Newsletter of

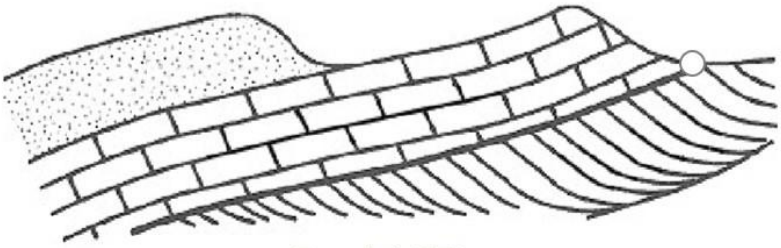
The Farnham Geological Society

Volume 24, Number 4, November 2021

Cover photo by John Williams, August 2021

Farnham Geological Society

Farnhamia farnhamensis



Founded 1970

A local group within the GA

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Contents

Editorial

Welcome to the fourth edition of the FGS Newsletter in 2021. I do hope you are all fit and well and are looking forward to getting back to a more "normal" life as more and more of us are vaccinated and Covid becomes less and less significant to our everyday lives.

You will have seen that your committee is recommending that we do not return to "face-to-face" meetings until Spring 2022. The first meeting back in March 2022 will be an afternoon social gathering at a Farnham location, followed by a face-to-face lecture in April. In addition, when we do return to face-to-face lectures the intention is to make them both "live" and available to view in real time via Zoom. This should allow those members who are unable or do not wish to travel to Farnham to continue to participate in the monthly meetings.

On the subject of our monthly meetings if there is someone you would like to see present a talk or a subject you would be interested in hearing more about please feel free to contact our Programme Secretary, Janet Catchpole (janet.catchpole14@gmail.com) with your ideas.

This month's Newsletter brings you some interesting articles, including reports from our monthly lectures for all those who didn't get a chance to view them online, including the rather long, but hopefully interesting **"Tales from the offshore; random stories of working in the oil industry"** by our very own Liz Aston, Mick Caulfield and Mike Millar.

And don't forget to zoom-in for Dr. Jon Copley's lecture entitled **"Exploring Life at Deep-sea Hydrothermal Vents: Patterns in Space and Time"** on **12 November**, as well as the following month when we welcome Professor Hilary Downes who will be talking on **"Lost Worlds of the Solar System"** on **10 December**: both look set to be excellent presentations.

John Williams has provided a brief review of our first post-Covid one day Field Trip. A small number of our members strolled around **"Albertropolis"** in South Kensington with Leonie Biggenden, a member of the Education Department of the Natural History Museum, who gave a very interesting guided tour of some of the building (and road) stones of the area. A follow-up tour inside the NHM is a possibility for early in the New Year.

Liz Aston provides us with another article in the Geoparks series … this time looking at the **Geology of Italy**, while news of a number of new dinosaur discoveries, climate change issues and the recent eruption on **Las Palmas** in the Canary Islands made the news. In addition, I hope you find the **"Interesting Places"** snippets of interest. Note we have also begun a **"Letters to the Editors"** spot … please feel free to write in with your views.

The success of our Newsletter depends upon you, the Members, providing material. So, if you have anything of interest please feel free to get in touch with the Newsletter Editor, Mick Caulfield (caulfm@hotmail.com).

Obituaries

It is with great sadness that we have to report the death of **Mary Clarke RIP**, a long-standing member of the FGS. Sadly, Mary lost her fight against cancer earlier this year. **Our sincere condolences go to all her family and friends.**

It is again with great sadness that we regret to inform you that **Paul Olver RIP**, who had been recently poorly after an operation last December, died on 25 October 2021. Paul was a member since 1974 and ran geology classes for many years, which a number of Society members participated in. **Our sincere condolences go to his wife Sue and all his family and friends.** The funeral will be a cremation in Hereford**.**

Front Cover

This month's Front Cover celebrates our first Field Trip of the year and features The Albert Memorial in South Kensington taken by our Field Trip Secretary, John Williams.

Farnham Geological Society
Committee 2021/22

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 April 2022.

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

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

Updated 1 Oct 2021

Our Field Trip Secretary, John Williams, is reviewing the potential for further Field Trips in 2021 & formulating a series for 2022.

It is likely that these will be day trips early in 2022, with longer trips scheduled for later in the year.

Geologists' Association
Lecture Programme 2021

Updated 1 Oct 2021

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

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

Zoom lecture time: 6.00 pm.

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

Reading Geological Society
Lecture Programme 2021-22

Updated 1 Oct 2021

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

Time: 7:45 pm for 8:00 pm
Venue: Zoom talks

The Devonian forests
Professor John Marshall Mon, 6 December
University of Southampton

13 Degrees of Warming: understanding the Eocene Earth
Dr. Tom Dunkley Jones Mon, 7 February
University of Birmingham

Mole Valley Geological Society
Lecture Programme 2021

Updated 1 Oct 2021

http://mvgs.org.uk

Time: 7:30 pm for 8:00 pm

The Cretaceous Lower Greensand Seaway of Northwest Europe
Dr. Martin Wells Thu, 11 November
BP

West Sussex Geological Society
Lecture Programme 2021

Updated 1 Oct 2021

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

Venue: Zoom talks

Lapis Lazuli
Dr. Chris Duffin Fri, 19 November
NHM

Harrow & Hillingdon Geological Society

Updated 1 Oct 2021

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

Venue: Zoom talks

Microbes to Marrows, the evolution of plants and flowers
Jane Tubb Wed, 10 November
East Herts Geology Club

Responsible sourcing of raw materials – at home & abroad
Prof Francis Wall Wed, 8 December
Camborne School of Mines, University of Exeter

NASA's Gateway moon-orbiting space station explained in pictures

https://www.space.com/nasa-lunar-gateway-moon-space-station-explained-pictures

It Happened in November & December

1 November 1755

A series of earthquakes occurred on the morning of 1 November 1755, causing serious damage to the city of **Lisbon, Portugal,** and killing an estimated 60,000 people. Violent shaking demolished large public buildings and about 12,000 dwellings. Because November 1 is "All Saints' Day", a large part of the population was attending mass at the moment the earthquake struck; the churches, unable to withstand the seismic shock, collapsed, killing or injuring thousands of worshippers.

1 November 1880

Alfred Wagner was born. During his lifetime he was primarily known for his achievements in meteorology and as a pioneer of polar research, but today he is most remembered as the originator of **continental drift hypothesis** by suggesting in 1912 that the continents are slowly drifting around the Earth. His hypothesis was controversial and widely rejected by mainstream geology until the 1950s, when numerous discoveries such as palaeomagnetism provided strong support for continental drift, and thereby a substantial basis for today's model of **plate tectonics**.

2 November 1959

The first section of the **M1 motorway,** the first of its kind in the UK, was opened between Watford and Crick/Rugby along with the motorway's two spurs, the M10 motorway, now the A414, to St Albans and M45 motorway towards Coventry.

5 November 1605

Guy Fawkes is arrested beneath the Houses of Parliament as a plot to blow up England's King James I is uncovered.

8 November 1656

Birth of **Edmond Halley**, English astronomer, and mathematician, best known for identifying the comet named after him. He sighted the Great Comet of 1682 and foretold its reappearance in 1758. **Halley's Comet** appears once each generation with the average time between appearances being 76 years. It is expected to be visible again in 2061.

10 November 1871

Explorer Henry M. Stanley found missionary David Livingstone at Ujiji, Africa. Stanley began his search the previous March for Livingstone who had been missing for two years. Upon locating him, he simply asked, **"Dr. Livingstone, I presume?"**

(Image: history.com)

Stanley died on 10 May 1904 and is buried in **St Michael and All Angels' Church** in **Pirbright**, Surrey, marked by a large piece of granite inscribed with the words "Henry Morton Stanley, Bula Matari, 1841–1904, Africa".

10 November 1852

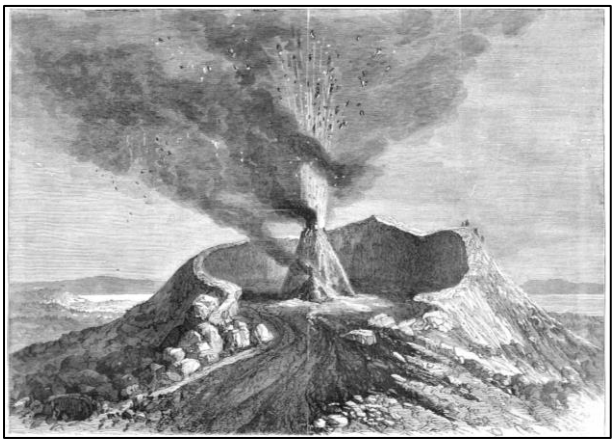
Gideon Mantell died. Gideon Algernon Mantell MRCS FRS (born: 3 February 1790) was an English obstetrician, geologist, and palaeontologist. His attempts to reconstruct the structure and life of the Iguanodon began the scientific study of dinosaurs. In 1822 he was responsible for the discovery (and the eventual identification) of the first fossil teeth, and later much of the skeleton, of the **Iguanodon**. Mantell's work on the Cretaceous of southern England was also important.

11 November 1918

At 5:00 am, in Marshal Foch's railway car in the Forest of Compiegne, **the Armistice** between the Allied and Central Powers was signed, silencing the guns of **World War I** effective at 11:00 am – the 11th hour of the 11th day of the 11th month. In many places in Europe, a moment of silence in memory of the millions of fallen soldiers is still observed.

12 November 1867

A major eruption of **Mount Vesuvius** in Italy began, lasting several months.



Mount Vesuvius in a state of eruption.

14 November 1797

Charles Lyell was born. Sir Charles Lyell, 1st Baronet, FRS (died: 22 February 1875) was a Scottish geologist who demonstrated the power of known natural causes in explaining the earth's history. He is best known as the author of ***Principles of Geology*** (1830–33), which presented to a wide public audience, the idea that the earth was shaped by the same natural processes still in operation today, operating at similar intensities. The philosopher William Whewell termed this gradualistic view **"uniformitarianism"** and contrasted it with catastrophism, which had been championed by Georges Cuvier and was better accepted in Europe. The combination of evidence and eloquence in *Principles* convinced a wide range of readers of the significance of "deep time" for understanding the earth and environment.

21 November 2017

Mount Agung, a volcano on the island of Bali in Indonesia, erupted five times in late November 2017, causing thousands to evacuate, disrupting air travel, and causing environmental damage.

(Credit: https://govinsider.asia)

24 November 1859

Charles Darwin publishes his book *"On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life"*.

26 November 1703

A **"Great Storm"** lasting two days struck southern England, flooding the Thames and Severn Rivers, killing at least 8,000 persons.

1 December 1990

England was connected to mainland Europe for the first time since the Ice Age as engineers digging a **railway tunnel** under the English Channel broke through the last rock layer. Known as **The Channel Tunnel**, it is the longest undersea tunnel in the world.

5 December 1791

Wolfgang Amadeus Mozart died a pauper at the age of 35 in Vienna, Austria. He had become seriously ill and rapidly declined, leading to speculation that he had been poisoned, although this was later proven false. During his brief life, he created over 600 musical compositions and is widely considered one of the finest composers who ever lived.

7 December 1941

The U.S. Naval base at **Pearl Harbour, Hawaii**, was attacked by nearly 200 Japanese aircraft in a raid that lasted just over one hour and left nearly 3,000 Americans dead.

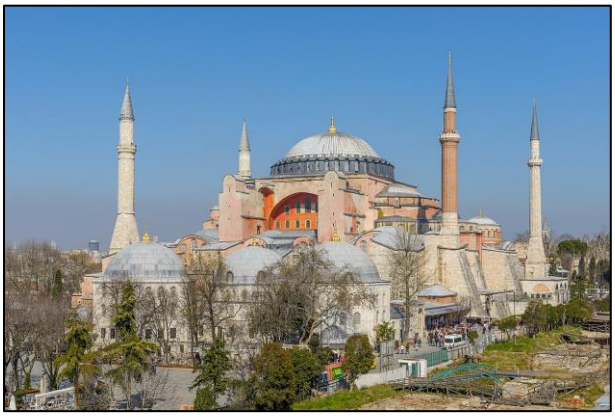
9 December 1960

Millions of viewers tune in as the first episode of **Coronation Street** airs. To date there have been over 10,230 episodes of the popular soap.

14 December 557

The earth moves in Constantinople. This earthquake, described in the works of Agathias, John Malalas, and Theophanes the Confessor, caused great damage to Constantinople, then capital of the Byzantine Empire in a region frequently afflicted with earthquakes. More minor quakes had preceded the large event, including two in April and October respectively.

The main quake in December was of unparalleled ferocity, and "almost completely razed" the city. It caused damage to the Hagia Sophia which contributed to the collapse of its dome the next year, as well as damaging the walls of Constantinople to the extent that Hun invaders were able to penetrate it with ease the following season.



The Hagia Sophia, Istanbul (Image: Arild Vågen)

14 December 1873

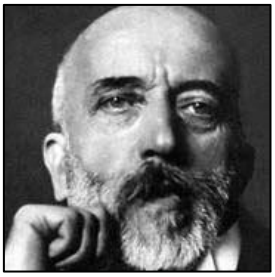
Louis Agassiz died. Jean Louis Rodolphe Agassiz FRS (For) FRSE (born: May 28, 1807) was a Swiss-born American biologist and geologist who is recognized as a scholar of Earth's natural history. Spending his early life in Switzerland, he received a Doctor of Philosophy and a medical degree at Erlangen and Munich, respectively. He emigrated to the United States in 1847 after he visited Harvard University. He went on to become professor of

zoology and geology at Harvard, to head its Lawrence Scientific School, and to found its Museum of Comparative Zoology. Agassiz is known for his regimen of observational data gathering and analysis. He made vast institutional and scientific contributions to zoology, geology, and related areas. He is particularly known for his contributions to **ichthyological** classification, including of extinct species such as megalodon, and to the study of geological history, including the founding of **glaciology**. In the 20th and 21st centuries, his resistance to Darwinian evolution, his belief in creationism and the scientific racism implicit in his writings on human polygenism have tarnished his reputation and led to controversies over his legacy.

17 December 1903

After three years of experimentation, **Orville** and **Wilbur Wright** achieved the first powered, controlled airplane flights. They made four flights near Kitty Hawk, North Carolina, the longest lasting about a minute.

18 December 1936



Andrija Mohorovičić died. Born on 23 January 1857, Mohorovičić was a Croatian geophysicist. He is best known for the eponymous **Mohorovičić discontinuity** and is considered as one of the founders of modern seismology. On 8 October 1909 there was an earthquake with its epicentre in the Pokuplje region, 39 km southeast of Zagreb.

A number of seismographs had been installed beforehand and these provided invaluable data, upon which he made new discoveries. Mohorovičić concluded that when seismic waves strike the boundary between different types of material, they are reflected and refracted, just as light is when striking a prism, and that when earthquakes occur, two waves - longitudinal and transverse - propagate through the soil with different velocities. By analysing data from more observation posts, Mohorovičić concluded that the Earth has several layers above a core. He was the first to establish, based on the evidence from seismic waves, the discontinuity that separates the Earth's crust from its mantle. This is now called the Mohorovičić discontinuity or (because of the complexity of that name) **The Moho**.

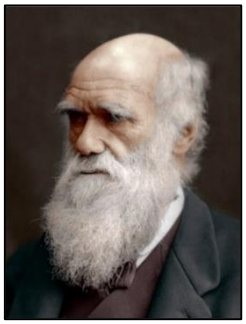
26 December 2003

The 2003 **Bam** earthquake struck the Kerman province of **south-eastern Iran** at 5:26 am Iran Standard Time. The shock had a moment magnitude of 6.6 and a maximum Mercalli intensity of IX *(Violent).* The earthquake was particularly destructive, with the death toll amounting to at least 26,271 people and injuring up to 30,000. The effects of the earthquake were exacerbated by the use of mud brick as the standard construction medium in Bam.

26 December 2004

A great earthquake occurred at 00:58:49 (UTC) on Sunday (Boxing Day) 2004 off the northwest coast of **Sumatra, Indonesia**. Its moment magnitude was M 9.3 making it in the top four largest earthquakes in the world since 1900 and the largest since the Alaskan 1964 event. The earthquake caused tsunami waves which killed more than 300,000 people in Southern Asia and Africa. There were 31 earthquakes with magnitudes between 5.5 and 7.3 in the 48-hour period after the main event, and it seemed that seismicity migrated northwards along a 1200 km fault.

27 December 1831



Charles Darwin set out from Plymouth, England, aboard the ship **HMS Beagle** on his five-year global scientific expedition. Darwin collected fossils and studied plants and animals, gradually beginning to doubt that many diverse species of living things had sprung into existence at one moment (creationism). In 1859 (*see above*), he published *On the Origin of Species by Means of Natural Selection*.

Next Lectures

Friday, 12 November 2021

Zoom: 6.50 pm for 7.00 pm start

Exploring Life at Deep-sea Hydrothermal Vents: Patterns in Space and Time

Dr. Jon Copley
Associate Professor in Ocean Exploration & Public Engagement, NOC, Southampton

Abstract

Since the initial discovery of colonies of abundant deep-sea animals around hydrothermal vents in the late 1970s, research has revealed biogeographic patterns of life in these ocean floor environments, with different taxa flourishing at vents in different regions of the global ocean, and a fossil record of life at hydrothermal vents that shows different taxa flourishing in different eras. This talk takes a tour of those patterns in space and time and considers some of the explanations for them.

Biography

Dr Jon Copley is Associate Professor of Ocean Exploration & Public Engagement at the University of Southampton, where his research explores island-like seafloor habitats such as hydrothermal vents to investigate ecology, biogeography, and evolution in the deep ocean. Jon is a Scientific Associate of the Natural History Museum, a National Geographic Explorer, and former Co-Chair of InterRidge, the organisation coordinating international research at mid-ocean ridges. He was also previously a reporter and news editor of New Scientist magazine, and a contributor to BBC Blue Planet II.

https://www.southampton.ac.uk/oes/about/staff/jtc.page

Friday, 10 December 2021

Zoom: 6.50 pm for 7.00 pm start

Lost Worlds of the Solar System

Professor Hilary Downes
Birkbeck College, University of London

Abstract

The early Solar System was a violent place. Before the familiar planets were formed, several earlier generations of small planets and asteroids were formed and were destroyed by impact and collisions. One planet is thought to have smashed into the growing Earth and formed the Moon from the collision. This talk will present evidence for the existence of these lost worlds, from which only tiny fragments remain, hiding in our meteorite collections.

Biography

Prof. Hilary Downes is Professor of Geochemistry, Department of Earth and Planetary Sciences at Birkbeck College, University of London.

Hilary was an undergraduate at the University of Durham, studying BSc Geological Sciences. She completed an MSc in Geology at the University of Calgary in Canada. A PhD followed from the University of Leeds, where she studied the geochemistry and petrology of Cantal, a large volcano in central France.

Hilary has been involved in Planetary Science since spending time at the Lunar and Planetary Institute in Houston, Texas and working with colleagues at the Johnson Space Centre (JSC) next door.

Her interests in planetary science include the origin and evolution of planets and asteroids. And she has done a lot of research on ureilite meteorites which are achondrites that represent the interior of a disrupted asteroid.

Reference:

https://www.bbk.ac.uk/our-staff/profile/8007589/hilary-downes

Field Trip Report

Building Stone Walk: "Albertropolis"

by John Williams, Field Trip Secretary
Thursday, 26 August 2021

After a long time without any Field Trips, we were able to hold a **Building Stone Walk** for a few participants, when restrictions were finally lifted and groups were permitted to meet, albeit with social distancing still maintained.

We were led by **Leonie Biggenden**, a member of the Education Department of the Natural History Museum, for a two-hour stroll around the area of South Kensington known as **"Albertropolis"** after its royal patron Prince Albert; the area was designed to elaborate the achievements and grandeur of Victorian Britain.

