity, its helicopter. This place will probably be a rock-strewn area not too far from the rover's current location. There, the rover will lower Ingenuity from its belly, drive off a safe distance and shoot a video as the helicopter takes to the Martian skies. "We're looking forward to those historic, aviation-first movies," said Jim Bell, a planetary scientist at Arizona State University in Tempe who leads one of the rover's camera teams. The helicopter test comes first because Ingenuity will fly with the rover as it drives, helping Perseverance to navigate its way across the landscape.

Until that first flight test, which is expected no earlier than the first week in April, team scientists will continue to explore the rocks around the landing site. Immediately surrounding the rover are lighter-coloured rocks peeking out from dark soil. Perseverance has used a laser-based instrument to determine that several of these rocks, including two that team scientists named Máaz and Yeegho, are chemically similar to basaltic rocks on Earth, which form from molten rock. The instrument zaps rocks with a laser to vaporize small portions and study their chemical make-up. Through this analysis, the scientists have seen that Yeegho shows signs of having water locked up in its minerals, said Roger Wiens, a geochemist at Los Alamos National Laboratory in New Mexico who is head of the laser-instrument team. These discoveries fit with what scientists had expected from Jezero — that it might have volcanic rocks on the crater floor, which could have interacted with water over time.

Many of the rocks around the landing site seem to have been sculpted by strong winds; one of these rocks is a dark, odd-shaped object that scientists

have dubbed the harbour seal, for its similarity to a seal perching on a rock. The winds seem to have scoured the rocks mainly from the northwest, a direction that matches the major wind patterns calculated by global circulation models for Mars, said Bell.

Another dark-coloured rock looks as if it has been weathered not by wind but by water, said Farley. That suggests it could have been tumbled around in running water — perhaps in the ancient river flowing into Jezero, or in its lake. “This is quite promising for our study,” he said.



Máaz is one of the rocks that Perseverance has so far studied with a laser-based instrument. The rover has determined it is chemically similar to basaltic rocks on Earth. (Credit: NASA/JPL-Caltech)

Perseverance scientists have been giving informal names to rocks, craters and other objects around the landing site using the Navajo, or Diné, language, which is spoken by many Native Americans in the southwestern United States. Following a tradition from earlier Mars landings, the scientists are choosing themes for names based on geological maps of Jezero, which are divided into sections named after national parks on Earth. Perseverance happened to land in the section named after Canyon de Chelly National Monument, which is in Arizona on Navajo tribal lands. Aaron Yazzie, an engineer on the rover team, is a member of the Navajo Nation and has led the effort to coordinate the names. Máaz, for instance, means Mars, while Yeehgo is an alternative spelling of the word for ‘diligent’.

After the helicopter test, and before Perseverance sets off for the delta, the rover will probably drill its first rock sample into the dark, fractured rock that makes up much of the Jezero Crater floor. Scientists have not yet determined whether this rock is volcanic — but if it is, it could help to determine the age of the crater floor. That’s because molten rock traps radioactive elements that decay at a predictable rate and can be used as a clock to date when the material was originally molten.

During its mission, Perseverance will collect approximately 30 tubes full of Martian rock and soil, laying them down on the Martian surface for a future mission to retrieve and fly back to Earth for scientists to analyse. When this happens, no earlier than 2031, it will be the first time that a sample has ever been returned from Mars.

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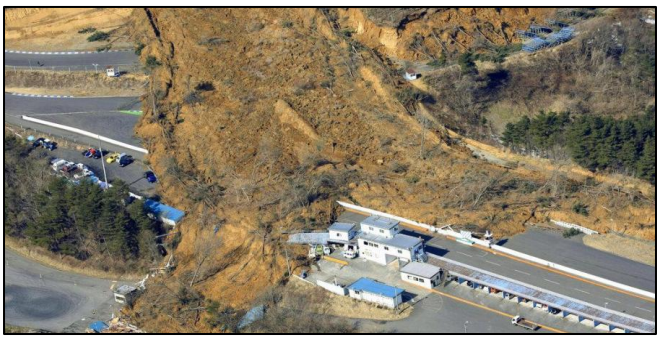
The Fukushima quake may be an echo of the 2011 disaster — and a warning for the future

15 February 2021

Mark Quigley, Associate Professor of Earthquake Science, University of Melbourne

A 7.1 magnitude earthquake was recorded off the coast of Fukushima Prefecture in north-eastern Japan on Saturday night (13 February 2021), injuring around 100 people, closing roads and trains, and leaving almost a million people without electricity overnight.



Powerful Japan quake sets off landslide, minor injuries. (Image: Geology Science)

It came almost 10 years after the nearby Tohoku quake of March 2011, a magnitude 9.0 earthquake that caused a catastrophic tsunami and resulted in thousands of deaths and a nuclear reactor meltdown.

In the hours after Saturday’s quake, there were several aftershocks up to magnitude 5, and officials warned there could be more to come.

The Japan Meteorological Agency said the quake itself was an aftershock of the 2011 event. That might seem odd, but aftershocks of a major earthquake can persist for years and even decades.

How do you know if it's an aftershock?

The earthquake occurred in what's called a "subduction zone", where the Pacific tectonic plate slides under the plate on which northern Japan sits at a rate of 7 to 10 cm per year. It's an area where there are a lot of earthquakes. It was a structurally simple earthquake: what's called a "thrust" or "reverse slip" quake, in which rock above the fault moves up and over the rock below the fault.

In areas with low seismic activity, we can recognise aftershock patterns for years and decades after a major quake. The Christchurch earthquake of 2016, for example, was an aftershock of the 2010 quake. Some scientists think aftershock sequences in regions like the eastern USA and Australia may persist for centuries.

In these seismically quiet places, it's relatively easier to spot aftershocks. The main hallmark is that the rate of quakes in an area is higher after a major quake than it was before. When the rate of quakes has dropped back to what it was originally, we say the aftershocks have stopped.

However, in places like Japan with high seismic activity, it can be hard to say whether one earthquake is an aftershock of another.

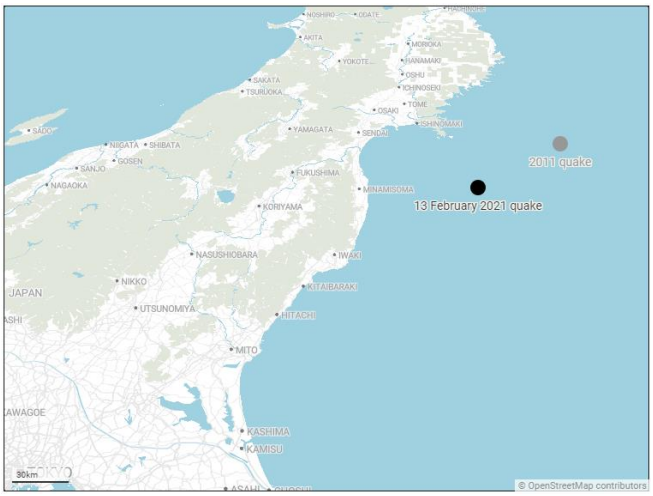
On the one hand, the rates of aftershocks reduced to pre-2011 rates within about 3 years of the Tohoku earthquake and thus the sequence may have concluded.

On the other hand, rates of seismic activity were continuing to decrease in a fashion consistent with an ongoing aftershock sequence. And Saturday's earthquake appears to have occurred in an area that generated fewer immediate aftershocks following the 2011 event, suggesting this earthquake could have occurred as rupture of a remaining "sticky part" of the 2011 fault that generated the Tohoku earthquake.

So, was this an aftershock?

It's certainly plausible that Saturday's quake was an aftershock.

The 2011 quake was enormous — the largest ever recorded in Japan, and the fourth-largest worldwide since modern record-keeping began around 1900. It released around 1,000 times as much energy as Saturday's earthquake, and created a rupture more than 500 km long with 10's of meters of slip. But the slip on the fault was not uniform and seismic activity continued in some areas that did not fail entirely in that earthquake.



Epicentres of the 2021 and 2011 quakes. (Map: The Conversation. Source: ISGS)

Given all this, it's almost certain there will be some relationship between the two quakes.

What's more, there have been relatively few aftershocks of the 2011 quake close to where this one happened. This suggests it might have been a "balancing out" of stresses.

On the other hand, there have been several magnitude 7 quakes over the past century within 100 km or so of this one, so it's hardly out of the ordinary.

A definite answer on whether this was an aftershock or not will require detailed analysis of the quake and others in the region.

What we can learn from this?

A quake like this one can be a valuable reminder of how important it is to learn the lessons of a disaster.

The earthquake generated very strong shaking in areas of Japan that were severely affected by the 2011 earthquake shaking and tsunami. Effects such as liquefaction are likely to have occurred again.

People sometimes think a big quake relieves stress built up in Earth's crust and you can relax afterwards. In reality, it's the opposite. When you have a big quake, there's a higher probability you'll have more to come. Subsequent earthquakes, whether they adhere to statistical definitions of

aftershocks or not, can induce recurrent hazards that cause more damage to buildings and infrastructure and present risks to human life.