It thrives today as the home of many of London's world-class museums, cultural institutes and scientific organisations.

Figure 1: Bomb damage on the V & A Museum on Exhibition Road, South Kensington. Similar damage can be seen on the NHM Earth Galleries entrance on the other side of Exhibition Road.

Meeting at the entrance to the Victoria & Albert Museum (Fig. 1) we had an opportunity to view bomb damage from the Second World War around the entrance.

Moving north on Exhibition Road we examined the former Met Office (from 1910 to 1919) and more recently Post Office, which is now part of the **Dyson School of Design Engineering**, the academic centre for design engineering at Imperial College London (Fig. 2).

Figure 2: The Dyson School of Design Engineering (former Post Office) building illustrating contrasting granites: (a) dark grey door surround: Aberdeen Rubislaw granite; (b) the steps: Cornish granite; (c) the pavement: Chinese granite.

Following a look at stromatolites in the walls of The Church of Jesus Christ of Latter-Day Saints, the group was led down the quieter side roads of Prince Gate Mews and studied the stone setts of the mews roads that abound in the area. The roads needed a hard rock surface to cope with the iron shod wheels of delivery vehicles and carriages of a bygone age. It provided an opportunity to study the varied geographical origins of the igneous stones.

The garden gate to The Holy Trinity Church, Brompton, provided a background for the group photograph (Fig. 3) and a chance to see the erosion of the Triassic Bunter Sandstone.

Figure 3: The intrepid few with Leonie in the centre at the garden gate to The Holy Trinity Church, Brompton which is built of Triassic Bunter Sandstone.

The group were then taken past the slope of Exhibition Road where the geomorphology of The Thames Terraces was explained.

Figure 4: The steps at the rear of The Royal Albert Hall, at the top of which is the Memorial to the Great Exhibition. (Credit: Bob Speel)

The stairs up to the Royal Albert Hall were climbed which allowed the weathering of the Portland Stone bollards to be discussed before studying the granites of the Memorial to the Great Exhibition of 1851.

Unfortunately, it was not possible to cross Kensington Gore, the road at the front of The Royal Albert Hall, to view the Albert Memorial close up due to road works and the inevitable barriers.

Figure 5: The Albert Memorial designed by George Gilbert Scott in 1863-72. Pink granite from Correnac, Aberdeen, appears with marble in the pedestal on which the statue of Albert sits, while Darley Dale sandstone from Derbyshire is used for the main capitals. The arches are of Portland Stone, while the pillars supporting the canopy are of red granite from the Ross of Mull and a grey granite from Castle Wellan Quarries, Northern Ireland.

A handout describing the various stones of this instructive outdoor geological “museum” was handed out.

The group were very appreciative of Leonie’s hard work, and she offered to provide a walk inside the NHM for the FGS to demonstrate the various UK and Irish stone used inside - a possible Field Trip for early in the New Year.

Sett: a small rectangular paving block made of stone, such as granite, used to provide a durable road surface.

Capital: decorative element that divides a column or pier from the masonry which it supports.

Additional comments by Mick Caulfield.

Lecture Summary

Friday, 10 September 2021

On Friday, 10 September 2021 39+ attendees from the FGS, together with Reading Geological Society members welcomed our Chair Liz Aston & FGS Members Mick Caulfield & Mike Millar to present our external lecture via Zoom.

Tales from the offshore; random stories of working in the oil industry

Liz Aston, Mick Caulfield and Mike Millar FGS

Liz Aston: The Earliest Days of UK Oil and Gas Production

In 1919 oil and gas was observed oozing out of rocks in wells, mines and outcrops across the UK from Sussex, Dorset, W Midlands and Lancashire to W Lothian and the Midland Valley of Scotland. These shows were investigated but the volumes were not significant or economic. But hopes were high and in 1934 the Petroleum Production Act allowed oil companies to become licenced to explore and produce hydrocarbons (HCs).

By 1938 gas discoveries were made near Edinburgh and Eskdale but again they were non-commercial. Then in 1939 the D'Arcy Oil Co (now BP), following (non-commercial) oil discoveries at Formby, Lancashire ended up with small but economic fields around Eakring, East Midlands; Eakring-1 was the **first commercial oil well** in UK (it produced from 1939 to the late 1960s) and the **first oilfield** was Dukes Wood & Eakring which had produced 47MM* BOE** by 1964. Whilst these oilfields were producing, UK officials were considering making a deal with Nazi Germany due to the serious lack of oil, but these oilfields managed to make up the shortfall at this critical time and by the end of World War II, Eakring had produced 2,269,305 BOE for the war effort; furthermore, the oil produced at Dukes Wood and Eakring was superior in quality to Middle Eastern and North Sea oil.

Figure 1: Eakring oil field (Credit: Dukes Wood oil museum)

Figure 2: Drilling crew of the Dukes Wood well 146 (Credit: Dukes Wood oil museum)

**MM* *million for production volumes; MMBBL – millions of barrels.*

***BOE** barrel of oil equivalent - a unit of energy based on the approximate energy released by burning one barrel (158.9873 litres) of crude oil – applies to the sum of all hydrocarbons under analysis.*

^***TCF** – trillion of cubic feet (1,000,000,000,000 cubic feet) used for the volume of gas in a field.*

Europe was also on the oil and gas trail. In 1949 France's Lacq field was discovered with 29 MMBBL* oil + 7.5 TCF^ gas, while in 1954 the Parentis Field was found with 210 MMBBL of oil in Upper Cretaceous and Upper Jurassic beds. Meanwhile in the Netherlands, a large field had been discovered on the German / Netherlands border, the Schoonebeck Field, and further onshore discoveries were made; this time it was gas in aeolian dune beds of the Permian Rotliegende Formation and oil in Zechstein and Lower Cretaceous carbonates. Meanwhile, all the UK had was minor production from Millstone Grit and Zechstein.

By 1960 major gas fields in W Europe, particularly N Netherlands, had economic discoveries and production from Zechstein and Rotliegende strata in fields such as Slochteren-1. The Groningen Field was a major gas discovery – it proved that the Rotliegende strata form a potential reservoir over most of the Southern North Sea (SNS) – offshore drilling would be profitable.

SNS exploration was difficult – the gas was below Zechstein salt – a very good cap rock but it prevented gas reaching higher (excellent) reservoirs. Further the salt was mobile (locally forms huge salt walls) so the thickness of the Zechstein was extremely variable. There were large structural closures at Bunter Sandstone level, but it was unlikely that any gas had made it up to that level. Further large structures with superb potential had been destroyed by deep burial which increased the pressures and temperatures to extreme levels destroying porosity, cooking any HCs, etc. before being uplifted to shallower depths. Also, facies changes and lack of salt as a seal across the SNS made exploration difficult and disappointments were frequent.

Nonetheless large gas fields were discovered and brought natural gas to the UK – every household with a gas cooker had to change to natural gas.

The first HC discovery in the North Sea was made by the jack-up rig Sea Gem but it was manned by Eakring workers - in fact most offshore workers came from Nottinghamshire. The Eakring workforce were very proud that they had trained many, if not most, of the initial British drilling engineers in the North Sea. It was to be several years before the Americans became seriously involved in North Sea drilling. There were early tragedies and 13 men died and 5 were injured when Sea Gem capsized in December 1965.

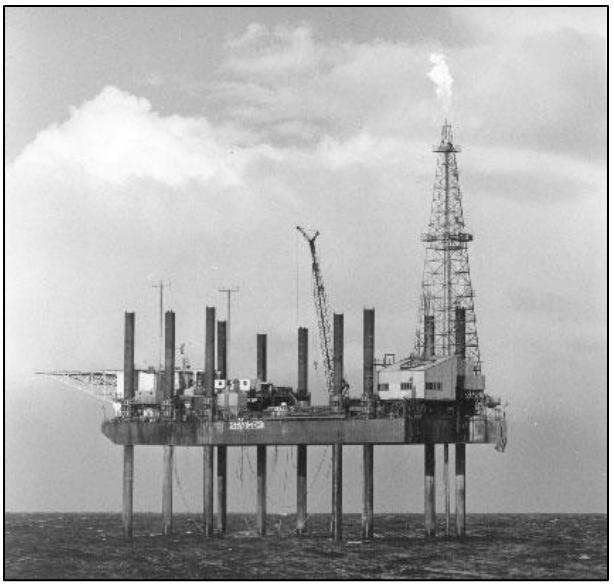


Figure 3: The Sea Gem was the first rig to find hydrocarbons in the British North Sea sector in what is now the West Sole Field. The members of the crew were employed by BP at Eakring.

The North Sea had been a gentle money spinner with very low geological excitement, but it became a hotbed of exploration overnight. For BP it was with well 21/10-1, 110 miles E of Aberdeen and the first well on the Forties Field which was the largest oil field in North Sea. It was announced to the Press on 7 October 1970 and first oil came ashore in 1975.

I had joined BP as their 'token female' in 1968; previously female geologists had been employed as librarians, map curators, etc. but as I was finishing my PhD at Imperial College I applied to and was employed by BP as a Petroleum Geologist. Initially the chief geologist was uncertain where to send me, the UAE was out of the question – they didn't want me to end up in a hareem, lose the company any money or credibility, so he opted for the North Sea – a geological backwater and I joined the Petroleum Geology Group at Sunbury Research Centre in the same 'band' as the new male geologists.

BP Sunbury were delighted – at last someone to complete a huge regional study of the Rotliegende across the SNS into The Netherlands, a mineralogist and petrographer for Alaskan reservoir rocks and other similar specialist work. My first weekend was spent at Eakring logging core from the Eakring Gas Field and my report on the reservoir quality was required for 9 am Monday. However, the Rotliegende sandstones were the key reservoir rock of the North Sea in 1968 and this became my core work. In those days, geoscientists were either geologists, geophysicists, micro- and macro-palaeontologists, palynologists, geochemists – all working in total isolation. My job became all things North Sea, particularly relating cores to wireline logs, and assisting Schlumberger with development of the Geodip Log.

When the 21/10-1 cores were recovered they were sent to a Core Services Company which had its core store in East London Docks. The cores had come from offshore so were immediately put into bonded warehouse, requiring the Revenue and Customs officials to release them – unfortunately the only wrapping materials offshore were old magazines – but they were all pornographic literature!

The Chief Geologist promptly told my boss to remove me from the North Sea, his reply was "No, I'll wait until she *xxxx,* then I'll move her". So, I went to the dockside core store building where the core hands were astonished at my presence, no woman had ever been in that building before. I learnt a lot – the importance of identifying the nearest pub (for a lady's loo); how to hasten getting the cores out of bonded warehouse; how to send urgent instructions to the rig that 'BP does NOT wish to import any more pornography'; teaching the lab hands how to clean the cores without disturbing any sections of rock and how to label and store the samples that I collected.

There was a long section of Forties cores and after several days cleaning the cores carefully and bagging all my samples from these cores, I was promptly offered free range to all the other cores on site which had just arrived. These were cores of Chalk from ConocoPhillips' Cod Field, so I noted the depths at the top and bottom of the cored intervals and accepted the samples they had decided to collect for me. BP was horrified that they had given me access to a competitor's cores and they instantly removed all the BP cores and withdrew all future contracts with that core handling contractor.

At the same time, it was critical for me as a novice to sit on a well in order to understand the workings of the drilling process at the rig site. Women were not allowed offshore at the time, so I was sent to Bridlington, North Yorks Moor. There were several snags – there were no clothing, shoes or hard hat for my size; the BP Rep (about to retire) was adamant that he would have NO women on HIS rig, but I arrived and had to visit him in hospital as he had had a heart attack that morning! I was now the BP Rep – responsible for all things except specific drilling issues. My junior (much older than me) was hastily returned to London following his treatment towards all the local women.

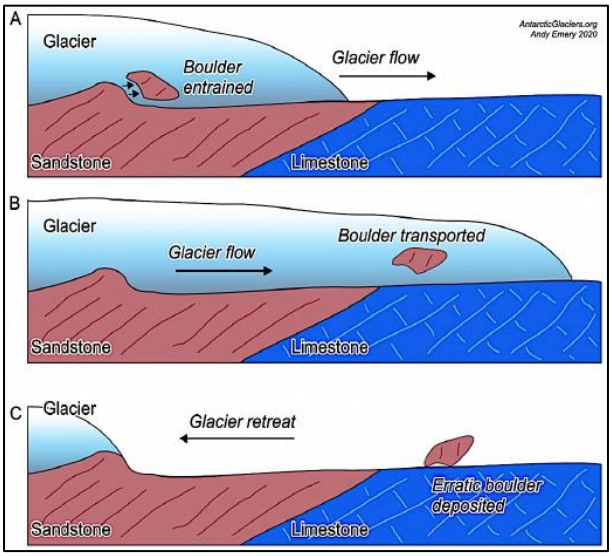


Figure 4: The process of formation of glacial erratics. A. Glacial erosion entrains a boulder of the bedrock. B. Continued glacier flow transports the boulder. C. As the glacier retreats, the boulder is deposited on a different type of bedrock, forming a glacial erratic. (Credit: Andy Emery 2020)

When drilling started in the CNS, the knowledge base was almost exclusively seismic; apart from the coastal outcrops, there was no knowledge of offshore subsea surface

geology or stratigraphy, and all drilling was going to be a long way offshore and in deep seawater. So, I went to Aberdeen to examine their glacial erratics to predict the best strata to target as reservoir rocks in the CNS.

My conclusion was that it could be anything from Palaeocene to fractured basement and Jurassic would probably be one of the best, but we still had no idea exactly what it would be.

Scouting was rife as every well was a complete wildcat - everything was top secret. I went to look at all the available cores (those that BP had traded). When arriving at Amoco offices, Gt. Yarmouth, to examine their latest cores I was refused entry as a Miss Whisker had already been (a female scout!), so it became necessary to carry my passport all the time.

There were a lot of surprises from the North Sea - the 100-year storms (the severest storms fishermen had ever survived) were not once every 100 years - there were ~8 in the first winter and the anemometer blew off the rig at >100 mph winds. There was a huge explosion whilst drilling Forties 21/10-3 due to a shallow gas pocket in the surface rocks close to the seabed. BP employed an oceanographer to analyse tides – both surface and seabed – they were very strong causing a lot of erosion around the legs.

There were also geological surprises - there was a large rift valley down the middle of the N Sea - the Central Graben - and the centre of this graben had a much higher heat flow than normal. The Jurassic subcrop along the edges of the Central Graben were severely faulted with many salt diapirs at the fault junctions. There was a period (in the Pliocene?) of gravity gliding when huge slabs of strata had slid down to the edge of the Central Graben distorting salt structures/compressing strata around the salt domes.

Interestingly, oil has been found in most stratigraphic intervals and even in the granitic basement of the UK offshore.

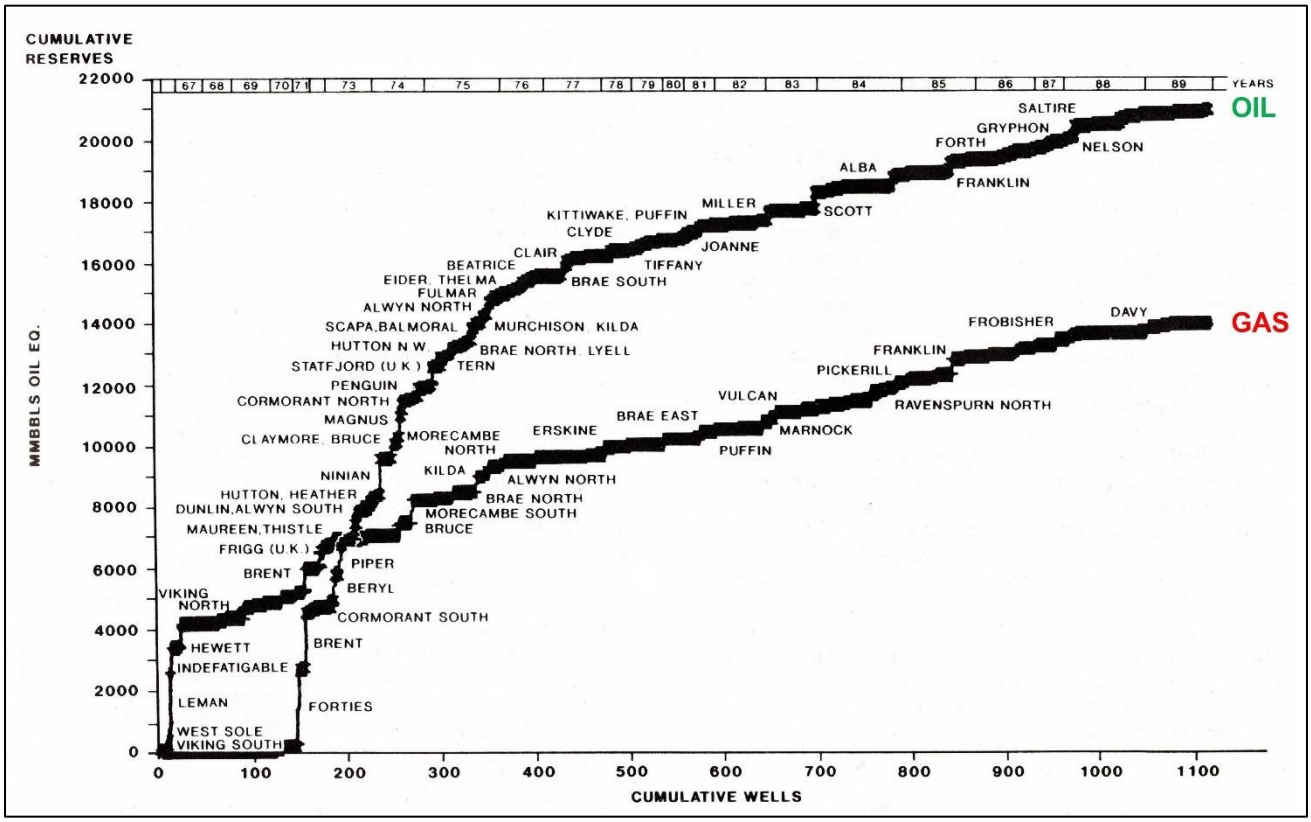


Figure 5. UKCS wildcat drilling and cumulative oil and gas reserves, 1965 – 1989. (Credit: Bowen 1991)

Mike Millar: Wells get drilled for a lot of reasons …

Our November 2020 evening talk entitled *'Calcareous Nannofossils': the smallest things can make a difference*, by Dr. Liam Gallagher, raised lots of questions about the drilling of wells and the data acquired from them. These notes are designed to answer some of those questions.

Wells are drilled for a variety of reasons, such as civil engineering, drinking water, minerals and metals, carbon capture, geological research, as well as the discovery and exploitation of oil and gas resources. One thing all these endeavours have in common is that the geology is buried, and the well is part of the process to understand what is happening in the subsurface.

Before we drill, we need to figure out the best place to site the well, to achieve its objectives. The common method for delving into the subsurface is with seismology. Geophysicists use reflected and refracted sound waves to identify structural and sedimentary features in the subsurface.