After a disaster, it is critical to act to reduce future exposure and vulnerability to future disasters through actions such as more considered land-use planning informed in part by better maps of seismic hazards, enhancing coastal protection through engineering of sea-walls and breakwaters and using vegetation, and making sure that warning and evacuation protocols are efficient and effective.

Japan is a world leader in many of these aspects, and the lessons learned from Tohoku are likely to have generated outcomes that minimised some of the loss and damage that could have otherwise occurred from Saturday's earthquake.

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Queen's property manager and Treasury to get windfarm windfall of nearly £9bn

BP among the winners in auction of offshore seabed rights for next decade

8 February 2021

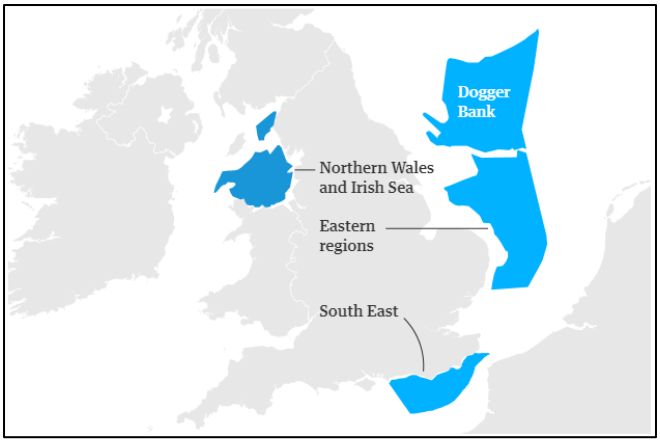
Jillian Ambrose

The Guardian

The Queen and the Treasury will receive an offshore windfarm windfall of almost £9bn over the next decade, after a major auction of seabed plots attracted runaway bids from energy companies including the oil company BP.

The crown estate's first auction of its seabed licences in a decade will earn the Queen's property manager £879m a year, for up to 10 years, and clear the way for six new offshore windfarms and enough clean electricity generation for more than 7m homes.

The windfall will more than double the profits made by the crown estate, which reported a net revenue of £345m for the last financial year, after it received record-breaking bids from energy companies hoping to build offshore windfarms off the coast of England and Wales.



The Crown Estate plans to offer new lease for windfarms in four seabed regions. (Image: Guardian graphic. Source: The Crown Estate)

The most lucrative bids were made by BP and its partner, Germany utility EnBW, for two offshore windfarm licences with a total capacity of 3 giga-watts in the Irish Sea. The seabed licences are worth £462m a year to the crown estate, or £4bn over the 10 years it usually takes to develop these projects. However, BP claims it will be able to make a final investment decision on the project in four years and begin generating electricity after seven.

The developers will effectively pay the crown estate "rent" on the option to develop the area each year until the project can agree to a permanent lease. This money will be handed to the Treasury before 25% is returned to the royal household in the form of the sovereign grant, meaning the Queen will directly benefit from the UK's renewable energy boom.

The sovereign grant was increased in 2017, from its previous level of 15%, to pay for extensive renovations at Buckingham Palace. It will stay at 25% at least until the next five-year review in 2021-22.

The renewable energy arm of Germany's RWE was another big winner in the auction after scooping up licences for two offshore windfarms in the Dogger Bank area off the coast of North Yorkshire.

The size of the crown estate's windfall has reignited calls for the profits of the offshore wind industry to be channelled into a "green sovereign wealth fund" that could invest in more green energy projects or local communities.

The Green party co-leader, Jonathan Bartley, said the initial capital from a renewable windfall could be invested "for future generations, similar to what

we've seen the likes of Alaska and Norway do in the past with their oil wealth".

"The boom in value of the right to develop offshore wind is so welcome – a signal that the transition away from fossil fuels is happening at speed. But we need to ensure that the value of this national resource is shared fairly and invested for all our futures," he said.

The crown estate had hoped to avoid a "runaway" auction by overhauling the auction rules in 2019, but industry players have said the changes did not go far enough and allowed for "bonkers" prices that could inflate the cost of the UK meeting its climate targets.

Anne-Marie Trevelyan, the energy minister, said the crown estate's latest leasing round would help power 7m homes and assist the UK in eliminating its contribution to carbon emissions by 2050 while "creating thousands of new jobs and ensuring Britain builds back greener".

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Medieval oil wells found in Guildford?

2 February 2021

Graham Dean

PESGB Newsletter

St Catherine's Chapel, on top of the hill, was built in the late 13th century in the reign of Edward I. (Image: Archaeology South East)

Have medieval oil wells been discovered in Guildford?

Excavations dating from medieval times have been discovered by workmen from Network Rail on the historic St Catherine's Hill on the southern edge of Guildford.

The workings were revealed during remedial work after a landslip in December closed the Guildford to Portsmouth rail line. The regrading had started on the sandy slopes above the railway tunnel that was bored through the hill in the mid-19th century.

Over the years evidence has been discovered of more distant human activity on the hill in the Iron Age, Bronze Age and even Mesolithic (middle Stone Age) periods.

Images taken from the medieval workings show a Gothic niche decorated in dots with a Calvary cross nearby.

Landslip on the Guildford to Portsmouth line & small cave believed to be a medieval shrine or hermitage. (Image: Archaeology South East)

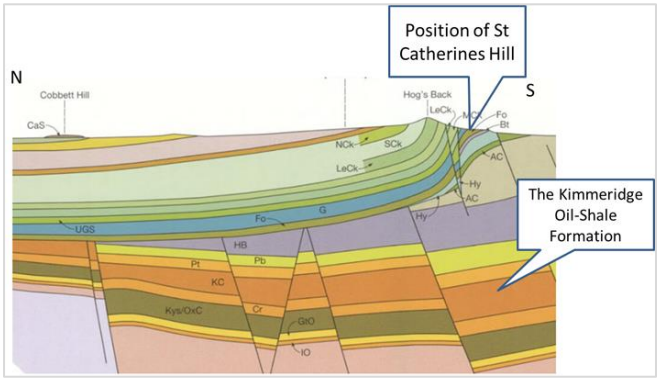
A spokesperson from Archaeology South East, said: "The cave contained what appear to be shrines or decorative niches, together with carved initials and other markings. The old name for St Catherine's Hill is Drakehull 'The Hill of the Dragon', so this has obviously been a site of ritual significance long before the construction of the church on the top of the hill in the late 13th century."

The sandstone workings are made up of several sections ranging from 0.3 m to about 0.7 m high. The small width of the workings has given rise to speculation that the workings may be medieval "horizontal oil wells" dug into the side of the hill in an attempt to pool and collect the oil that seeps to the surface at St Catherine's.

Today the oil comes to the surface only occasionally as an oil sheen on a spring in one of the private gardens at the bottom of the hill but in earlier times the flow of oil may have been much greater. The oil source is likely to be the underlying Jurassic Kimmeridge and if so might hint that the shale is geochemically more mature than previously assumed.

The Dragon Hill name could derive from the presence of oil and gas. Gas seeping from the ground sometimes ignites and burns continuously.

If this happened on St Catherine's Hill it would be easy to imagine a fire-breathing dragon lurking beneath.



A geological N-S cross section showing the position of St Catherine's south of the North Downs Hogs Back Hill. The oil has been squeezed out of the underlying Kimmeridge Oil-Shale (Clay) Formation and rises to the surface over geological time. (Image: Graham Dean/PESGB)

The oil seep is probably why the hill is named after St Catherine. In the middle ages the monks of St Catherine's monastery in Sinai in Egypt collected and sold oil from an oil seep. They marketed the oil as the tears of St Catherine. The oil was hugely popular as it was claimed to heal leprosy and many other complaints. Oil does not cure leprosy, but it did help clear up skin rashes that were very common during medieval times. One of the reported miracles of Edward the Confessor was that he rubbed some of the oil on a man's face to cure him.

In medieval times demand for St Catherine's oil was so large that oil seeps across Europe were rebranded in the name of St Catherine. One example is St Catherine's Well in Liberton in Edinburgh. The Edinburgh oil well had a chapel similar to the Guildford chapel until Oliver Cromwell banned oil production. The Saint Catherine cult was especially popular in Normandy and in Norman times many English churches had a shrine to St Catherine, but the cult seemed to wane in England in the years just before the reformation.

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Dinosaur footprint found by girl, four, on Barry beach

29 January 2021

BBC Science

A well-preserved dinosaur footprint has been discovered by a four-year-old girl on a beach.

Lily Wilder spotted it at Bendricks Bay, Barry, in the Vale of Glamorgan - and scientists believe it could help establish how they walked.

The footprint, spotted in January, is 220 Ma old and had been preserved in mud.

While it is impossible to tell what type left it, the print is 10 cm long and likely from a 75 cm tall dinosaur.

Dinosaur footprint dates back 220 Ma. (IMAGE COPYRIGHT NATIONAL MUSEUM WALES)

National Museum Wales palaeontology curator Cindy Howells described it as "the best specimen ever found on this beach".

"It was Lily and Richard (her father) who discovered the footprint," said mum Sally. "Lily saw it when they were walking along and said, 'daddy look'. When Richard came home and showed me the photograph, I thought it looked amazing. Richard thought it was too good to be true. I was put in touch with experts who took it from there."