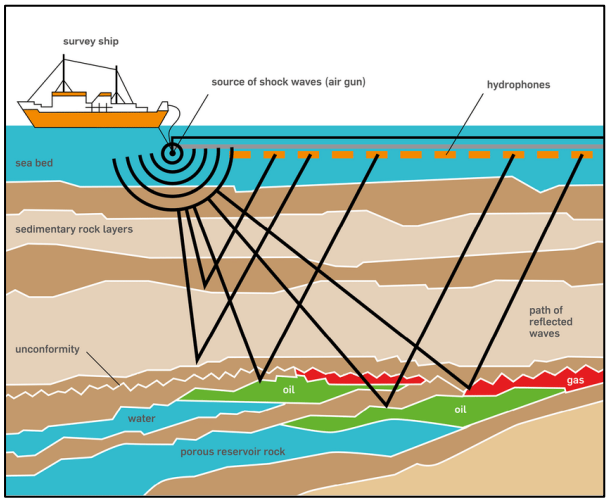


Figure 5: Geophysicist's use reflected and refracted sound waves to identify structural and sedimentary features in the subsurface. (Credit: OpenLearn)

For **seismic acquisition offshore** (Fig. 5), an air gun towed behind the survey ship transmits sound waves through the water and into the subsurface. Changes in rock type or fluid content reflect the sound waves back towards the surface. Receivers towed behind the vessel record how long it takes for the sound waves to return to the surface. The data is acquired in a grid and recorded in time. The same principles apply to onshore acquisition, but the logistics are very different.

Seismic interpretation consists of picking reflectors and relating them to geological horizons such as bedding, unconformities, and faults. The geophysicist then makes maps of those reflectors on the seismic grid to show underground structures and features. As seismic is recorded in time, it needs to be converted to depth, usually using well data.

The geophysicist then talks to the geologist to see if they can build a model or theory of what they expect to encounter in the mapped structure. The geologist will use information from nearby wells, combined with an understanding of the history of the sedimentary basin to define a **prospect** worth drilling. The well is then drilled to test just how good their hypothesis is.

Mick Caulfield: How do we drill a well?

The way we drill wells both onshore and offshore is by utilising a drilling rig. In the offshore realm they comprise 3 basic types:

1. **Jack-up**, which can drill in up to 190m water depth (WD) (Fig. 6).
2. **Semi-submersible**, up to 3000m WD (Fig 7).
3. **Drillship**, up to 3650m (Fig 8).

As a rule-of-thumb we would use a Jack-up in the Southern North Sea, English Channel and the Irish Sea, a Semi-submersible in the Central and Northern North Sea and in the West of Shetlands, and a Drillship in the West of Shetlands.

Figure 6: Maersk Highlander Jack-up rig. (Credit: Maersk Drilling)

Figure 7: Maersk Explorer Semi-submersible drilling rig. (Credit: Maersk Drilling)

Figure 8: Maersk Voyager Drillship. (Credit: Maersk Drilling)

When exploring for hydrocarbons there are essentially 3 types of wells that we drill:

1. Exploration well: the first well to be drilled on a prospect.
2. Appraisal well: once hydrocarbons have been discovered, appraisal wells are drilled to investigate the size of an accumulation, the type of hydrocarbon and their flow rate, and the type of rock the reservoir comprises.
3. Production (or Development) well: drilled to produce the hydrocarbons. Usually drilled from a production platform.

The rigs themselves comprise common equipment whether onshore or offshore and include a derrick (Fig. 9) which holds the weight of the drill string, a circulation system which allows the drilling mud to lubricate and cool the drill bit while returning rock cuttings to the surface for analysis. The mud plays a critical role in ensuring the well is always under control and drilled safely and efficiently.

Figure 9: The derrick on the Rowan Gorilla VI. (Credit: Rowan Drilling)

In addition, the blowout preventer (BOP) is a critical safety system which is designed to help prevent a blowout and potential oil spill.

Mike Millar: What data do we gather from a well?

Wells are generally drilled with a rotating bit which grinds up the rock, and it is these drill cuttings that are circulated to the surface. They are collected from the shale-shakers on a regular basis, and usually washed and dried before being viewed under a microscope so they can be described and then noted on the Mud-log. These are very useful, but it is not like looking at an outcrop. So, we need to acquire

some more data to know what is going on in the well.

Conventional coring uses a specially designed drilling bit which has a hole in the middle to allow some of the rock to be captured and brought to the surface; it's the same principal as an apple corer. The core is brought to the surface in an inner barrel, generally made of aluminium. Coring is able to cut big rock samples, usually 4" or 5" diameter, but sometimes smaller, depending on the diameter of the borehole (Fig. 10). And anything from a few feet to over a hundred feet long.

Figure 10: Conventional core laid-out in the laboratory prior to being described. (Credit: Mike Millar)

A piece of drill pipe is 30' long, and cores are usually cut in multiples of this. Cores require detailed planning and cooperation between the well engineers, the geoscientists and the coring company, to get safe and effective operations and useful core. There are a number of issues with core that can limit their acquisition. As they take longer and require more trips in-hole than drilling, they are more expensive and potentially less safe. Also, we cannot always guarantee full recovery, some of the core maybe rubble, or even left in the hole.

The principal method of acquiring additional data through most of a well-bore is by "electric" logging. Here, instruments are run into the well on wireline (Fig. 11), or built into the drill-pipe, which make recordings that can then be interpreted to give us information such as lithology, interval thickness, porosity and permeability estimates, fluid types, and formation pressures.

Wireline is the original method of acquiring electric logs; it dates back to the Schlumberger brothers in France in 1927. We generally log the open-hole section from section TD (total depth) up to the last casing shoe. Basically, we dangle a tool on a cable and take measures as we pull out of the hole. We can also record some logs as we run into the hole, and we should always do this when feasible. For wireline logging we need a logging unit, a cable with a winch and depth measuring device, a power supply, and recording equipment - used to be film, now digital. It is possible to log deviated holes up to about 50 to 60 degrees inclination on wireline, depending on hole shape and tool configuration.

Figure 11: Wireline logging tool being "run-in hole". (Credit: Mike Millar)

A more recent development has been **Logging While Drilling (LWD)**. LWD tools are part of the bottom-hole assembly (BHA) at the end of the drill string and we acquire data while we are drilling. During drilling, data can be transmitted by mud pulse to surface as 'real-time' data. It is also recorded in down-hole memory to be recovered at the next trip to the surface. Real-time data transmission rates are being improved all the time, but much more data is recorded in the down-hole memory. LWD logging is often used in directionally drilled wells such as high angle to horizontal development wells. It is also used in vertical exploration and appraisal wells too.

The main advantages of LWD logging over wireline include its ability to acquire the data prior to significant filtrate invasion into the formation and when the borehole is likely to be in the best condition. Also, as mentioned, to be able to acquire data in high-angle and horizontal boreholes. Real-time data allows for real-time decisions, which can lead to significant savings in time and cost.

Sadly, we don't have logs that actually measure all the things we really want to know. They acquire measurements about natural background radioactivity, resistance of the rocks and fluids to an electrical current, the speed at which sound travels through the rocks, the response of the rocks to induced radioactivity, the diameter or radius of the borehole, the direction of the borehole and the depths at which these measurements are taken. It is the job of the petrophysicist to interpret these measurements to produce the information we really want such as lithology, interval thickness, porosity and permeability estimates, fluid types, and formation pressures.

The **Gamma Ray Log** is probably the most common logging tool (Fig. 12). It is a 'passive' tool which measures the natural radioactivity of the formation (and borehole). The main response coming from natural potassium, thorium and uranium found in rocks in the subsurface. Potassium and thorium are often found in claystones, and uranium is often associated with organic material. Its primary uses are as a basic lithology indicator (sand/shale) and for correlation between wells.

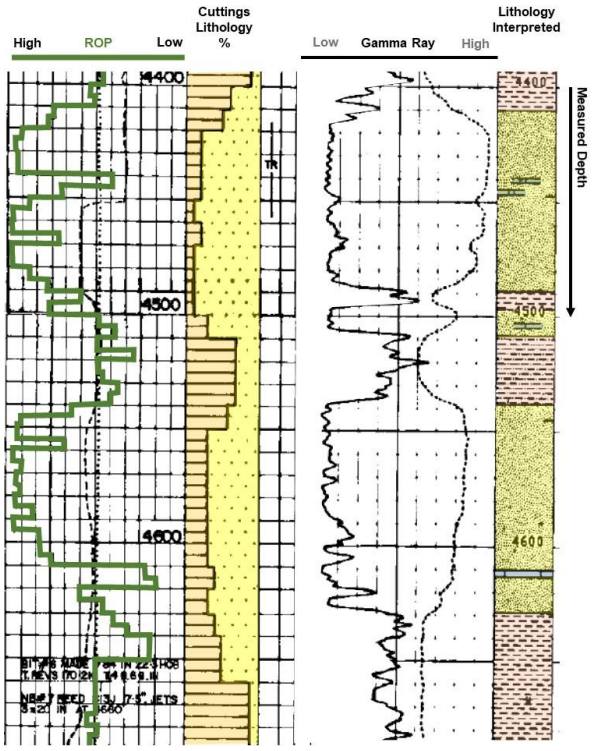


Figure 12: Mud-log showing rate of penetration (ROP) and cuttings description, alongside gamma ray log and lithology interpretation from the same hole section. (Credit: Mike Millar)

Resistivity Logging measures electrical conductivity (or more correctly the reciprocal of) in the formation due to brine in the pore space, capillary bound water, and water in clays. By contrast, hydrocarbons and the rock matrix are not conductive. So, its primary uses are to identify fluids (water or oil/gas) and to quantify water saturation for volumes of hydrocarbons.

We can use combinations of log responses to determine lithology. The most useful tools for this include the gamma-ray, sonic, bulk density, and neutron porosity tools. And it can be possible to determine sand, shale, limestone, dolomite, halite, anhydrite, and coal intervals. It should be remembered that logs respond mainly to composition, and lithology is also based on grain size, morphology, and colour, so for example, mica and illite have similar composition, but very different physical properties. Thus, you should back-up your log interpretations with all available data to help determine lithology, for examples rock cuttings, mud-logs, cores, off-set well data, etc.

What could possibly go wrong? Logging tools are designed and built by humans, based on assumptions and simplifications of the real world. They have measurement uncertainty, including depth uncertainty, and resolution issues. They are run in physically and operationally demanding conditions which may, limit their effectiveness and damage them. But if these data are acquired in the right way and used with caution, they can be a very effective method for delving into the subsurface.

References:

1. http://www.dukeswoodoilmuseum.com/eakring.htm
2. http://www.antarcticglaciers.org/glacial-geology/glacial-landforms/glacial-depositional-landforms/glacial-erratics/
3. https://mem.lyellcollection.org/content/memoirs/14/1/1.full.pdf

Real-time data from Logging While Drilling Tools (LWD).

Mike Millar, with grateful thanks to Adrian Leech

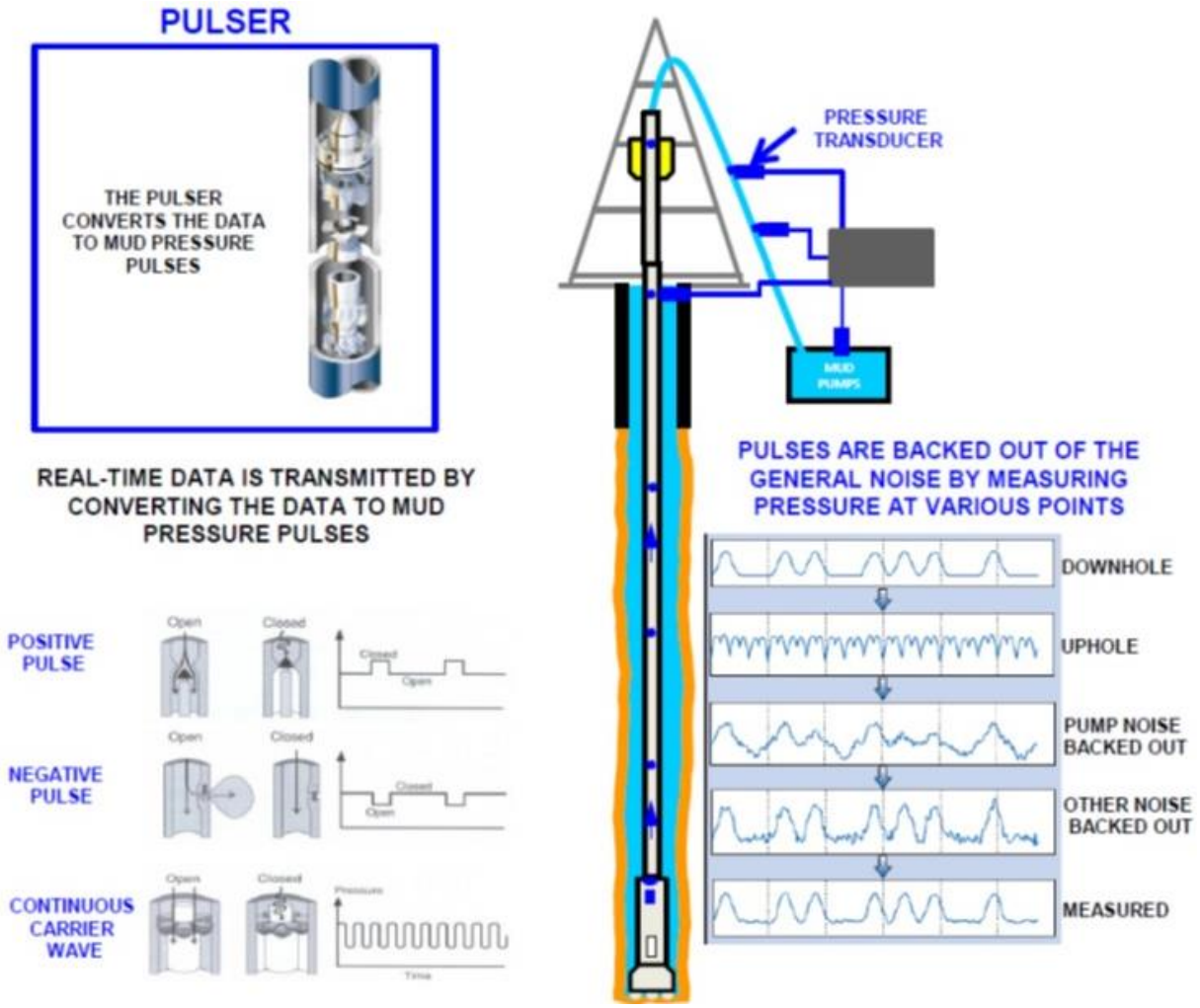
Mud-pulse telemetry is the most common method of data transmission used by LWD tools. Downhole, a valve is operated to restrict the flow of the drilling fluid (mud) according to the digital information to be transmitted. This creates pressure fluctuations representing the information. The pressure fluctuations propagate within the drilling fluid towards the surface where they are received from pressure sensors. On the surface, the received pressure signals are processed by computers to reconstruct the information. The technology is available in three varieties, positive pulse, negative pulse, and continuous wave.

Positive pulse tools briefly close and open the valve to restrict the mud flow within the drill pipe. This produces an increase in pressure that can be seen at surface. The digital information can be encoded in the pressure signal using line codes or pulse-position modulation.

Negative pulse tools briefly open and close the valve to release mud from inside the drill pipe out to the annulus. This produces a decrease in pressure that can be seen at surface. The digital information can be encoded in the pressure signal using line codes or pulse-position modulation.

Continuous wave tools gradually close and open the valve to generate sinusoidal pressure fluctuations within the drilling fluid. Any digital modulation scheme with a continuous phase can be used to impose the information on a carrier signal. The most widely used modulation scheme is continuous phase modulation.

Potential issues with real-time data transmission include resonance and / or noise from drilling, or the mud pumps, and mud solids blocking the mud port.



Mud pulse technology (Credit: Adrian Leech)

9 July 2021

On Friday, 9 July 2021 our Chair Liz Aston and 34+ attendees from the FGS, together with GA and Reading Geological Society members welcomed FGS members Christina Fisher & Ben Dixon of the Natural History Museum to present our external lecture via Zoom.

Is It a Meteorite, Precious Gem or Dinosaur Claw? Behind the scenes at Natural History Museum's Identification and Advisory Service

Christina Fisher & Ben Dixon
Identification & Advisory Officers, NHM

The Angela Marmont Centre ID Service (Natural History Museum, London)

Do you have a mineral, rock or fossil that needs to be identified? The Angela Marmont Centre will help identify the specimens that you have collected. Originally opened in 2010 as a citizen science centre, the AMC is a place where you can investigate all aspects of the natural world with resources, equipment, and staff to help you.

The general public have made many important finds in the UK, with the press reporting fossil finds of dinosaur footprints and mammoth bones. A number of these have first come through the Angela Marmont Centre. Many of these finds do not make the news but are no less important. Within the past couple of years, we have had a number of important finds:

- The upper jaw of *Pterodon dasyuroides*, a creodont (a type of carnivorous mammal) from the Isle of Wight: an exceedingly rare Palaeogene fossil as it is only known from a few fragmentary teeth.
- A very large Cretaceous turtle limb bone from the Wealden Clay (possibly the largest from that time period found in the UK).
- The Lower Jurassic ray finned fish, *Dapedium*, found for the first time in Wales (Fig.1).

Are you interested in learning more about your fossil finds or learning more about UK geology? Citizen scientists are welcome to book a series of visits to help study their rocks and fossils in more detail.

Figure 1: Lower Jurassic ray finned fish.

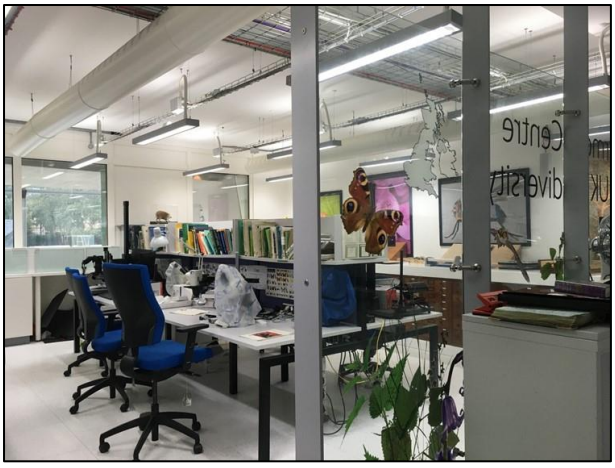


Figure 2: Visitor space.

Use our visitor space (Fig. 2) which includes the following facilities for you to book:

- Photo-stacking equipment, allowing you to make macro images of small specimens in pin-sharp detail (Fig. 3).
- Microscopes are available to look closer at your specimens.
- A British fossil synoptic collection with more than 1600 specimens (Fig. 4).
- A mineral collection that has over 200 rocks and minerals found in the UK - from albite to zoisite.
- Also, on location we have the London Natural History Society's library with a range of geological books and periodicals.

If you are a member of a natural history organisation, you can book our workshop space and meeting rooms. An over-screen projector and microscopes are available if

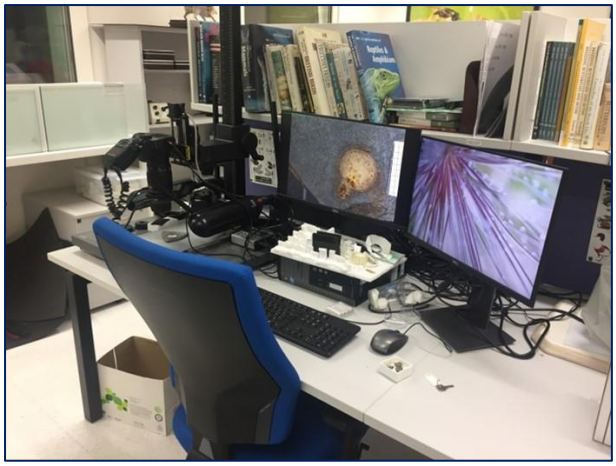


Figure 3: Photo stacking equipment.

Figure 4: A small selection from synoptic collection.

needed. We support individuals, schemes, and societies to record, monitor and protect the UK's biodiversity – and geodiversity.

Although we are under restrictions due to Covid, we are still able to discuss enquiries or future bookings by email or telephone:

- Send photos of your finds to our Earth Science Identification service at esid@nhm.ac.uk
- or phone us on 020 7942 5703 from 10:00 to 12:00 and 2:00 to 4:00.