The dinosaur which left it was described as "a slender animal" which would have walked on its two hind feet and actively hunted other small animals and insects.

Similar footprints in the USA are known to have been made by the dinosaur *Coelophysis*.

Specimens found at Bendricks Bay in the past are thought to be from more crocodilian-type reptiles rather than dinosaurs.

Special permission had to be sought from Natural Resources Wales to legally remove the footprint, with the fossil extracted this week and taken to National Museum Cardiff where it will be preserved.

Dinosaurs first appeared about 230 Ma ago, with the footprint shedding light on an early point in their evolution, when the different groups of dinosaurs were first diversifying.

"Its spectacular preservation may help scientists establish more about the actual structure of their feet as the preservation is clear enough to show individual pads and even claw impressions," National Museum Wales said in a statement.

Why is the area important?

The Bendricks is a stretch of coastline between Barry and Sully in the Vale of Glamorgan.

It is an important palaeontologist site and a site of special scientific interest.

The south Wales group of the Geologists' Association called it "the best site in Britain for dinosaur tracks of the Triassic Period".

It said: "The footprints can be difficult to see. Many are covered at high tide so it is best to go after high tide when the tracks may retain small puddles of water.

"It is also easier to spot the footprints when the sun is low in the sky as longer shadows will help throw the footprints into relief."

Reference:

https://www.bbc.co.uk/news/uk-wales-55863928

Rock collector finds rare gemstone that looks like Cookie Monster

28 January 2021

Stephanie Pappas

Thanks to Suzanne Millar for providing the reference to this article.

You never know what you're going to get when you crack open a geode-like rock called an agate, but a new specimen is even more surprising than usual: it looks just like **Cookie Monster**.

The agate, found in Soledade, a precious stone hotspot in southern Brazil, is a dead ringer for the blue, googly-eyed Sesame Street Muppet. After its owner, California mineral collector Mike Bowers, posted about the agate on Facebook, it went viral, with write-ups in newspapers from Australia to Israel to the United States.

A rock collector in Brazil found this agate, a type of volcanic rock, that looks just like Cookie Monster. (Image: Live Science)

"I didn't realize that Cookie Monster was so well known and part of the world cultural heritage!" Bowers told *Live Science*. He's since been contacted by the actor who plays Cookie Monster on "Sesame Street," he said.

The agate came to Bowers in November via Brazilian gemologist Lucas Fassari, who had acquired it in a batch of many agates from Soledade. Bowers immediately purchased the Cookie Monster agate, but didn't post it online until 16 January, as he was ill with COVID-19.

Agates are a form of quartz, the crystalline form of silicon dioxide, that develop within cavities in volcanic rocks. The cavities are formed by gas bubbles in hot lava. Over time, as the lava cools, water infused with silicon dioxide percolates through the cavities. As the water evaporates, the silicon dioxide is left behind on the cavity walls, creating colourful layers of crystals. The colours are caused by chemical impurities in the silicon dioxide and by the spacing of the crystals.

Some agates completely fill their volcanic voids, but many leave small spaces inside, lined with sparkly, inward-facing quartz crystals. In the case of the Cookie Monster agate, these voids just happen to look like a pair of Muppet eyes and an enthusiastically grinning mouth.

"It is somewhat uncommon to find a face shape in agates, but in many instances it's like looking at the clouds. You kind of see a face," Bowers said. "What makes the Cookie Monster unique is there is just no doubt: clear-cut, it is Cookie Monster, no explanation required."

Another unique feature of the Cookie Monster agate is that the face appears on both sides of the

cut stone, Bowers added. Usually, the voids are not lined up so neatly as to create a mirror image.

For now, Bowers said, he plans to keep the stone. It may eventually end up in a museum or in the hands of a high-end collector, he said. "It is totally unique and awesome to see everyone loving this stone as much as we do" he said.

Reference:

Originally published on *Live Science*.

https://uk.news.yahoo.com/rock-collector-finds-rare-gemstone-143455756.html

Dinosaur fossils found in Argentina could belong to largest creature ever to have walked the Earth

Titanosaur in Patagonia 'probably exceeds' largest known land animal, palaeontologists say

18 January 2021

Harry Cockburn,
Independent

A new and gigantic dinosaur which could rival the largest known species is being unearthed in Argentina.

A collection of bones found in Neuquén Province in northwest Patagonia have been identified as those from the sauropod family of dinosaurs, which had immensely long necks and tails, pillar-like legs, and includes species that grew to the largest sizes of land animals known to have ever existed.