Also try your hand at identifying - use our new **Fossil Explorer app** for your iPhone or Android. http://www.nhm.ac.uk/take-part/identify-nature/fossil-explorer-app.html

Or join our new **Facebook** site and get involved with our online community: https://www.facebook.com/groups/NHMUKBiodiversity

Interesting Facts

Thagomizer: Why Stegosaurus' spiky tail was named after a cartoon

Kaushik Patowary, Amusing Planet
13 July 2020

Humans and stegosaurus missed each other by more than 150 Ma, but people have always wondered how difficult or terrifying life would have been if dinosaurs and humans co-existed. This premise is often explored humorously in cartoons and in movies. Cavemen and dinosaurs frequently featured in cartoonist Gary Larson's ***The Far Side*** - a single-panel comic that ran for fifteen years during the 1980s and 90s. ***The Far Side*** was known for its surrealistic and dark humour based on uncomfortable social situations and improbable events, including aliens, talking cows, as well as human-dinosaur interaction.

"Now this end is called the thagomizer . . . after the late Thag Simmons."

In 1982, Larson drew a comic depicting a prehistoric classroom. A caveman is giving a lecture to an audience of other cavemen. Before them is a large image of a stegosaurs' tail. The professor points towards the spikes at the end of the tail and explains that they are

called the "**thagomizer**", after the late Thag Simmons.

Presumably, caveman Thag Simmons had gone too close to the stegosaurus and was clubbed to death by its spiky tail. Having learned a valuable lesson that it was best to avoid the tail of this particular animal, the other cavemen who witnessed the unfortunate incident decided to immortalize Thag's name on the prehistoric animal's anatomy.

Larson later joked that if there were confessionals for cartoonists, he would have gone to seek absolution: *"Father, I have sinned - I have drawn dinosaurs and hominids together in the same cartoon."*

Of course, ***The Far Side*** is fiction, and no one named Thag Simmons was fatally wounded by an extinct animal. But the "thagomizer" itself is real.

It turns out that this arrangement of spikes at the tip of a stegosaurus's tail had no formal name. A 2006 article in the *New Scientist* explains why that happened:

Paleontologists don't get many chances to name new bones. Evolution uses the same bones over and over again, altering their shape and purpose but preserving their basic nature, so anatomists simply use the same old terms to describe them. A humerus is a humerus, whether it's in a chicken wing, a walrus flipper, the massive front leg of a brachiosaurus or our own upper arm.

Only in a few animals do bones evolve into something different enough to earn their own distinct name, like the fearful-looking spikes at the end of a stegosaurus' tail. Nevertheless, nobody had bothered to give an easy-to-remember name to the spikes, until Gary Larson came up with "**thagomizer**". Larson, being a biologist, was aware of the deficiency.

In 1993, at the annual meeting of the *Society of Vertebrate Palaeontology* at the Denver Museum of Nature and Science, palaeontologist Ken Carpenter was making a presentation about a recently discovered stegosaurus skeleton. One of the spikes had apparently broken and healed, and there was compelling evidence that the stegosaur had used its spiky tail as a weapon.

Carpenter remembered Larson's cartoon that he read years ago, and he found the joke too good to pass. That was the first time anybody, outside Larson, had used the word "thagomizer" in a professional way.

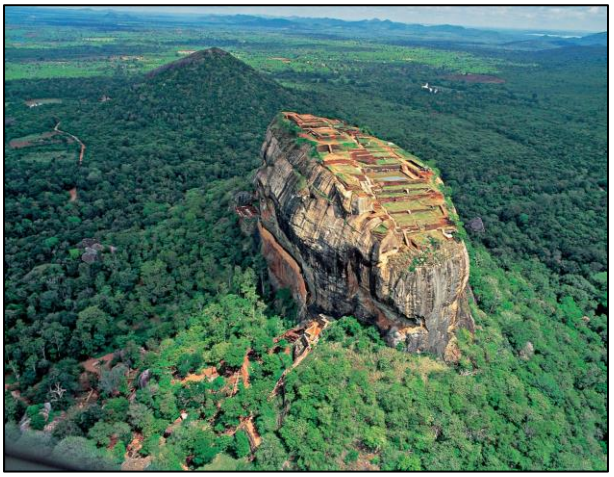
Shortly after, the Dinosaur National Monument in Utah got the thagomizer label on its spikes, and James Orville Farlow of Indiana University included the term in his book *The Complete Dinosaur*. Smithsonian Institution's stegosaur fossil display also has the label thagomizer.

Since then, the word has become a semi-formal term for that part of the stegosaur's anatomy.

Reference:

https://www.amusingplanet.com/2020/07/thagomizer-why-stegosaurus-spiky-tail.html

Interesting Places 1



Aerial view of the Sigiriya Fortress in Sri Lanka

Sigiriya, or Lion Rock, towers 180 metres off the ground in central Sri Lanka, jutting dramatically out of the heart of this island country and serving as a formidable monument to the past. The king of Sri Lanka himself, King Kashyapa, who ruled from 473 to 495, once made this the site of his new capital. He ordered that his palace be constructed atop the rock, and about halfway up, he had a large

gateway carved into the side of the outcrop in the shape of a large lion (hence the name). His fortress was abandoned when he died, and the site later served as a monastery. Sigiriya is composed of granitic material. It is a hardened magma plug from an extinct and long-eroded volcano. A plug is the solidified rock mass within the former feeding pipe of a volcano. These days the rock fortress and its landscaped gardens are a UNESCO World Heritage Site. *(Image: Sri Lanka Holiday Tours)*

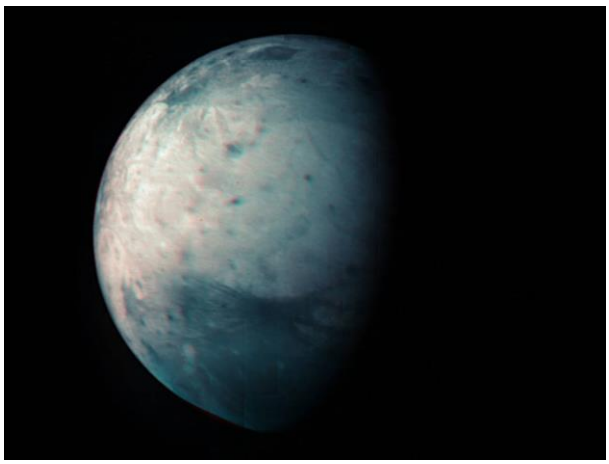
Venice as seen from space

31 August 2021: Venice Italy's floating city & one of the world's most iconic. *(Source: ESA)*

Astronaut Thomas Pesquet: “Most of us know Venice for its watery canals, bridges and melodic gondoliers but the unsung heroes of Venice are actually thick wooden planks. That's not an insult by the way, when the city was established, stakes of alder wood from nearby forests were driven deep into the lagoon to support construction. Salt water and a lack of air hardened and protected this wood from damage and rot and most of the city's buildings still rely on these clever historic foundations. Now one of the biggest challenges Venice faces (aside from climate change, which is huge) is human movement stirring up the water. Earlier this month, a ban on large vessels came into force, stopping cruise ships from entering the lagoon and hopefully helping to sustain this UNESCO site for the future.”

Apollo 15: Image of receding Earth

Near the end of flight day one (26 July 1971), the Apollo 15 crew took this photo of the receding Earth from a distance of about 55,000 miles. Apollo 15 marked the 7th time humans had travelled beyond low Earth orbit (the first time being the historic voyage of Apollo 8 in December 1968). *(Image: NASA Photo ID AS15-91-12344)*



NASA’s Juno Celebrates 10 Years with New Infrared View of Moon Ganymede

This infrared view of Jupiter’s icy moon Ganymede was obtained by the Jovian Infrared Auroral Mapper (JIRAM) instrument aboard NASA’s Juno spacecraft during its July 20th, 2021, flyby. *(Credits: NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM)*

UNESCO Geoparks

In this article **Liz Aston** describes the Geology of Italy. Future articles will describe the Italian UNESCO Geoparks.

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.

THE GEOLOGY OF ITALY

By Liz Aston

The geology of Italy is complicated, it comprises several micro continents; some are part of Europe and others part of Gondwana. They lay in the jaws between the continents of Africa and Eurasia during the gradual closure of the Mesozoic Variscan Rheic Ocean and the Alpine Ocean Tethys. Worse still it has been 'chewed' (micro continents possibly split further and/or rotated). Notably Italy and the Western Mediterranean *(W Med from now on)* is actually a separate arm of Tethys, related to the Atlantic opening. Today, the modern Mediterranean is closing as Africa continues to collide with Europe.

The Italian peninsula is an extremely active tectonic region today, as shown by the frequent earthquakes and the presence of active volcanoes: Vesuvius, Stromboli, Vulcano, Etna and the supervolcano, Campi Flegrei.

Italian geology is also dominated by 2 different mountain chains, the Alps (running W-E) in the N and Apennines (running N-S), the backbone of the peninsula.

Geologically, Italy can be subdivided into 7 specific areas:

1. Alpine chain proper; in the North along the border with Switzerland – Austria.
2. Po Plain; part of Europe, basin of deposits from the Alp & Apennine Mt systems.
3. Apennines; Mountain Chain with active faults running down the spine of Italy.
4. Apulia foreland; SE coastal area of Italy / S part of Adriatic & part of Gondwana.
5. Calabrian-Peloritan arc; arc joining the 'toe' of Italy to N Sicily.
6. Sicily; the ultimate 'teeth of Africa-Europe collision'.
7. Sardinia (Corsica included here for completeness), European continental plate.

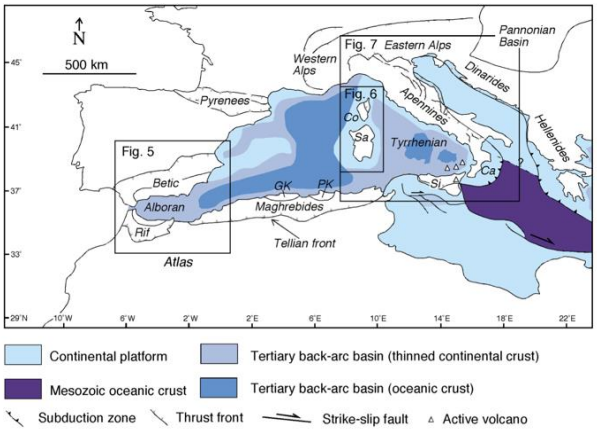


Figure 1. Tectonic setting of W Med basins and the Alpine orogen. Ca = Calabria; Co = Corsica; GK = Grand Kabylie; PK = Petite Kabylie; Sa = Sardinia; Si = Sicily.

Since the Oligocene the W Med includes numerous microplates and continental terranes which have been rotating during the evolution of the W Med basins. Everything has been controlled by the relative motions (with respect to Europe) of Africa (the Adriatic plate represents an African promontory) and Iberia, part of Europe.

- During the Alpine orogeny, a very wide zone between Africa and Europe underwent back-arc extension in the overriding plates, due to the (rapid) rollback of subduction zones, where the old, dense oceanic lithosphere was subducting.
  - The extension led to drifting & rotation of continental terranes towards the retreating slabs by >100-800km.
  - These terranes, Corsica, Sardinia, the Balearic Islands, the Kabylies blocks, Calabria and the Rif-Betic Belt, continued to drift whilst rollback took place, and were eventually accreted onto the adjacent continents.

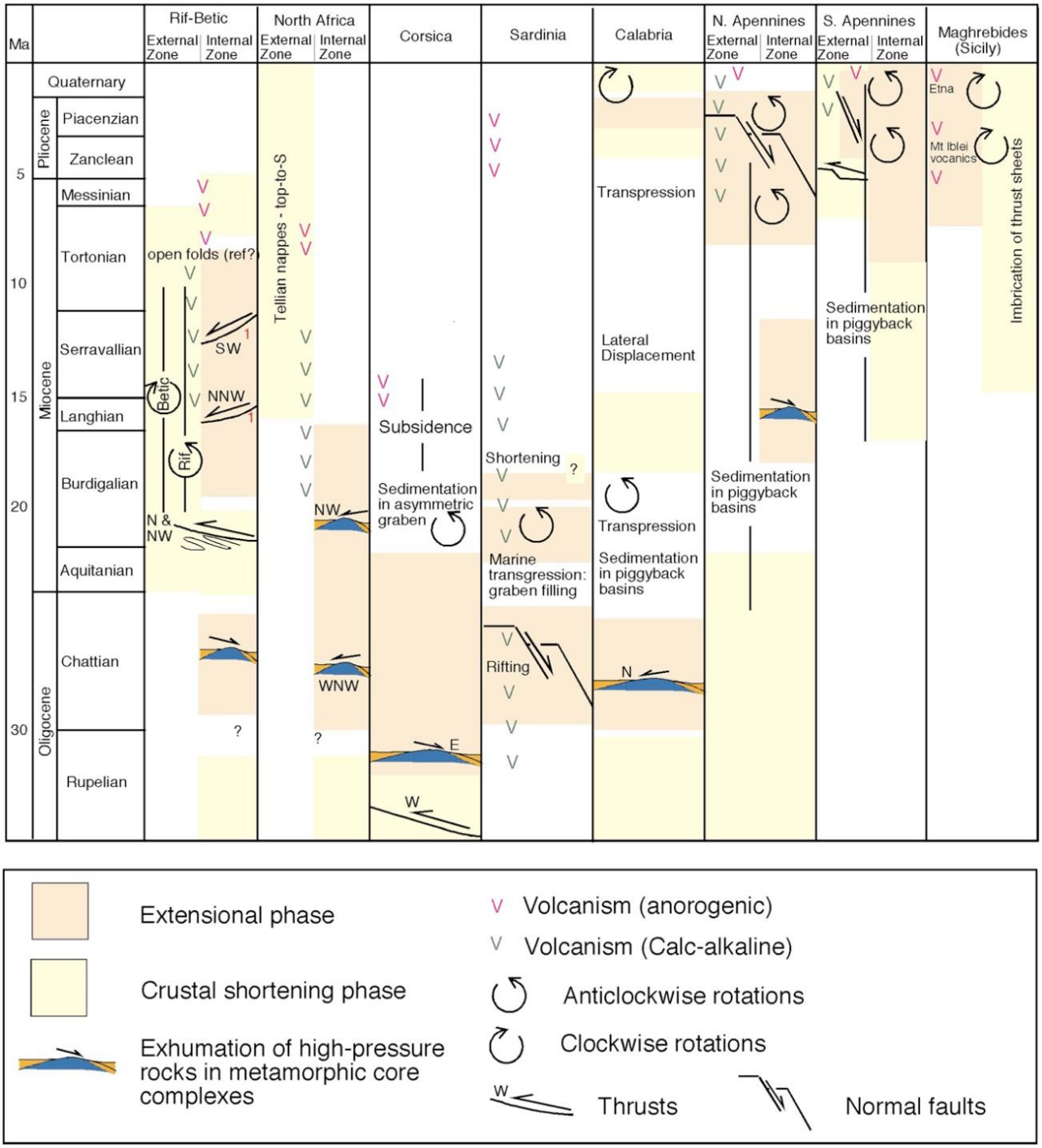


Figure 2: The Time: Space relationships of the structures throughout the W Med. Note the frequency of rotations and the variation in direction between clockwise (cw) and counter-clockwise (ccw).

- Large-scale horizontal motions from the subduction rollback, back-arc extension and the accretion of allochthonous (distant, exotic) terranes were all important parts of the Alpine orogeny (mountain building).

Thus, the W Med shows complicated interactions between the orogenic (compressional) processes and widespread back-arc/continental extensional tectonics.

Fig. 1 shows the converging continental plate margins of Africa and Europe and the marine back-arc basins which have all formed since the Oligocene:

a) the Alboran Sea

b) the Algerian-Provençal Basin
c) the Valencia Trough
d) the Ligurian Sea and
e) the Tyrrhenian Sea.

The evolution of these basins during the convergence of Africa with Europe and the associated widespread extension led to either a) considerable thinning of the continental crust (as in the Alboran and N Tyrrhenian Seas, Fig. 1); or b) to sea floor spreading (as in the S Tyrrhenian & Provençal Basins).

During this extensional tectonism in W Med, orogenesis was dominant within the surrounding areas forming the adjacent mountain chains, see Fig. 4:

a) Rif-Betic cordillera
b) Maghrebides of N Africa and Sicily
c) the Apennines
d) the Alps and the Dinarides.

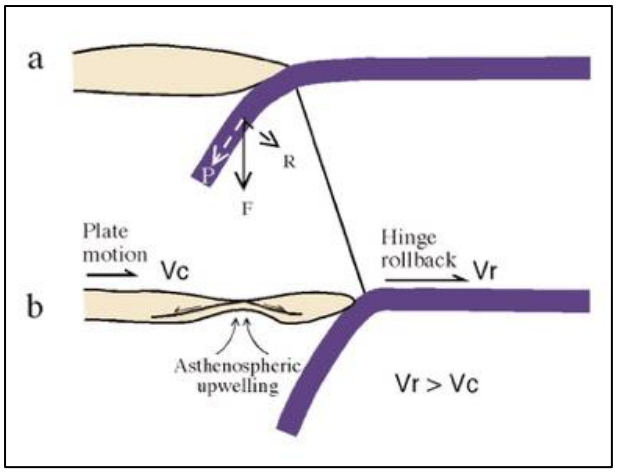


Figure 3. Simplified cross section showing the evolution of subduction rollback (modified after Lonergan & White 1997).
(a) P and R are two components of the vertical negative buoyancy (F) of the subducting slab. If the subducting slab is cold and dense, the component R cannot be supported by the mantle asthenosphere, and the subduction zone is pulled backward.
(b) back-arc extension forms when the rate of subduction rollback (Vr) exceeds the rate of convergence (Vc).

The simultaneous formation of extensional basins whilst there was thrusting and folding in the adjacent mountain belts has been explained by large-scale horizontal movements associated with the subduction trench rollback. These explain the allochthonous (distant, exotic) terranes, which have drifted great distances to their present locations (e.g., Calabria). However, some issues remain unexplained.

There are complex interactions between subduction processes, horizontal extension, block rotations and accretion events; it emphasises the roles of subduction rollback and episodic accretion of allochthonous terranes during orogenesis.

Extension commenced at 32-30 Ma and was primarily controlled by subduction rollback. During the back-arc extension, marine basins progressively formed from N to S, floored either by thinned continental crust or new oceanic crust.

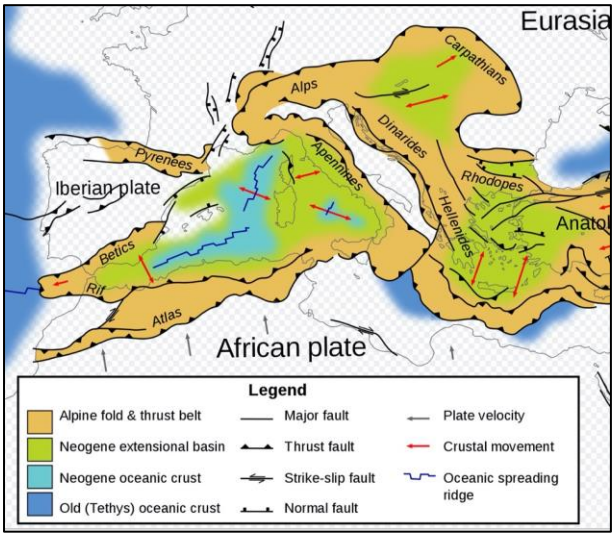


Figure 4. Tectonic map of the Mediterranean, showing the position of the Alps within other structures of the Alpide belt.

Fig. 4 shows
1. the multiple convergence zones within the Western end of the Mediterranean (W Med) and
2. the multiple extension zones due to slab roll back in the W Med., and
3. the difference in age of the oceanic crust in the W Med. (Neogene) compared to that of the Tethys Ocean (much older).