However, the remains are not a complete skeleton, and consist mainly of pelvic bones and vertebrae, only giving an indication of the enormous scale of the animal.

The authors of a paper presenting the research on the find published in the journal *Cretaceous Research* suggest the animal could come from a previously unknown population of Patagonian sauropods.

The closest relative is *Andesaurus*, a type of "super-sized titanosaur" which existed during the middle of the Cretaceous Period in South America. These large sauropods grew to be 18 m long.

However, the fossilised bone fragments indicate the new titanosaur was far larger, easily exceeding *Andesaurus* in size and likely making it bigger than the largest known land animals, the *Patagotitan* and *Argentinosaurus* - both types of sauropods.

The new specimen is "considered one of the largest sauropods ever found, probably exceeding *Patagotitan* in size", the authors said.

The dig team uncovering fossils of the 98 Ma titanosaur in Neuquén Province, Argentina. (Photo credit: Alejandro Otero and José Luis Carballido/CONICET)

Patagotitan was only announced by palaeontologists in 2014, after the first bones were uncovered in Patagonia in 2013. It is believed to have weighed almost 60 tonnes, reached lengths of over 31 m and at the time, experts said: "Given the size of these bones, which surpass any of the previously known giant animals, the new dinosaur is the largest animal known that walked on Earth."

The researchers said: "The record of super-sized titanosaur sauropods has traditionally been extremely fragmentary, although recent discoveries of more complete taxa have revealed significant anatomical information previously unavailable due to preservation biases."

The find provides palaeontologists with a greater understanding of the emergence of gigantic sauropod dinosaurs, how they evolved, and how they lived.

It appears numerous sauropod species lived alongside one another, suggesting they occupied different roles in the food web, the scientists said.

"The specimen here reported strongly suggests the co-existence of the largest and middle-sized titanosaurs with small-sized *rebbachisaurids* (a family of sauropod dinosaurs) at the beginning of the Late Cretaceous in Neuquén Province, indicating putative niche partitioning."

Sauropod dinosaurs were once widespread, and fossilised remains have been found on every continent on Earth, including Antarctica.

When early palaeontologists first studied the bones of these enormous dinosaurs during the Victorian period, it was commonly thought that due to their size sauropod species were largely water-dwelling animals, however, later research revealed the adaptations which allowed these huge creatures to live on land. These include a system of air sacs, the existence of which are indicated by indentations and cavities in most of the vertebrae, and pneumatic, hollow bones, similar to those of present-day birds, which made their huge limbs lighter.

The largest animal ever to have existed remains the blue whale, which can reach maximum sizes of 33.5 m long and weigh 173 tonnes.

Reference:

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2. https://phys.org/news/2021-01-gigantic-dinosaur-unearthed-argentina-largest.html
3. https://www.sciencedirect.com/science/article/abs/pii/S019566712100001X

Mary Anning

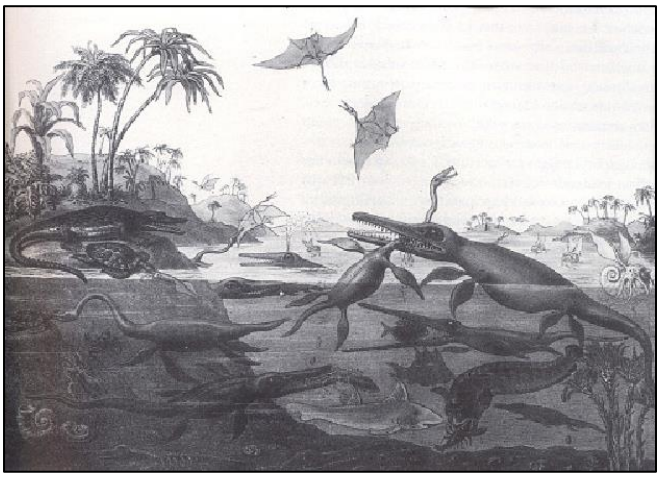
Mary Anning (21 May 1799 – 9 March 1847) was an English fossil collector, dealer, and palaeontologist who became known around the world for finds she made in Jurassic marine fossil beds in the cliffs along the English Channel at Lyme Regis in the county of Dorset in Southwest England. Anning's findings contributed to changes in scientific thinking about prehistoric life and the history of the Earth.

Anning searched for fossils in the area's Blue Lias and Charmouth Mudstone cliffs, particularly during the winter months when landslides exposed new fossils that had to be collected quickly before they were lost to the sea. Her discoveries included the first correctly identified ichthyosaur skeleton; the first two nearly complete plesiosaur skeletons; the first pterosaur skeleton located outside Germany; and fish fossils. Her observations played a key role in the discovery that coprolites, known as *bezoar stones* at the time, were fossilised faeces, and she also discovered that belemnite fossils contained fossilised ink sacs like those of modern cephalopods.