The W Med. is bound by the subduction zone along the E edge of the Adriatic Ocean / Adria-Apulia Plate.

Figure 5: Regions of Italy.

1. The earliest basins form in Late Oligocene times in
    a. Gulf of Lion
    b. The Ligurian
    c. Valencia Trough.
2. In Early Miocene, back-arc extension propagated to
    a. Provençal
    b. Algerian and Alboran basins, and
3. In the Upper Miocene
    a. Extension in the Tyrrhenian Sea commenced.

Rifting led to the breakup of continental terranes, which drifted and rotated as long as the subduction zone continued to rollback.

In the Alpine orogen, this led to the fragmentation of a continuous belt into continental terranes, which in turn, collided with the passive margins of the surrounding continents.

Subduction rollback temporally or permanently ceased when continental crust arrived at the subduction zone, impeding subduction processes. The continental terranes were then accreted to the continents and considerable crustal shortening occurred.

Subduction rollback consumed Mesozoic oceanic lithosphere and the subduction zone

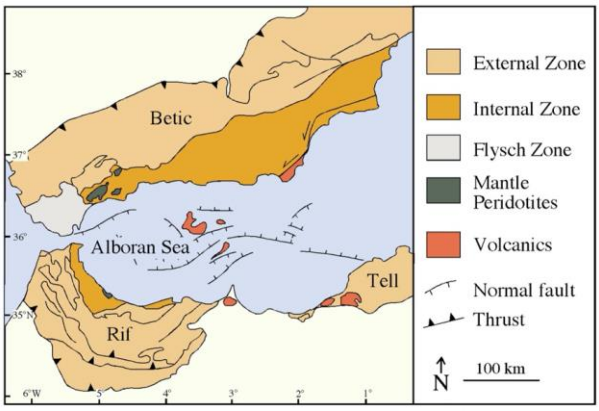


Figure 6. Geological map of the Alboran Sea and the Rif-Betic cordillera (after Platt & Vissers, 1989).

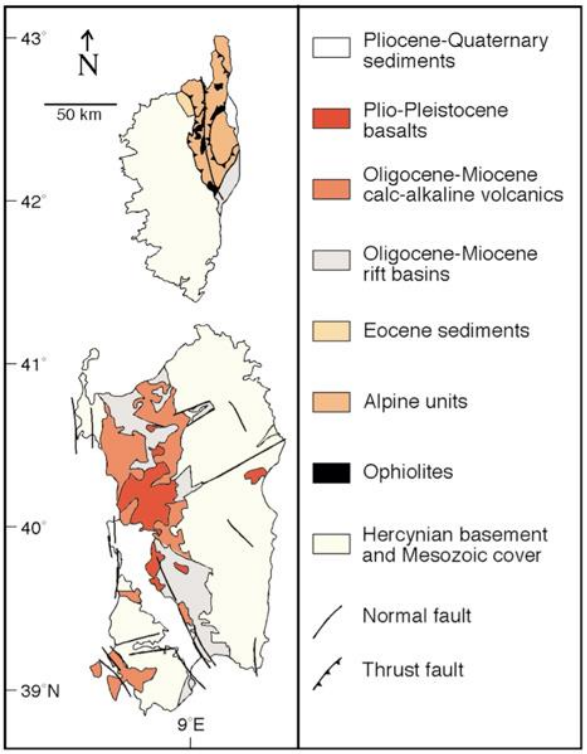


Figure 7. Geological map of Corsica and Sardinia after Cherchi & Montadert (1982) and Jolivet et al. (1990).

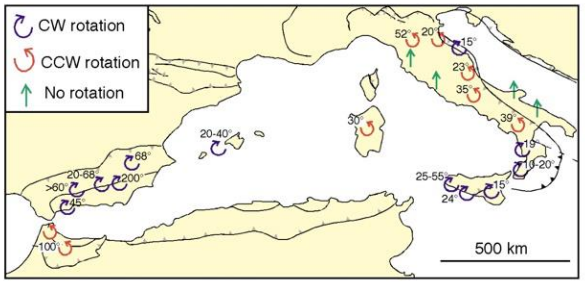


Figure 8. Map shows the multiple rotations, clockwise (cw) & counter-clockwise (ccw) that have occurred in W Med.

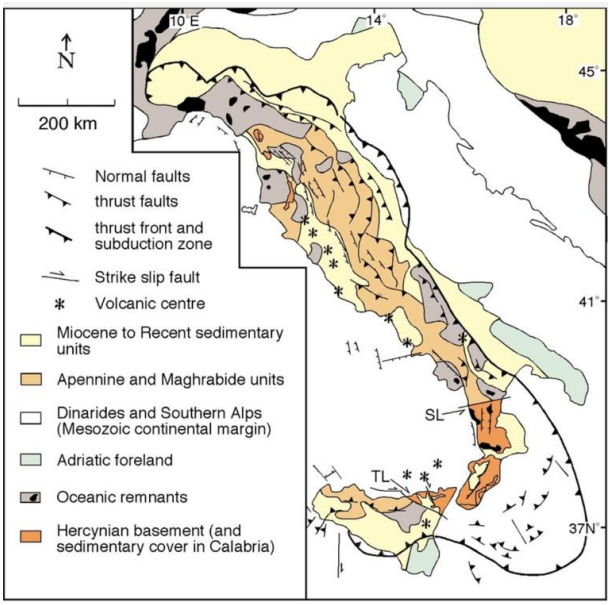


Figure 9. Simplified geological map of the Italian Peninsula and Sicily, modified after Channell et al. (1979) and Patacca et al. (1993). SL = Sagiento; TL = Taormina Line.

progressively retreated to the S from its Oligocene position, near the S margin of Europe, to its final location in the Calabrian, N African and Alboran arcs.

In the W Med, subduction rollback occurred during a period of relatively slow convergence between Africa and Europe.

Convergence alone could not fill the gap formed by subduction retreat, so back-arc extension occurred in the overriding plate.

This period of slow convergence was characterised by large-scale horizontal movements of the microplates & distant, exotic (allochthonous) terranes.

Orogenesis is therefore not subduction followed by collision of two continental plates but includes accretion of numerous continental terranes. Further, microcontinents can migrate great distances, often rotating, before colliding with continents.

In the W Med fragments of continental crust were subjected to large amounts of horizontal transportation, block rotations on vertical axes, and episodic alterations from crustal shortening to extension.

Since Oligocene times volcanicity has been very common and Fig. 10 shows the areas and ages of the volcanic provinces.

The oldest (Oligocene) are restricted to the Hercynian continental area in the W; the Miocene are all in a band running along the S & E edges of this Hercynian Basement; the youngest are restricted to Sicily and the Boot of Italy.

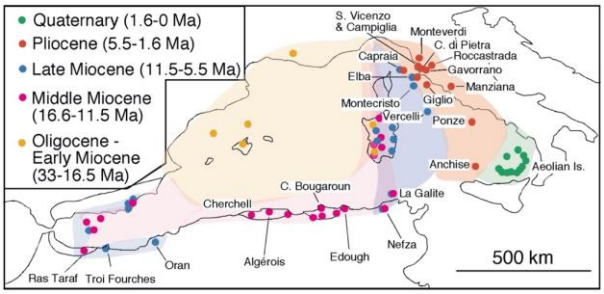
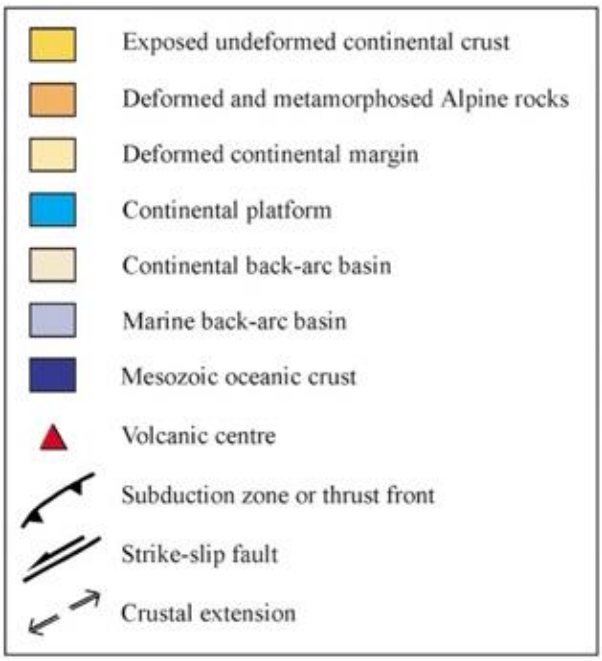


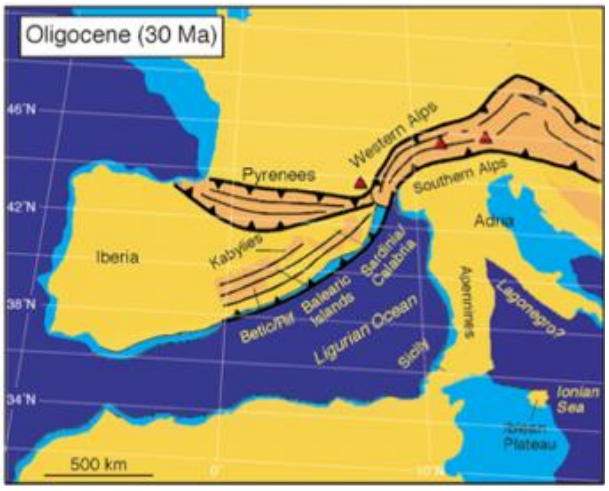
Figure 10. Map showing the distribution of volcanic rocks in the western Mediterranean.

The Mediterranean subduction history is complex and reconstructing the paleogeography after Jurassic extension between Iberia, Eurasia, and Africa (121 Ma) may help. It includes:

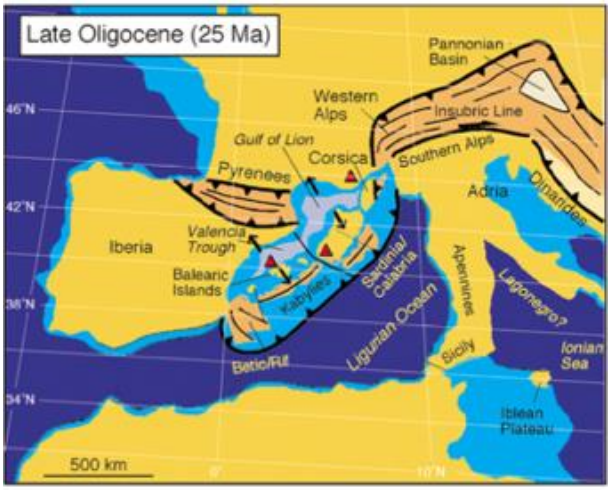
- Iberia rotates ~35° counterclockwise (ccw) during the Aptian (121–112 Ma).
- Sardinia-Corsica rotates ~45° ccw and ~50° ccw between Eocene & Miocene (~50-30 Ma).
- Iberia and Sardinia-Corsica were separated by a (transform) plate boundary, the NBTZ (maps at 50, 30 Ma & 'Present').
- The Sardinia–Corsica rotated again in Miocene (~50° cw) between ~20-15 Ma which was synchronous with and responsible for N-S shortening in Provence and in connecting the Briançonnais continental domain to Corsica and into the W Alps (see Fig. 11h).



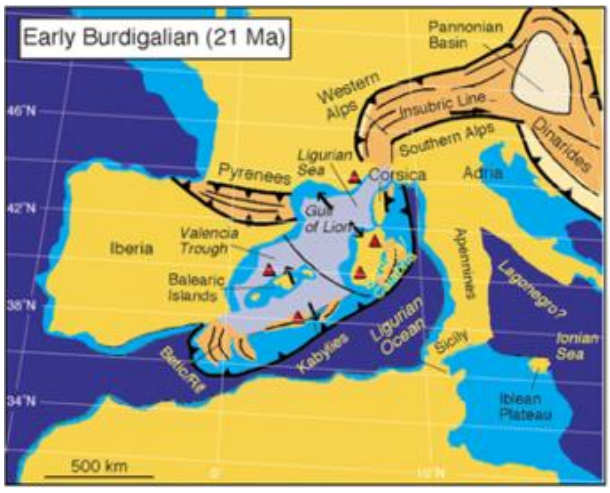
Key to principal colours and symbols.



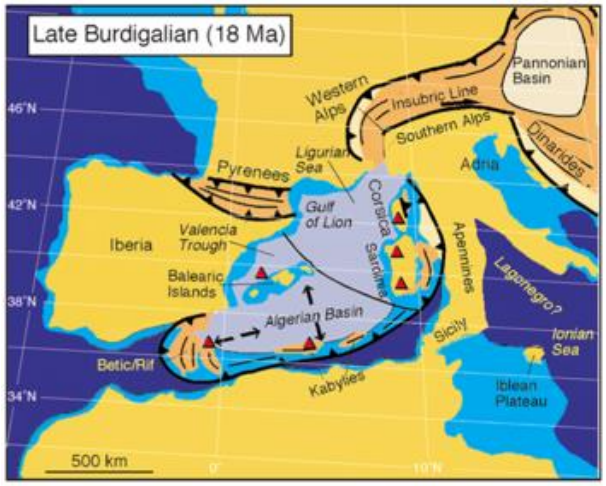
(a) Oligocene reconstruction (30 Ma).



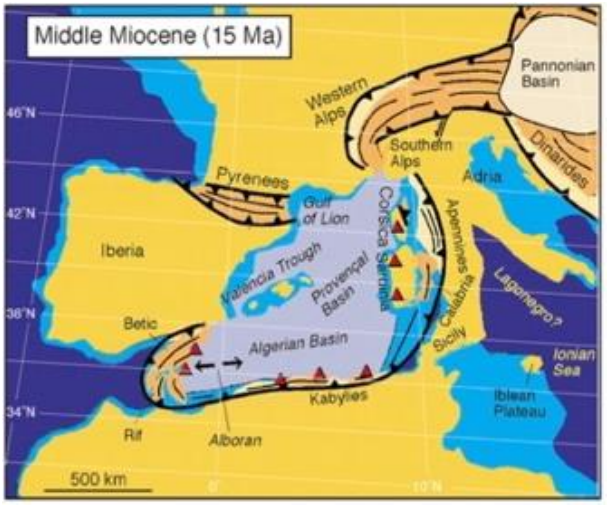
(b) Late Oligocene reconstruction (25 Ma).



(c) Early Burdigalian reconstruction (21 Ma).

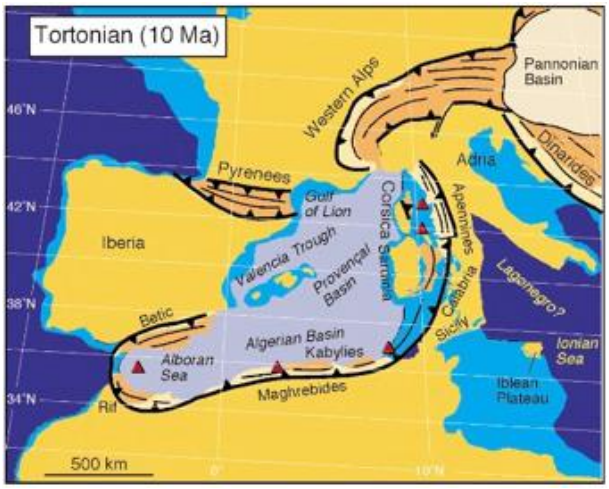


(d) Late Burdigalian reconstruction (18 Ma).

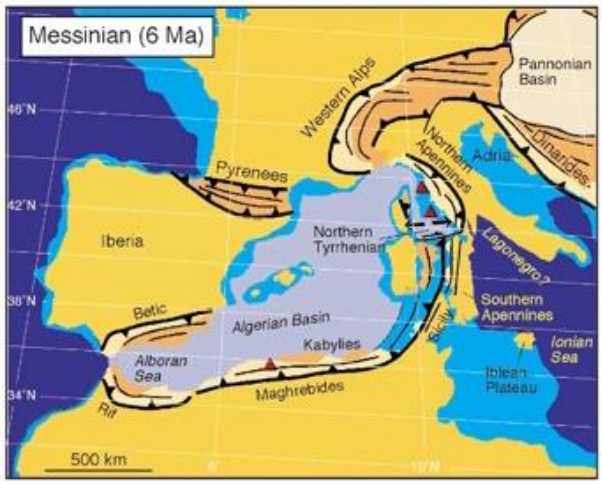


(e) Middle Miocene reconstruction (15 Ma).

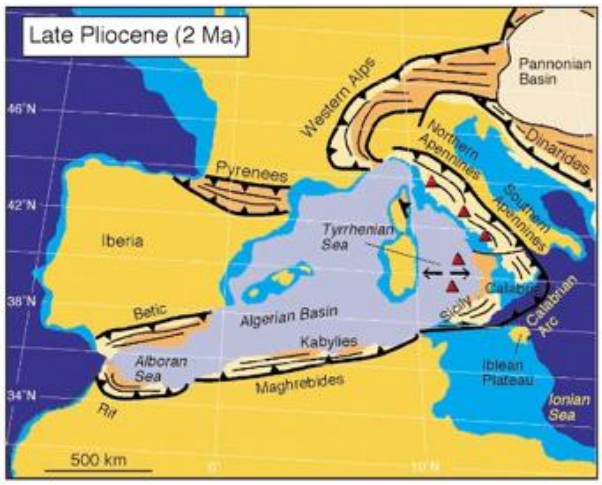
Ga	**(giga-annum)**	**billion years**
Ma	**(mega-annum)**	**million years**
ka	**(kilo-annum)**	**thousand years**



(f) Tortonian reconstruction (10 Ma).



(g) Messinian reconstruction (6 Ma).



(h) Late Pliocene reconstruction (2 Ma).

Figure 11. Palaeogeographic reconstruction of the Western Mediterranean from Oligocene to Recent (after G. Rosenbaum, G. S. Lister and C. Duboz).
This sequence of diagrams (a to h) shows the palaeogeographic reconstructions of the W Med since the Oligocene. Note the numerous areas suffering different types of compressions and extensions.

This rotation resulted from the interplay between a S 'Alpine' subduction zone at Corsica, retreating N, and a static N subduction zone near Sardinia.

- Present day – Several Alpine chains are: Baetic-Rif, Pyrenees, Alps, Apennines, SE of Italy, N of Sicily.
- Calabria slides to the 'Toe' of Italy.

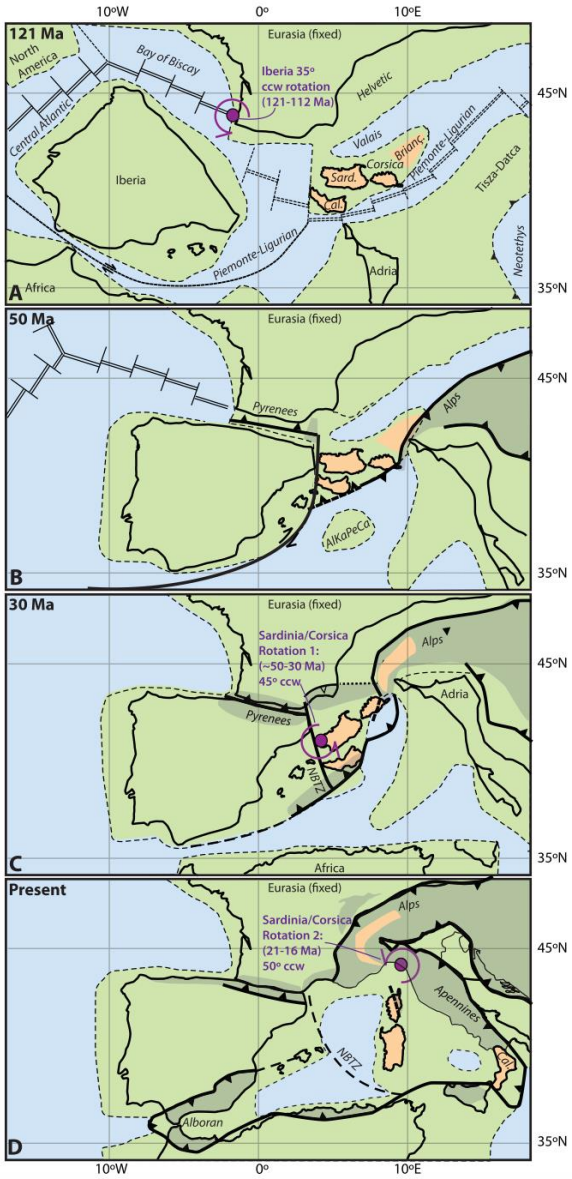


Figure 12. Tectonic reconstructions of central-W Mediterranean.
A. 121 Ma, preceding Iberia's rotation.
B. 50 Ma, onset of the Eocene Corsica–Sardinia rotation.