As a Dissenter and a woman, Anning was not able to fully participate in the scientific community of 19th-century Britain, who were mostly Anglican gentlemen, and she struggled financially for much of her life. As a woman, she was not eligible to join the Geological Society of London and she did not always receive full credit for her scientific contributions. However, her friend, geologist Henry De la Beche, painted *Duria Antiquior*, the first widely circulated pictorial representation of a scene from prehistoric life derived from fossil reconstructions, based it largely on fossils Anning had found, and sold prints of it for her benefit. Anning became well known in geological circles in Britain, Europe, and America, and was consulted on issues of anatomy as well as about collecting fossils, but the only scientific writing of hers published in her lifetime appeared in the *Magazine of Natural History* in 1839, an extract from a letter that Anning had written to the magazine's editor questioning one of its claims.

Portrait of Mary Anning with her dog Tray and the Golden Cap outcrop in the background, Natural History Museum, London. This painting was owned by her brother Joseph and presented to the museum in 1935 by Miss Annette Anning.

After her death in 1847, Anning's unusual life story attracted increasing interest. Charles Dickens wrote an article about Anning's life in February 1865 in his literary magazine *All the Year Round*. In 2010, the Royal Society included Anning in a list of the ten British women who have most influenced the history of science. It has been claimed that Anning's story was the inspiration for the tongue-twister "She sells seashells on the seashore", but there is no evidence for this.



Lithographic print produced in 1830 by Georg Scharf (1788 – 1860) from Henry De la Beche's (1796 – 1855) Duria Antiquior wator color.

Reference:

https://en.wikipedia.org/wiki/Mary_Anning

Mother-daughter duo helps to raise £100,000 for statue honouring 'extraordinary' fossilist Mary Anning

8 March 2021

By Katie Grant

A mother-daughter duo has helped raise more than £100,000 to erect a statue in honour of 18th Century palaeontologist and fossil collector Mary Anning. The campaign was born four years ago when Evie Swire, now 13, asked her mother, Anya Pearson, if they could visit a statue of the fossilist after she studied her at school.

"I had to explain to her that she was a woman, and she was working class, and those kinds of people don't get statues to them, unfortunately," Ms Pearson said.

"I thought, you know what, I am annoyed, my daughter's annoyed and we said, 'Right let's do something about this'."

Anning, a ground-breaking palaeontologist, was born in 1799 in Lyme Regis, in Dorset, where Evie and her mother live. As a young girl she began helping her father collect fossils, and, though she received little formal education, she was able to read and taught herself geology and anatomy.

As she grew older she developed a reputation for finding and identifying fossils, but the scientific community refused to recognise her work, which was often credited to her male peers.

A 'lifetime of extraordinary discoveries'

Anning died aged 47 from breast cancer and it was only after her death that her "lifetime of extraordinary discoveries", as the Natural History Museum puts it, was fully celebrated.

Now, the campaigners who made the case for a statue have announced that they hope to unveil the artwork, which depicts Anning walking to the beach with her dog, on what would be her 223rd birthday, next May.

A design on which the new statue of Mary Anning is based. (Photo: Mary Anning Statue Campaign/PA)

Gender equality ambition

There are further female statues in the works elsewhere, too. In Brighton, there are plans to erect a statue of Mary Clarke, the first woman to die in the name of female suffrage, while in Richmond, south-west London, campaigners have raised tens of thousands of pounds toward putting up a statue of author Virginia Woolf.

Sculptor Laury Dizengremel who was commissioned to make the latter artwork said the drive for more female statues was "not about excluding men". Instead, she said, "it's about just recognising that there's a long way to go still on gender equality."

References:

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2. https://www.nhm.ac.uk/discover/news/2021/january/work-to-begin-on-mary-anning-statue-for-lyme-regis.html
3. https://www.bbc.co.uk/news/uk-england-dorset-55953490
4. https://www.lymeregismuseum.co.uk/collection/mary-anning/

Ammonite film review – a chilly love among the fossils

Kate Winslet and Saoirse Ronan's 19th-century romance showcases their talents but doesn't warm the heart

28 March 2021

Mark Kermode, Observer film critic

3 out of 5 stars

This handsome second feature from the writer-director of 2017's brilliant *God's Own Country* is another hesitant love story set against the backdrop of a bracing British locale: the sea-battered Dorset coast around the famous Cobb of Lyme Regis harbour. It has been the setting for some overcooked screen moments in the past, although the emotional weather forecast here is frosty with occasional storms.