C. 30 Ma, Oligocene, opening of the Liguro-Provençal Basin.
D. Present-day.
AlKaPeCa (Al = Alboran, S Spain and N Morocco; Ka = Kabylides, Algeria; PeCa = Calabria– Peloritai Arc). NBTZ = N Balearic Transform Zone. Poles of Iberia and Sardinia–Corsica rotations are purple dots with arrow. Movements from: Torsvik et al. (2012); Gaina et al. (2013); Vissers and Meijer (2012a, 2012b); van Hinsbergen et al. (2014); Vissers et al. (2013).

Modern Day Italy

- The important Gargano fault system (GFS) is located in the central Adriatic foreland, between the opposite-thrusting fold belts of the Apennines (thrusting W) and Dinarides-Albanides (thrusting E). Major foredeeps occur along the fronts of these belts.
- The Apulian region and Adriatic form a NW-trending promontory of the African Plate; Apulia formed during Pliocene-Pleistocene folding of this Adriatic foreland beneath the S Apennines.
- This area is discussed under the "Adria-Apulia Problem" in Geoparks of Italy.

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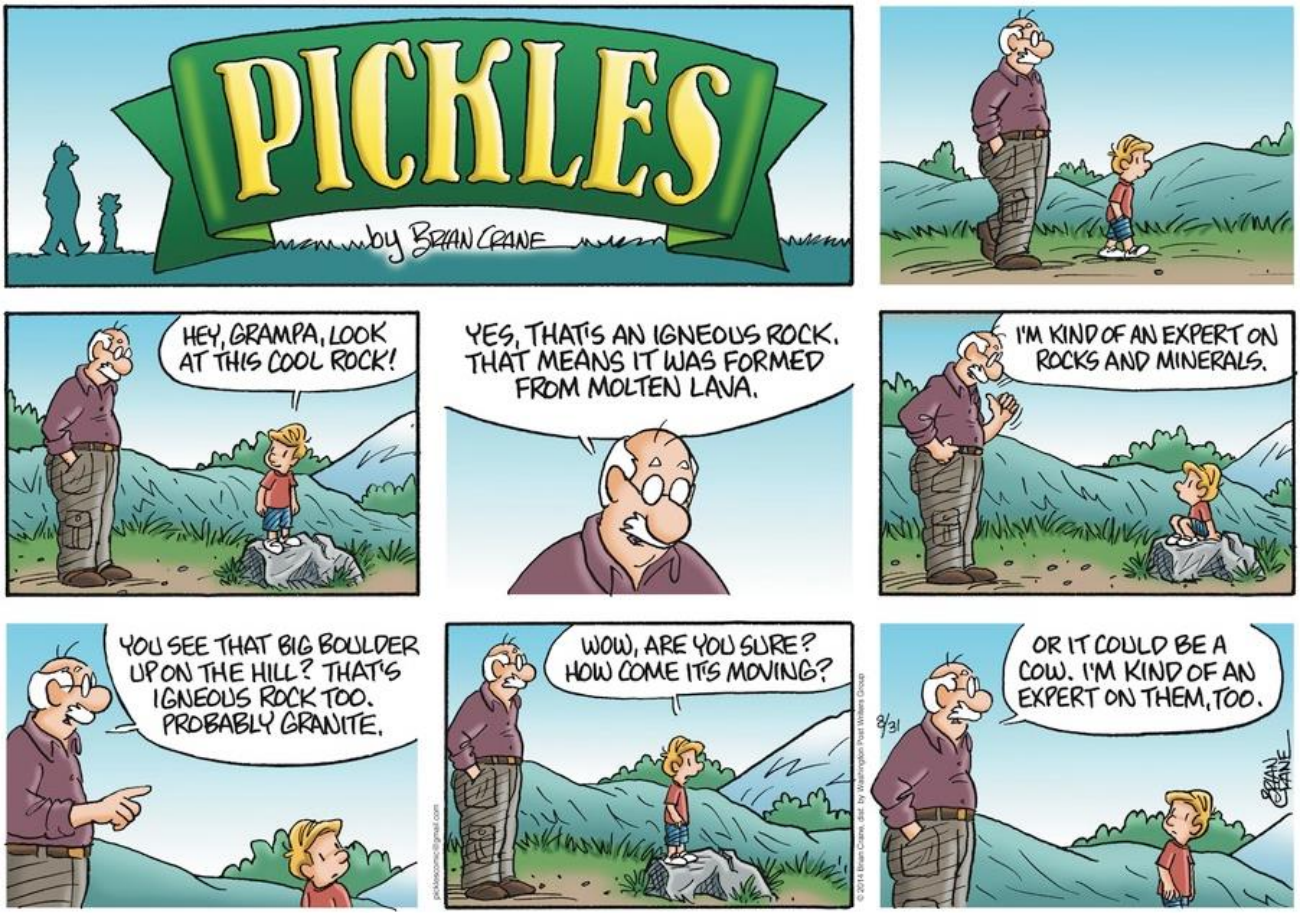
2. https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2021GL093618

Cartoon Corner

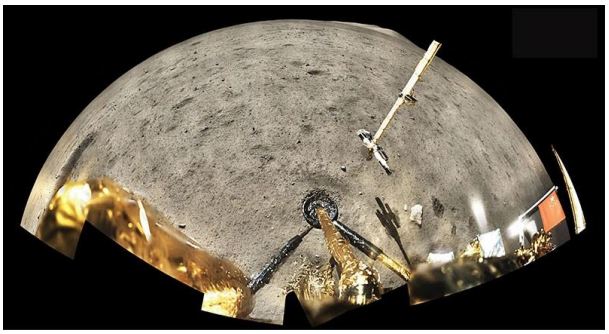


31 August 2014

China's Moon trip reveals surprisingly recent volcanic activity

The Chang'e-5 mission returned the first lunar samples since the 1970s, with bits of lava dated at two billion years old.

Jonathan O'Callaghan, Nature News
7 October 2021



A fish-eye view of Chang'e-5's landing site. The mission collected and shipped back to Earth 2 kilograms of lunar rock. (Credit: Chinese National Space Agency's (CNSA) Lunar Exploration and Space Engineering Center)

The first samples to be brought back from the Moon in half a century — and the first ever by a Chinese mission — carry evidence of the most recent lunar lava ever analysed. Researchers used only tiny fragments from the 2 kilograms of rock returned last December by the Chang'e-5 lander to confirm predictions about the Oceanus Procellarum region, where the spacecraft had landed.

At about two billion years old, the samples reveal volcanism that is at least one billion years younger than any found by NASA's Apollo astronauts or by the Soviet Union's uncrewed Luna missions in the 1960s and 1970s. "This is the youngest-ever lava flow dated from the Moon," says Katherine Joy, a planetary scientist at the University of Manchester, UK, and a co-author of the study, published in *Science* on 7 October. The findings fill a vital gap in the Moon's geology and will also help scientists to understand the history of other Solar System bodies.

China achieved a historic feat when its Chang'e-5 lander touched down on the Moon on 1 December 2020, scooped up samples of the lunar surface and lifted off again two days later. It then performed an automated rendezvous with its mother ship in lunar orbit, which subsequently flew back to Earth. A re-entry capsule carrying the samples landed in China's Inner Mongolia region on 16 December.

The mission's target, Oceanus Procellarum on the Moon's near side, is a region of interest to scientists because it is thought to contain young, solidified lava, an indication of relatively recent volcanism on the Moon.

Based on samples returned by the Apollo and Luna programmes, scientists already had evidence for volcanic eruptions on the Moon stretching back more than 4 billion years, with the majority occurring between 3.8 billion and 3 billion years ago. But no mission had landed in an area as young as Oceanus Procellarum — Latin for 'Ocean of Storms' — which stretches 2,500 kilometres from north to south. Lunar scientists were eager to try to find evidence of more recent volcanism in a region such as this. "I was very pleased with the selection of this landing site," says Harald Hiesinger, a planetary scientist at the University of Münster in Germany.

Lunar lava

As on Earth, lunar volcanism is thought to occur when magma is pushed up to the surface and erupts, leaving 'seas' (*maria* in Latin) of basaltic rock on the surface, which are easily seen from Earth. In Oceanus Procellarum, nearly 2,000 cubic kilometres of basaltic magma are thought to have spewed on to the surface, a big eruption by lunar standards.

The Chang'e-5 lander used a scoop and a drill to collect samples here, at least some of which are now known to be basaltic rock, and their age was determined by radioactive dating.

The findings provide a vital data point about the history not just of the Moon, but of the wider Solar System too. By knowing the exact age of Oceanus Procellarum and matching that to the number of its craters — which accumulate over

time as impacts occur — scientists can infer that locations on other worlds, such as Mars, with similar numbers of craters are of a comparable age. This process, known as crater counting, has so far relied almost entirely on the dating of lunar samples collected by the Apollo missions, leaving a huge gap in the timeline between one and three billion years ago. “It’s absolutely essential to get more data points,” says Ian Crawford, a planetary scientist at Birkbeck, University of London. “That’s what this paper has done.”

Unsolved puzzle

What’s unclear at the moment, however, is what would have driven volcanism on the Moon at the time when Oceanus Procellarum formed. By this time, the Moon had begun to cool, and “the amount of magma being generated dropped off quickly”, says Joy. One possibility is that residual radioactive uranium, thorium, and potassium in the Moon’s interior provided the heat necessary for late volcanism to occur. But the Chang’e-5 samples do not show an abundance of such radioactive elements. “This is really a puzzle,” says Joy.

Another explanation might be that the tidal pull of Earth’s gravity gave the Moon the necessary heat. “Two billion years ago, the Moon was significantly closer to Earth, maybe halfway closer than it is now,” says Alexander Nemchin, a planetary scientist at Curtin University in Perth, Australia, and a co-author of the study. “So, this effect was probably amplified quite significantly.” However, it’s not clear why this would produce localized heating in regions like Oceanus Procellarum, and not much more widely across the lunar surface.

There could be even younger areas to be found on the Moon. Hiesinger, who has contributed to much of the crater-counting work, says that some regions appear to be just a few tens or hundreds of millions of years old — which poses a conundrum. “That would mean the Moon was volcanically active until about 50 million years ago,” he says, which seems “highly unlikely”.

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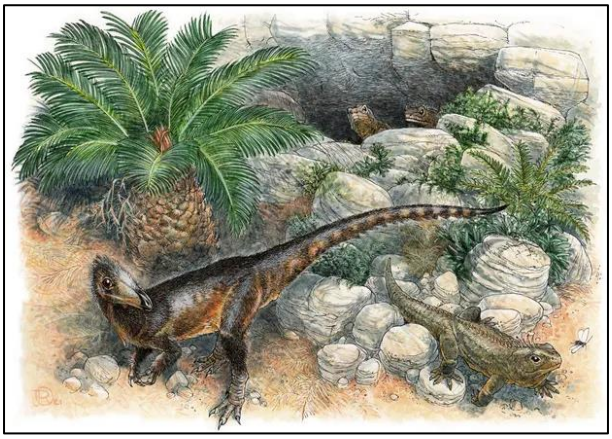
Scientists discover Welsh ‘dragon’ dinosaur – the size of a chicken

Pendraig milnerae was related to T rex and likely to have been apex predator despite its size, say experts

Steven Morris, The Guardian
6 October 2021



Artist’s depiction of how the dinosaur Pendraig milnerae – meaning “chief dragon” – might have looked. (Photograph: © James Robbins)

A dinosaur distantly related to *Tyrannosaurus rex* – but with a body the size of a chicken – that would probably have ruled the roost about 200 Ma ago has been discovered.

The diminutive but fearsome creature, whose fossilised remains were found in a quarry in south Wales, is the oldest theropod – a group that includes *T rex* and modern birds – found in the UK.

It has been named *Pendraig milnerae* – *pendraig* meaning "chief dragon" in middle Welsh and *milnerae* in honour of the late Angela Milner, a stalwart of the Natural History Museum's dinosaur gallery and a researcher and deputy keeper of palaeontology at the museum for more than 30 years.

Fragmentary fossils of *Pendraig milnerae* were discovered in a quarry in south Wales in the 1950s but in recent years had been stashed away in a drawer with some crocodile samples until they were found by Milner.

It is thought the dinosaur lived between 200 Ma and 215 Ma ago during the Late Triassic period. It probably had a body size similar to that of a modern-day chicken, but with its tail taking it to about a metre-long.

Dr. Stephan Spiekman, a research fellow at the Natural History Museum, said: "*Pendraig milnerae* lived near the beginning of the evolution of the meat-eating dinosaurs. It's clear from the bones we have that it was a meat-eater, but early in the evolution of this group these animals were quite small, in contrast to the very famous meat-eating dinosaurs like *T rex* which evolved much later."

Spiekman and his colleagues gave it the name dragon chief to honour its probable position as the apex predator. The reference to Milner, who died in August, was apt as she played a vital role in relocating the specimen, as well as contributing significantly to the understanding of theropod dinosaurs.

The discovery of this new species could also provide evidence for potential island dwarfism. Spiekman said: "The area where these specimens were found was most likely an island during the time period in which it lived. Species which live on islands often tend to become smaller than those on the mainland in a phenomenon called island dwarfism."

He said that because *Pendraig* was not fully grown, it was not possible to reach conclusions on this. "We need more evidence from more species to investigate the potential for island dwarfism in this area during that time, but if we could prove it, it would be the earliest known occurrence of this evolutionary phenomenon."

Richard Butler, co-author on a paper on the dinosaur and professor of palaeobiology at the University of Birmingham, said: "Dinosaur discoveries are really rare in Wales, and this is only the third dinosaur species known from the country. It's very exciting to learn more about the dinosaurs that lived here in the UK during the Triassic, right at the dawn of dinosaur evolution."

The remains were found in the 50s by the palaeontologists Pamela Robinson and Kenneth Kermack. They were studied, but the creature was not named.

Dr. Susannah Maidment, a senior researcher in ES Vertebrates and Anthropology Palaeobiology at the Natural History Museum, was trying to track the specimen down and turned to Milner for help. "She went away and about three hours later she had it. She found it in a drawer with crocodile material."

Reference:

https://www.theguardian.com/science/2021/oct/06/scientists-discover-welsh-dragon-dinosaur-size-of-chicken

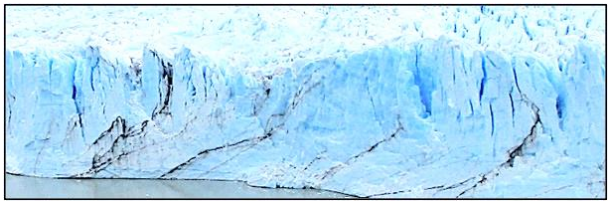
Vanishing ice is warping Earth's crust

By Stephanie Pappas
30 September 2021
Originally published on Live Science
Summarised here by Liz Aston

Ice calving from fracture zones of glaciers continually crash into the oceans (as in Greenland). Melting of the Earth's polar ice is subtly warping the planet's crust both below and hundreds of miles away from the ice sheets. Researchers hope to monitor the warping in order to understand how climate change will affect sea level and to help correct for ground motion in other geological processes.

Scientists already know that when ice disappears, the crust underneath changes – similar to lifting your head from a memory foam pillow which slowly returns to its original shape.

Something similar happens when a glacier retreats: the crust beneath it, no longer under all the weight, slowly recovers to its isostatic position. This is isostatic rebound and is a very slow process - in some high-latitude regions, the ground is still rebounding from the retreat of the Pleistocene ice sheets.



Glacier calving (Credit: Liz Aston, personal photo)

Today, polar regions are losing ice at an increasing rate due to climate change. From 2000 to 2010, ice loss from Antarctica, Greenland and mountain glaciers increased 60% compared with the ice loss between 1990 to 2000. This melting is affecting the shape of the Earth's crust - research shows changes both under and around the ice sheets - and further afield; this change is not just vertical but 3-dimensional, i.e., shifting horizontally, too.

The research is by Sophie Coulson (Los Alamos National Laboratory) whilst at Harvard University, using satellite data collected from 2003 to 2018, to obtain a global view. By looking for tiny movements in the crust and comparing those changes with ice loss in Antarctica, Greenland, and high-latitude glaciers year to year a 3D assessment is made of the impact from ice loss during this century.

The results showed that in many cases, the horizontal movement of the crust was greater than the vertical uplift. Although the movements were very dependent on how much ice was lost each year, in both high-loss and low-loss years, most of North America averaged more horizontal than vertical motion. The horizontal creep, mostly to the N, peaked in 2012 at ~0.45mm. In low-loss years, movement averaged ~0.1mm.

In early 2000s, ice retreated rapidly from the Antarctic Peninsular and West Antarctica, but East Antarctica gained ice. The gain/loss averaged out in terms of Earth's crust, so most deformation was in a relatively small area in the S Pacific.

The N Hemisphere was different - ice loss there was linked to an average of 0.4mm horizontal (mostly N-ward) motion each year (~0.3mm movement in Canada / USA, ~0.2mm in Europe / Scandinavia). Insignificant amounts but over time the warping may affect how future ice loss plays out.

"In some parts of Antarctica … the rebounding of the crust is changing the slope of the bedrock under the ice sheet, and that can affect the ice dynamics … A steeper slope means a faster flow of ice toward the sea". Coulson told the Harvard Gazette.

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Fossilised 'hell heron' dinosaur unearthed on Isle of Wight

Discovery along with another species enhances island's reputation as Europe's best place to find dinosaurs

By Hannah Devlin, The Guardian
29 September 2021

The two new species of dinosaur that may have once roamed what is now the Isle of Wight 125 Ma ago. (Credit: Anthony Hutchings/PA)

The fossilised remains of a dinosaur nicknamed **"the horned crocodile-faced hell heron"**, have been unearthed on the Isle of Wight.

The 125 Ma old predator had a 9-metre-long body, powerful claws, a gigantic skull covered in horns and bumps, and long crocodile-like teeth. The fearsome creature lived on the fringes of ancient floodplains where it would have lain in wait for aquatic prey, research suggests.

The braincase and snout for a Ceratosuchops inferodios. (Photograph: Chris Barker/Dan Folkes/PA)

Scientists say the discovery, along with the skeleton of a second species at the same site, offers unique insights into how the Spinosauridae family of dinosaurs made the transition from land-dwelling to semi-aquatic predators over a period of tens of millions of years.

"This is a really exciting piece of news for the dinosaur world as these are some of the most charismatic and enigmatic predators," said Neil Gostling of the University of Southampton, who supervised the project.

The new finds also cemented the Isle of Wight's status as the best place in Europe to find dinosaurs, he added.

The first specimen has been named *Ceratosuchops inferodios*, which translates as the "horned crocodile-faced hell heron", with the second specimen, *Riparovenator milnerae*, named "Milner's riverbank hunter", in honour of the late British palaeontologist Angela Milner.

During the Early Cretaceous (Barremian) period, the Isle of Wight was a floodplain with a Mediterranean-like climate, balmy forest and rivers containing fish, sharks, and ancient crocodiles. Scientists believe the two dinosaurs would have lived at the margins of the waterways and probably hunted in the water and on land.

The "hell heron" fossil revealed a long muzzle and cylindrical teeth, rather than the sabre-like blades that are normally seen in terrestrial carnivores such as *T rex*. This anatomy suggests it may have hunted like a modern-day heron, standing motionless in the water before plunging its jaws downwards at the sight of prey, according to the analysis published in the journal *Scientific Reports*.

"The fact they have these crocodile-like teeth, which are good for catching slippery fish, means we suspect they were standing in the water and using their jaws to hunt," said Gostling.

Another possibility is that the dinosaurs would have waited, semi-submerged, like a crocodile, or used their large claws to hook fish out of the water like a bear.

The haul of bones were discovered on the beach near Brighstone over a period of several years by fossil collectors Brian Foster, from Yorkshire, and Jeremy Lockwood, a retired GP who lives of the Isle of Wight and is now doing a PhD in palaeontology. The two independently donated their finds to the local Dinosaur Isle Museum.

"We realised after the two snouts were found that this would be something rare and unusual," said Lockwood. "Then it just got more and more amazing as several collectors found and donated other parts of this enormous jigsaw to the museum."

The only spinosaurid skeleton previously unearthed in the UK belonged to *Baryonyx*, which was initially discovered in 1983 in a quarry in Surrey. Most other finds since have been restricted to isolated teeth and single bones.

The new fossils will go on display at Dinosaur Isle in Sandown.

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Dinosaurs' ascent was driven by volcanoes powering climate change

University Of Birmingham
27 September 2021

(Credit: NASA)

The rise of dinosaurs coincided with environmental changes driven by major volcanic eruptions over 230 Ma ago, a new study reveals.

The Late Triassic Carnian Pluvial Episode (CPE) saw an increase in global temperature and humidity - creating a major impact on the development of animal and plant life, coinciding with the establishment of modern conifers.

Researchers analysed sediment and fossil plant records from a lake in northern China's Jiyuan Basin, matching pulses of volcanic activity with significant environmental changes, including the CPE's 'mega monsoon' climate, some 234 to 232 Ma ago.

The international research team, including experts at the University of Birmingham, today published their findings in *Proceedings of the National Academy of Sciences (PNAS)* - revealing four distinct episodes of volcanic activity during this time period, with the most likely source being major volcanic eruptions from the Wrangellia Large Igneous Province, the remnants of which are preserved in western North America.

Co-author Jason Hilton, Professor of Palaeobotany and Palaeoenvironments at the University of Birmingham's School of Geography, Earth, and Environmental Sciences, commented: "Within the space of two million years the world's animal and plant life underwent major changes including selective extinctions in the marine realm and diversification of plant and animal groups on land. These events coincide with a remarkable interval of intense rainfall known as the Carnian Pluvial Episode.

"Our research shows, in a detailed record from a lake in North China, that this period can actually be resolved into four distinct events, each one driven by discrete pulses of powerful volcanic activity associated with enormous releases of carbon dioxide into the atmosphere. These triggered an increase in global temperature and humidity."

The researchers found that each phase of volcanic eruption coincided with large perturbation of the global Carbon cycle, major climatic changes to more humid conditions, as well the lake's deepening with a corresponding decrease in oxygen and animal life.

Geological events from a similar timeframe in Central Europe, East Greenland, Morocco, North America, and Argentina, among other locations indicate that increased rainfall resulted in widespread expansion of drainage basins converging into lakes or swamps, rather than rivers or oceans.

"Our results show that large volcanic eruptions can occur in multiple, discrete pulses - demonstrating their powerful ability to alter the global carbon cycle, cause climate and hydrological disruption and drive evolutionary processes," added co-author Dr Sarah Greene, Senior Lecturer also in the School of Geography, Earth, and Environmental Sciences at the University of Birmingham.

Dr Emma Dunne, a Palaeobiologist also at the University of Birmingham, who was not involved in the study, commented: "This

relatively long period of volcanic activity and environmental change would have had considerable consequences for animals on land. At this time, the dinosaurs had just begun to diversify, and it's likely that without this event, they would never have reached their ecological dominance we see over the next 150 Ma"

Professor Hilton also added "In addition to dinosaurs, this remarkable period in Earth history was also important for the rise of modern conifer groups and had a major impact on the evolution of terrestrial ecosystems and animal and plant life - including ferns, crocodiles, turtles, insects and the first mammals."

The research team investigated terrestrial sediments from the ZJ-1 borehole in the Jiyuan Basin of North China. They used uranium-lead zircon dating, high-resolution chemostratigraphy, palynological and sedimentological data to correlate terrestrial conditions in the region with synchronous large-scale volcanic activity in North America.

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Man killed as Crete struck by 5.8-magnitude earthquake

BBC News
27 September 2021

At least one person has been killed and nine injured after a 5.8-magnitude earthquake hit the Greek island of Crete, local officials say.

The man died when the dome of a church that was being renovated in the town of Arkalochori caved in.

People were sent rushing out on to the streets when the earthquake struck at 09:17 (06:17 GMT). Several aftershocks followed. Civil protection authorities said many buildings had been damaged.

Both Greece and Turkey sit on fault lines and earthquakes are common. The European Mediterranean Seismological Centre (EMSC) initially recorded a magnitude of 6.5 while the United States Geological Survey (USGS) put it at 6.0. The Athens Geodynamic Institute later said the 5.8 quake struck 23km (14 miles) north-west of the coastal village of Arvi, at a depth of 10km.

Canary Islands: 5,000 evacuated as La Palma volcano eruptions continue

At least 20 homes destroyed, and people told to stay away as lava pours from volcano on Spanish island

By Sam Jones in Madrid, The Guardian and agencies (Reuters and the Associated Press)
20 September 2021

Authorities on the Canary Island of La Palma have told spectators to stay away from the continuing volcanic eruptions that began on Sunday and has forced the evacuation of 5,000 people and destroyed at least 20 homes.

The island had been on high alert after more than 22,000 tremors were reported within a week in Cumbre Vieja, one of the most active volcanic regions in the archipelago.

Officials had begun evacuating the infirm and some farm animals from nearby villages before the eruption at 3.15pm local time on Sunday 19 September on a wooded slope in the sparsely populated Cabeza de Vaca area, according to the government.

Two hours later, with lava edging down the hillside from five fissures, the municipality ordered the evacuation of four villages, including El Paso and Los Llanos de Aridane.

After nightfall, footage showed fountains of lava shooting hundreds of metres into the sky, and at least three incandescent orange rivers of molten rock pouring down the hill, tearing gashes into woods and farmland, and spreading as they reached lower ground.

Mariano Hernández, the president of La Palma's council, asked people to keep away from the affected areas because spectators were hampering the evacuation effort.

"People shouldn't come near the eruption site where the lava is flowing," he said. "We're having serious problems with the evacuation because the roads are jammed with people who are trying to get close enough to see it."

The regional president of the Canaries, Ángel Víctor Torres, said while there would be "considerable material damage", the authorities hoped no one would be injured. "We're not expecting any other eruption," Torres told SER radio.

Mount Cumbre Vieja erupts in El Paso. (Photograph: Anadolu Agency/Getty Images)

One stream, several hundred metres long and tens of metres wide, crossed a road and began engulfing scattered houses in El Paso. Footage shared on social media showed the lava entering a house.

"When the volcano erupted today, I was scared. For journalists it is something spectacular, for us it is a tragedy. I think the lava has reached some relatives' houses," a local resident, Isabel Fuentes, 55, told Spanish television TVE.

"I was five years old when the volcano last erupted, in 1971. You never get over a volcanic eruption," added Fuentes, who said she had moved to another house on Sunday for her safety.

Spain's prime minister, Pedro Sánchez, arrived in La Palma, the most north-westerly island of the archipelago, late on Sunday for talks with the islands' government on managing the eruption. "We have all the resources [to deal with the eruption] and all the troops, the citizens can rest easy," he said.

Stavros Meletlidis, a volcanologist at the Spanish Geographical Institute, said the eruption had torn five holes in the hillside and he could not be sure how long it would last. "We have to measure the lava every day and that will help us to work it out," he said.

On Monday, the Canary Island airline Binter cancelled four flights to and from the island of La Gomera because of the smoke and ash plume from neighbouring La Palma.

In 1971, one man was killed as he was taking photographs near the lava flows, but no property was damaged.

The earliest recorded eruption in La Palma was in 1430, according to the Spanish National Geographical Institute.

Reference:

https://www.theguardian.com/world/2021/sep/19/spanish-canary-island-volcano-erupts-after-weeks-of-earthquakes

Forget oil or water. In Iceland, well diggers seek to tap a volcano's magma.

Probing magma directly could answer questions about composition and flow, and guide early warning systems

By Paul Voosen, Science.org
15 September 2021

A version of this story appeared in Science, Vol 373, Issue 6561.

In 2009, well diggers seeking geothermal energy accidentally tapped a magma chamber that vented a plume of steam and glass shards. (G.O. FRIDLEIFSSON/IDDP)

KRAFLA VOLCANO IN ICELAND

After years of effort, volcanologists are ready to open a gateway to hell. From the rim of the Víti ("hell" in Icelandic) crater — a smaller crater within Krafla's 10 km caldera — Ottó Elíasson looks down at a tranquil grassy field disturbed only by a spindly weather station. That will change soon, says Elíasson, science chief at Eimur, a geothermal research centre. "Ten years from now, this could be the centre of volcanology."

The main attraction lies 2 kms below this spot on this volcanically hyperactive island, which is being split in two by the spreading Mid-Atlantic Ridge. In 2009, drillers trying to tap hot water for geothermal energy here accidentally pierced a hidden magma chamber. After an outpouring of steam and glass shards from quenched magma, the borehole created the hottest geothermal well ever measured—until the casing failed.

Now, researchers are returning to penetrate the molten rock on purpose, using hardier equipment, to create the world's only long-term magma observatory. "We've been to Mars. We've been to Venus," says Paolo Papale, research director at Italy's National Institute of Geophysics and Volcanology. "But we have never observed magma below the Earth's surface." Results could help explain how magma moves through the crust, while improving eruption forecasts. They could also shed light on how the continents formed and grew.

In May, the ***Krafla Magma Testbed (KMT)*** received financing from the International Continental Scientific Drilling Program, which said the project was one of its top priorities for the decade. With that support, along with several million dollars in funding from Iceland and other European science agencies, the project this month entered its preparation phase. It will prove out the technologies needed to hold the well open despite the corrosion that comes with superheated water, take geophysical soundings of the magma chamber, and model how the chamber will behave once penetrated. The first borehole, costing as much as $25 million, could begin as soon as 2023.

Unable to study magma directly, volcanologists rely on surface measurements from seismometers, GPS sensors, and radar satellites to guess its movements. They can examine solidified magma chambers exhumed by Earth's upheavals — but those remnants are incomplete, selectively depleted by ancient lava flows. They can study lava at the surface, but the samples have by then lost most of the trapped gases that drive eruptions and influence the magma's original temperature, pressure, and composition. Crystals, inclusions, and bubbles in the hardened lava hold clues to its original state. But a sample from the Krafla chamber will tell researchers whether those estimates "are fictional or reliable," says John Eichelberger, a volcanologist at Southern Methodist University and KMT leader.

Getting a sample will also reveal the true nature of the magma chamber. Most scientists reject the cartoonish view of magma chambers as hellish underground lakes. "We think of these systems as a mush" — small amounts of liquid between crystallized grains — "rather than a liquid balloon," says Marie Edmonds, a petrologist at the University of Cambridge.

But Krafla, which last erupted in 1984, may be an exception. The glassy bits from the 2009 drilling campaign hinted that the magma was not only liquid, but also circulating, interacting with melt lower down. "That's the most shocking thing from what little we've gleaned

so far," Eichelberger says. But little is known about the magma chamber's size or how long it has persisted — questions KMT can help answer. "It's seeing through a glass darkly, as it were," Eichelberger says.

Island of fire and ice. *Riven by tectonic plates, Iceland hosts many active volcanoes. At Krafla, magma is close to the surface.* ***(****Credits: (GRAPHIC) N. DESAI/SCIENCE; (DATA) P. BIRD, GEOCHEMISTRY, GEOPHYSICS, GEOSYSTEMS, 4(3), 2003, DOI:10.1029/2001GC000252)*

KMT will also help answer basic questions about the raw material of continental crust. The world's sea floors, and much of Iceland, take shape from basaltic magma — much the same stuff that exists in the mantle. But the granite rocks of the continents form from a stickier, silica-rich "rhyolitic" magma that is thought to lie below the KMT site. No one is sure how the continent-forming magma originates; one idea is that basaltic magma gets altered by seawater, remelts, and eventually erupts from volcanoes as rhyolite. Samples of rhyolite from basalt-dominated Iceland could provide a window on how this process works worldwide, Eichelberger says.

KMT intends to collect multiple samples over time and embed sensors in and near the magma to measure heat, pressure, and even chemistry despite temperatures of more than 1000°C. "The technical challenges are formidable," says Wendy Bohrson, a volcanologist at the Colorado School of Mines. KMT's drilling partners are testing flexible couplings that can allow the steel liner of the well to expand and contract with extreme heat. And others are developing innovative electronics to withstand the heat and pressure, which could someday be used on Venus.

The technologies could also benefit Iceland's many geothermal energy companies, which have shied away from the hottest rock. Getting closer to magma could dramatically increase the power potential of individual wells — as was clearly seen with the accidental 2009 well, which on its own could have powered a small city. "The geothermal industry is really looking to understand the real source of its energy," says Hjalti Páll Ingólfsson, managing director of Iceland's Geothermal Research Cluster.

The large amounts of water injected to cool and lubricate the drill will likely perturb the volcanic system a bit, and geophysicists will be watching closely. (There is little worry of triggering an eruption, given the mild behaviour of the 2009 borehole, but the site's remote, uninhabited location is another selling point.) Changes in the speed of seismic waves after drilling could reveal the magma's extent, Papale says. Watching these subtle changes could also help with predicting future rhyolite eruptions. Although scientists have gotten quite good at detecting a volcano's warning signs, false alarms abound.

And if KMT remains in place, scientists will eventually get to watch an eruption in action — from the perspective of the underground source of magma. "That will be gold," says Yan Lavallee, a volcanologist at the University of Liverpool. "It is bound to happen."

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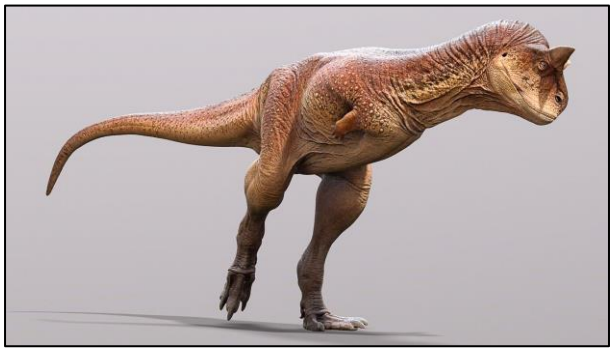
2. doi: 10.1126/science.acx9122

Scientists reveal the fossilised skin of a bull-like carnivorous dinosaur

By University of New England
10 September 2021

One of the strangest carnivorous dinosaurs ever discovered has been given a makeover by a pair of Belgian and Australian palaeontologists.

The remarkable fossil was discovered in 1984 by celebrated Argentine palaeontologist José Bonaparte who named the animal ***Carnotaurus***, which translates as "carnivorous bull" in reference to its strange skull with large horns.



Artist's reconstruction of Carnotaurus based on the scaly skin of described in the present study. (Credit: Jake Baardse)

The skeleton, which comes from Chubut Province of Patagonia, was preserved along with sheets of its scaly hide. Although scientists at the time knew other types of dinosaurs were scaly, *Carnotaurus* was the first meat-eating dinosaur discovered with skin.

Although a number of scientists had looked at the fossilized skin, no one had studied it in detail. Palaeontologist Dr. Christophe Hendrickx from the Unidad Ejecutora Lillo in San Miguel de Tucumán, who led the present study said, "by looking at the skin from the shoulders, belly and tail regions, we discovered that the skin of this dinosaur was more diverse than previously thought, consisting of large and randomly distributed conical studs surrounded by a network of small elongated, diamond-shaped or subcircular scales."

Hendrickx worked with Dr. Phil Bell, an expert in dinosaur skin, from the University of New England in Australia who pointed out the large studs and small scales of *Carnotaurus* is reminiscent of the thorny devil lizard found in Outback Australia.

Unlike more recent discoveries of feathered dinosaurs, particularly from China, the 8-meter-long *Carnotaurus* was entirely scaly, with no evidence of feathers. As an active predator, the scientists speculate the scales would have been important in regulating the animals body temperature, as they do in modern reptiles.

The study was published in the journal *Cretaceous Research*.

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https://phys.org/news/2021-09-scientists-reveal-fossilised-skin-bull-like.html?fbclid=IwAR28STN4t43indk0VhYd7ilwwNoqWauQmGxNoeoq3n-A-U_My5U0M_NbrDM

New fossil reveals a fearsome shark-toothed dinosaur

The new dino was five times bigger than local tyrannosaurs and the first to be discovered in Central Asia.

By Hannah Seo, Popular Science
9 September 2021

Rising out from the Kyzylkum Desert of Uzbekistan is the Bissekty Formation, a structure of rock and sediment between 90 and 92 Ma old that has preserved many a dinosaur fossil. Out of this formation, palaeontologists have discovered an imposing new dinosaur species that was likely the apex predator of the area at the time.

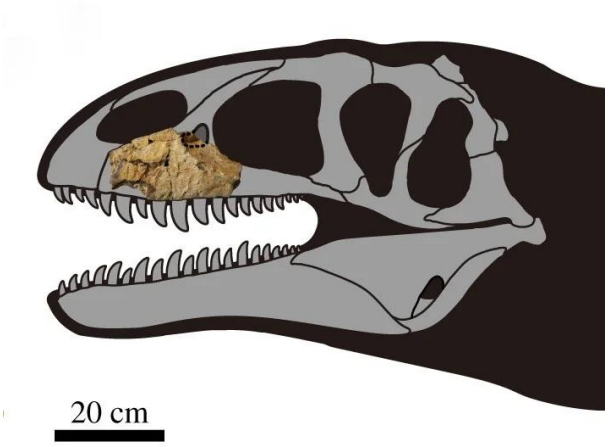
The discovery, *Ulughbegsaurus uzbekistanensis*, was a carcharodontosaur, or a "shark-toothed" dinosaur, a kind of allosaur characterized by its large size and serrated

teeth. It's the first of its kind to be found in Central Asia. And while palaeontologists only had a single fossil to work with — a part of the dino's upper jaw — researchers have concluded that this specimen likely measured around 8 meters in length and weighed about 1,000 kilograms.

Those massive dimensions means that *U. uzbekistanensis* was twice the length and more than five times heavier than the predator previously thought to be the apex of the area, the tyrannosaur *Timurlengia*, which measured 4 meters in length and weighed in at 170 kilograms. The findings were published in *Royal Society Open Science*.

"The skull would have measured about a meter. It had knife-like, sharp teeth and was a meat-eater," lead researcher of the study, palaeontologist Kohei Tanaka, told *Express*.

University of Minnesota palaeontologist Peter Makovicky, who was not involved in the study, agreed with the paper that *U. uzbekistanensis* was likely at the top of the local food chain. "I think this bone is so big that this would have been a very large predatory dinosaur and very likely the apex predator in its ecosystem," he told *Live Science*.



The jawbone fragment that helped scientists determine the size of the new apex allosaur. (Image: Kobayashi et al.)