Kate Winslet is superbly flinty as Mary Anning, the 19th-century palaeontologist whose under-attributed finds have graced the display cases of the British Museum since her childhood. An early image sees a handwritten label for the historic "Sea Lizard, found by Miss Mary Anning" being tuttingly replaced by a floridly embellished sign reading "Ichthyosaurus, Lyme Regis, Presented by H Hoste Henley Esq". It's a concise way of illustrating both Anning's outsider status (her role in the discovery is effectively usurped) and the snobbery of an establishment averse to inclusivity.

Anning runs a shop selling "Fossils and Curios", which she gathers from the rugged coastline, striding purposefully over rocks and foam. Like Daniel Plainview in the opening movement of *There Will Be Blood*, Winslet's heroine is a figure of few words and imposing stature, driven by an internal engine that seems to require no human contact. Her mother, Molly (the redoubtable Gemma Jones), is equally insular; theirs is not a household filled with warmth and laughter. Watching this, I longed for a shawl to wrap snuggly around my shoulders.

Things change when Mary meets Charlotte Murchison (Saoirse Ronan, excellent), a young woman in the throes of a debilitating depression whose husband wants her to stay with Anning, albeit temporarily. Perhaps the invigorating air and the chance to observe Anning at work will restore the once-vibrant spirit that has withered in his company. Mary is not keen, but payment is promised, and arrangements made. Soon, Charlotte's fine clothes are becoming muddied and torn on the rocks. Gradually, the pair's growing friendship gives way to passion – strangely desperate couplings amid the stark silences of the house.

The real-life Murchison was an accomplished geologist and illustrator who became close to Anning, although Lee's decision to portray them as lovers has inevitably ruffled some feathers. In response, Lee has stated: "After seeing queer history be routinely 'straightened' throughout culture, and given a historical figure where there is

no evidence whatsoever of a heterosexual relationship, is it not permissible to view that person within another context?"

It's a powerful point, eloquently made, although, in the end, issues of class and gender, rather than sexual orientation, seem more central to Lee's film. It's no accident that *Ammonite* opens with a woman industriously polishing a floor, only to recoil in head-bowed subservience as "gentlemen" march by. While Ralph Fiennes's archaeologist Basil Brown was snubbed in *The Dig* for being largely self-taught, Winslet's Anning faces the double whammy of being both an autodidact and a woman. Wisely, Lee lets these events speak for themselves, rather than hammering home any sociopolitical message through needless expository dialogue.

Stéphane Fontaine's crisp cinematography perfectly captures the bleak chilliness of the environment, while Dustin O'Halloran and Volker Bertelmann's sparingly used score is as notable for the gaping voids in which it doesn't appear as for those carefully chosen moments when it does. It adds up to an expertly crafted film that nonetheless feels somewhat distanced and removed, like an exhibit under glass. At times, I was reminded of the austere atmosphere of Michael Winterbottom's *Jude*, another critical triumph for Winslet. Both films have much to admire artistically; both left me just a little cold.

Reference:

https://www.theguardian.com/film/2021/mar/28/ammonite-review-a-chilly-love-among-the-fossils

Interesting Places 2

25 January 2021: Mount Taranaki, a dormant stratovolcano, on New Zealand's North Island is pictured from the International Space Station as it orbited 431 km above the South Pacific. (Credit: Roscosmos)

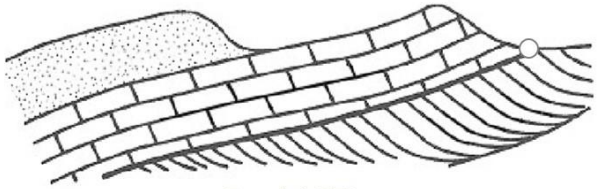
24 April 2020: The Susquehanna River cuts through the folds of the Valley-and-Ridge province of the Appalachian Mountains, USA in this photograph taken by the crew of the International Space Station. (Credit: NASA, ISS Astronaut photograph ISS061-E-98033)

Aerial view of the Sichelkamm mountain, in Switzerland. The huge fold (syncline) in the flank of the Sichelkamm mountain is an impressive witness of the collision between Africa and Europe. The layers, originally deposited on the sea floor in a horizontal position, were compressed and shifted. The large fold is formed by Cretaceous limestone of the so-called Säntis nappe. (Image credit: Bernhard Edmaier (https://www.bernhard-edmaier.de/en/) (https://geologyscience.info/))

Farnham Geological Society

[www.farnhamgeosoc.org.uk]

Farnhamia farnhamensis



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