The giant jawbone was found in Uzbekistan in the 1980s, but researchers rediscovered the fossil when looking through the collection of an Uzbekistan museum. Senior author and Hokkaido University Museum palaeontologist Yoshitsugu Kobayashi explained in a statement the value of this finding: "The discovery of *Ulughbegsaurus uzbekistanensis* fills an important gap in the fossil record, revealing that carcharodontosaurians were widespread across the continent from Europe to East Asia."

The study authors also write that, sometime before the Late Cretaceous period (between 66 and 100 Ma ago), carcharodontosaurians like *Ulughbegsaurus* disappeared from Central Asia, ceding that top predator spot to tyrannosaurs. But a scarcity in research and fossil discovery means that not a lot is known about this transition. *U. uzbekistanensis* is now the latest known carcharodontosaur known to coexist with tyrannosaurs in this time period.

"For many tens of millions of years, tyrannosaurs were the understudies of the allosauroids," University of Edinburgh palaeontologist Stephen Brusatte, who was not involved in the new research, told Smithsonian Magazine. "Allosauroid" refers to the larger family that carcharodontosaurians like *Ulughbegsaurus* belonged to.

Though it's clear that tyrannosaurs took over the area as carcharodontosaurs disappeared, it's still unclear why, and new fossils like this can help illuminate the question: "Given that allosauroids were holding back tyrannosaurs for so many tens of millions of years, I can't envision that tyrannosaurs suddenly figured out how to out-compete [them]," Brusatte said. Having this new fossil, therefore, is a great new piece of the puzzle to have: "This is one new bone, and really just part of a bone, but its importance far eclipses its looks."

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State-of-the-Art Technology, Serendipity, and Secrets of Stonehenge

The first comprehensive analysis of what the sarsen stones are made of came about with new technology — and good old-fashioned luck.

By Richard J. Sima, Science Writer, EOS 8 September 2021

As suggested by Liz Aston

The Sun sets at Stonehenge. A sample of one of Stonehenge's large sarsen stones may be "the most analysed piece of rock on Earth." (Credit: Andre Pattenden/English Heritage)

Stonehenge is an iconic monument that has withstood the tests of time. Its main architecture is composed of **sarsen stones**, grey megaliths towering more than 6 meters tall and weighing 18 metric tons. Despite their prominence, little is known about the 52 stones that remain of the roughly 80 that were erected during the middle–third millennium BCE.

But now, new technology and an unexpected stroke of luck have allowed researchers to analyse a puzzle at the heart of the site: What are these stones made of? Published in *PLOS One*, the study provides a comprehensive characterization of the physical and chemical makeup of Stonehenge's sarsens.

"What's exciting about the new study is that [researchers] have…attacked Stonehenge, as it were, with all this [new technology]," said Mike Pitts, an archaeologist and journalist who led excavations at the site in 1979 and 1980. "And they're able to extract information at a really, really fine level in a way that was impossible until quite recently."

Stone Surfaces and Serendipity

David Nash, a physical geographer at the University of Brighton in the United Kingdom, led the study. His team began by analysing the surface of each sarsen over multiple night shifts and one "very early morning shift" when tourists were not around.

Using a portable X-ray fluorescence spectrometer ("it looks like a big sci-fi ray gun," Nash said), the researchers took five measurements from each of the 52 stones, making sure to hold perfectly still for 2 minutes each time. The team stood in the dark, cold night with headlamps, trying to find patches of stone without lichen cover. Save for a few security guards, there was nobody else around, Nash said. "So, yeah, it's a bit creepy."

The team's measurements, careful though they might have been, could go only so deep. They could not provide information about what lies beneath the surface. And because Stonehenge is so protected by the government, they could not take any samples of the stones' interiors.

But then serendipity struck: as his team was wrapping up the fieldwork at Stonehenge, Nash received an email from the English Heritage Trust, the non-profit organization that manages Stonehenge and hundreds of other historic sites in Britain.

"They emailed me and said, 'We understand that you're doing work on the chemistry of the stones at the moment. Could you give us a ring?'" Nash said. "My immediate reaction was, 'Oh, God, what have we done wrong?'"

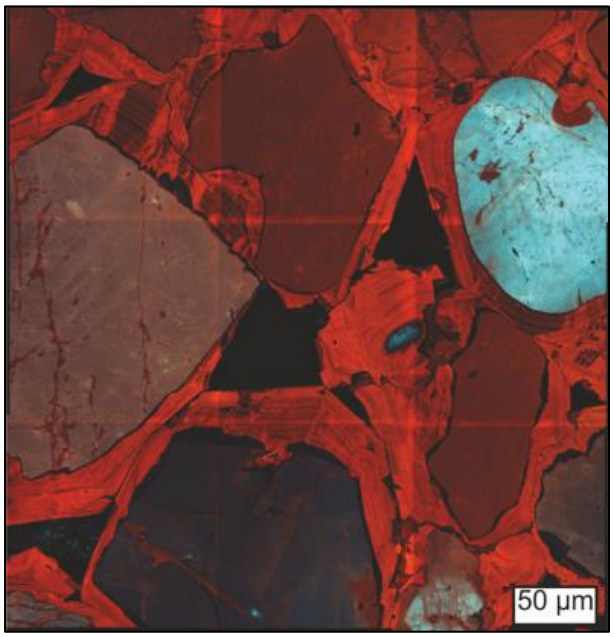
English Heritage shared information about the massive 1958 restoration project at Stonehenge. The project re-erected three stones at the site, including **Stone 58**, a large upright sarsen that had toppled in 1797. To reinforce a fissure, three cores were drilled

One core was gifted to Robert Phillips, a worker at the drilling company involved in the

project. (Part of a second core was later uncovered at nearby Salisbury Museum in a box labelled “Treasure Box.” The location of the third core is still unknown.) Phillips hung the core in a protective tube in his office until his retirement, and kept it through his subsequent moves to New York, Illinois, California, and, finally, Florida. As Phillips approached 90, he sought to return this important artifact and had it delivered to English Heritage in 2018.

Phillips’s Stone 58 core, whose existence was previously unknown to any of the researchers, was lent to Nash’s team, which was able to sample and examine it in detail.

“It’s the first time that we’ve been able to look inside one of the stones at Stonehenge,” Nash said. “They just did everything imaginable with it,” said Pitts, who was not involved in the study. “I mean, it has to be the most analysed piece of rock on Earth.”



Cathodoluminescence imaging of a sarsen stone reveals the outlines of sand grains (pale blue, black) and multiple layers of quartz cement (red). (Credit: Trustees of the Natural History Museum)

Remarkably Pure and Incredibly Durable

Scrutinizing the cores with state-of-the-art petrographic, mineralogical, and geochemical techniques revealed a reason why the long-standing sarsen stones at Stonehenge may be so enduring.

The core was 99.7% silica—almost entirely quartz, through-and-through, which was purer than any sarsen stone Nash had worked on. Under the microscope, its sand-sized quartz grains were tightly packed together and supporting each other. The grains were then coated in an overgrowth cement — at least 16 different growth layers that could be counted almost like tree rings — which produced an “interlocking mosaic of quartz crystals that bind the stone together,” Nash said.

“That’s probably why the sarsens were so big and have been so durable,” Nash said. “Because it’s an incredibly well cemented stone.”

The research also indicated that the dull grey Stonehenge we see today is probably not what it looked like when it was first built.

“When the stones were originally raised, they were dressed, they were cleaned up on the outside,” Nash said. “The fresh rock would have looked a creamy white colour, and it must have been amazing.”

The large sarsen stones at West Woods in Wiltshire are the probable source of most sarsens used to construct nearby Stonehenge. (Credit: Katy Whitaker/Historic England/University of Reading)

Data about Stone 58 can be applied to most of the other sarsens and to where they originated: In a 2020 paper published in *Science Advances*, Nash and his colleagues found that Stone 58 is geochemically similar to and representative of 50 of the remaining 52 sarsens at Stonehenge. These sarsens share geochemical signatures with sarsens in West

Woods in Wiltshire, about 25 km north of Stonehenge — the stones' most probable source.

The new study also lays the groundwork for future research by making all the data open-access.

"We were basically being given access to an absolutely unique sample that was of national importance," Nash said. "And what we wanted to make sure we did was analyse it using every single modern technique that we could, with the view being that for future studies of Stonehenge, if other people are doing more work … there was a big suite of data that people could use."

"Having access to this stone, you realize that you're really privileged to be able to do this work," he added. "So, you want to do it right because you can't go back."

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2. https://www.science.org/doi/10.1126/sciadv.abc0133
3. Sima, R. J. (2021), State-of-the-art technology, serendipity, and secrets of Stonehenge, Eos, 102, https://doi.org/10.1029/2021EO162951. Published on 08 September 2021.

400-million-year-old fossil reveals how first roots emerged in Earth's early plants

The ancient plant's roots developed in an 'entirely different way' than how they grow in modern plants

Vishwam Sankaran, The Independent
30 August 2021

A new study of a 400 Ma old plant fossil from a geological formation in Scotland has shed light on the development of the earliest known form of roots.

The evolution of the first plant roots dramatically impacted our planet and atmosphere, resulting in transformative ecological and climate change, said the research, published last week in the journal *eLife.*

Artist's reconstruction of what the plant, 'Asteroxylon mackiei', would look like. (Credit: Matt Humpage)

In the study, scientists, including a team from the University of Oxford, developed a three-dimensional reconstruction of the *Asteroxylon mackiei* plant from the Devonian era, about 400 Ma ago, based exclusively on fossil evidence.

The fossil, preserved in a type of flint near the village of Rhynie in Aberdeenshire, Scotland, represents the most structurally complex ancient plant from the area and had developed roots and other types of axes, from which roots branch, noted the researchers.

The reconstruction revealed the organisation of the three distinct branching axis types of the plant – leafy shoot axes, root-bearing axes, and rooting axes – in its body plan.

From the 3D reconstruction, scientists studied both the anatomical and developmental properties of this mysterious fossil and found the roots developed in an entirely different way in these plants than how they do in modern plants.

“These are the oldest known structures that resemble modern roots and now we know how they formed. They developed when a shoot-like axis formed a fork where one prong maintained its shoot identity and the second developed root identity,” Liam Dolan, study lead author from Gregor Mendel Institute, said in a statement.

“No roots develop in this way in living plants, demonstrating that this mechanism of root formation is now extinct,” Dr Dolan added.

Understanding the structure and evolution of *A mackiei* can provide insights into events at a key time in Earth history just after plants colonised the dry surfaces of the continents and began to spread across the land, the researchers said.

“Their evolution, radiation and spread across all continents had a dramatic impact on the Earth system. Plant roots reduced atmospheric CO2 levels, stabilized the soil and revolutionized water circulation across the surfaces of continents,” Alexander J Hetherington, a co-author of the study from the University of Edinburgh, said in a statement.

“Using digital 3D techniques, it is possible for the first time to visualise the complex body plan of *A mackiei* allowing us to discover how these enigmatic plants developed. It was brilliant to finally see details that had previously been hidden,” Dr Hetherington added.

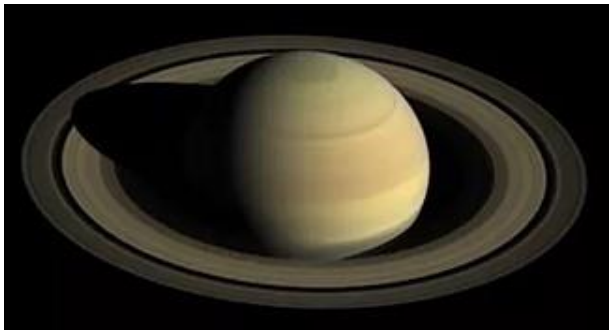
Reference:

https://www.independent.co.uk/news/science/earth-early-plants-fossil-study-b1911122.html

New Research into Saturn's Core

Tereza Pultarova,
Senior Writer, Space.com
16 August 2021

Saturn's rings have been used to investigate the planet’s core and have “determined that instead of a solid sphere like Earth's, the core of Saturn appears to consist of a 'soup' of rocks, ice and metallic fluids that slosh around and affect the planet's gravity”.



Saturn’s rings. (Image credit: NASA/JPL-Caltech/Space Science Institute)

The 2013 data from NASA's Cassini mission revealed that Saturn's innermost ring, the D-ring, ripples, and swirls in a way that cannot be explained by the gravitational influences of the planet's moons.

"We used Saturn's rings like a giant seismograph to measure oscillations inside the planet," Jim Fuller, assistant professor of theoretical astrophysics at Caltech and one of the authors of the paper said in a statement. "This is the first time we've been able to seismically probe the structure of a gas giant planet, and the results were pretty surprising."

The results indicate that:

- the core appears to extend across 60% of the planet's diameter (much larger than previously estimated).
- it might be ~55 times as massive as planet Earth.
- ~17 Earth masses comprise ice and rock.
- ~38 comprise a (H + He)-based fluid.
- the core seems ‘sludgy’, but, despite ‘sloshing’, the core comprises stable layers of various densities.
- the heavier materials are around the centre of the planet; the lighter materials closer to the surface – but they don't mix together.

Christopher Mankovich* explained “motions in the core cause Saturn's surface to constantly ripple ... Saturn is always quaking … and … its surface moves ~1m every 1-2 hrs like a slowly rippling lake. Like a seismograph, the rings pick up the gravity disturbances and the ring particles start to wiggle around … In order for the planet's gravitational field to be oscillating with these particular frequencies, the interior must be stable, and that's only possible if the

fraction of ice and rock gradually increases … towards the planet's centre," Fuller* said. The material in the core (is like) sludge with … "a layered but liquid nature … akin to the salinity of Earth's oceans, which increases with depth. The hydrogen and helium gas in the planet gradually mix with more and more ice and rock … towards the planet's centre".

*Hedman noted: "The findings might challenge some of the established models of the formation of gas giants, planets with no hard surface, which are composed mainly of hydrogen and helium, the study suggests. These models assume that the rocky cores of these planets formed first and then attracted large envelopes of gas. If the cores of the planets are, however, fuzzy as the study indicates, the planets might instead incorporate gas earlier in the process. In fact, recent findings by NASA's Juno mission suggest that another of the solar system's gas giants, Jupiter, might also have a similarly fuzzy core."

**Christopher Mankovich is Lead Author and Postdoctoral Scholar Research Associate in Planetary Science who works in *Jim Fuller's Group. They showed these results to *Matt Hedman, a planetary scientist at the University of Idaho, who was part of the team that first discovered that the motions in Saturn's rings can't be fully explained by the gravity of its moons, however Hedman did not collaborate on the new paper.*

The research is described in a paper published on 16 August in the *Journal Nature*.

It was reported by Tereza Pultarova @Spacedocom and is summarised here by Liz Aston.

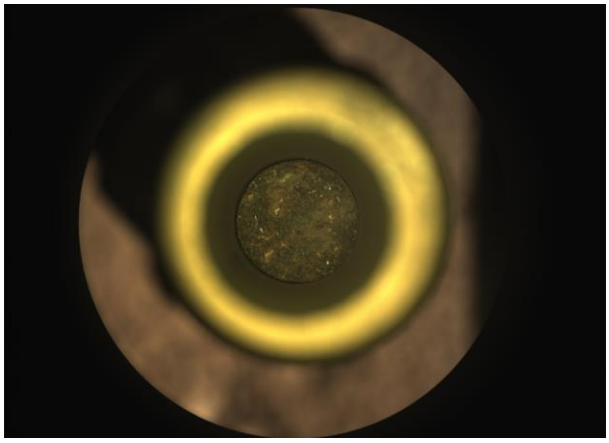
Reference:

https://www.space.com/saturn-rings-study-reveals-soupy-core

First Mars Rock Sample collected by Perseverance Rover

Press Release - Source: NASA

6 September 2021



The rock core is now enclosed in an airtight titanium sample tube and will be available for retrieval in the future. (Image: NASA)

NASA's Perseverance rover today completed the collection of the first sample of Martian rock, a core from Jezero Crater slightly thicker than a pencil.

Mission controllers at NASA's Jet Propulsion Laboratory (JPL) in Southern California received data that confirmed the historic milestone.

The core is now enclosed in an airtight titanium sample tube, making it available for retrieval in the future. Through the Mars Sample Return campaign, NASA and ESA (European Space Agency) are planning a series of future missions to return the rover's sample tubes to Earth for closer study. These samples would be the first set of scientifically identified and selected materials returned to our planet from another.

"NASA has a history of setting ambitious goals and then accomplishing them, reflecting our nation's commitment to discovery and innovation," said NASA Administrator Bill Nelson. "This is a momentous achievement, and I can't wait to see the incredible discoveries produced by Perseverance and our team."

Along with identifying and collecting samples of rock and regolith (broken rock and dust) while searching for signs of ancient microscopic life, Perseverance's mission includes studying the Jezero region to understand the geology and

ancient habitability of the area, as well as to characterize the past climate.

"For all of NASA science, this is truly a historic moment," said Thomas Zurbuchen, associate administrator for science at NASA Headquarters in Washington. "Just as the Apollo Moon missions demonstrated the enduring scientific value of returning samples from other worlds for analysis here on our planet, we will be doing the same with the samples Perseverance collects as part of our Mars Sample Return program. Using the most sophisticated science instruments on Earth, we expect jaw-dropping discoveries across a broad set of science areas, including exploration into the question of whether life once existed on Mars."

First Sample

The sample-taking process began on Wednesday, September 1, when the rotary-percussive drill at the end of Perseverance's robotic arm cored into a flat, briefcase-size Mars rock nicknamed "Rochette." After completing the coring process, the arm maneuvered the corer, bit, and sample tube so the rover's Mastcam-Z camera instrument could image the contents of the still-unsealed tube and transmit the results back to Earth. After mission controllers confirmed the cored rock's presence in the tube, they sent a command to complete processing of the sample.

Today Perseverance transferred sample tube serial number 266 and its Martian cargo into the rover's interior to measure and image the rock core. It then hermetically sealed the container, took another image, and stored the tube.

"With over 3,000 parts, the Sampling and Caching System is the most complex mechanism ever sent into space," said Larry D. James, interim director of JPL. "Our Perseverance team is excited and proud to see the system perform so well on Mars and take the first step for returning samples to Earth. We also recognize that a worldwide team of NASA, industry partners, academia, and international space agencies contributed to and share in this historic success."

First Science Campaign

Perseverance is currently exploring the rocky outcrops and boulders of "Artuby," a ridgeline of more than 900 meters bordering two geologic units believed to contain Jezero Crater's deepest and most ancient layers of exposed bedrock.

"Getting the first sample under our belt is a huge milestone," said Perseverance Project Scientist Ken Farley of Caltech. "When we get these samples back on Earth, they are going to tell us a great deal about some of the earliest chapters in the evolution of Mars. But however geologically intriguing the contents of sample tube 266 will be, they won't tell the complete story of this place. There is a lot of Jezero Crater left to explore, and we will continue our journey in the months and years ahead."

The rover's initial science foray, which spans hundreds of sols (Martian days), will be complete when Perseverance returns to its landing site. At that point, Perseverance will have travelled between 2.5 and 5 kilometres and may have filled as many as eight of its 43 sample tubes.

After that, Perseverance will travel north, then west, toward the location of its second science campaign: Jezero Crater's delta region. The delta is the fan-shaped remains of the spot where an ancient river met a lake within the crater. The region may be especially rich in clay minerals. On Earth, such minerals can preserve fossilized signs of ancient microscopic life and are often associated with biological processes.

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Major climate changes inevitable and irreversible – IPCC's starkest warning yet

Report warns temperatures likely to rise by more than 1.5C bringing widespread extreme weather

Fiona Harvey,
The Guardian Environment correspondent
9 August 2021

Human activity is changing the Earth's climate in ways "unprecedented" in thousands or hundreds of thousands of years, with some of the changes now inevitable and "irreversible", climate scientists have warned.

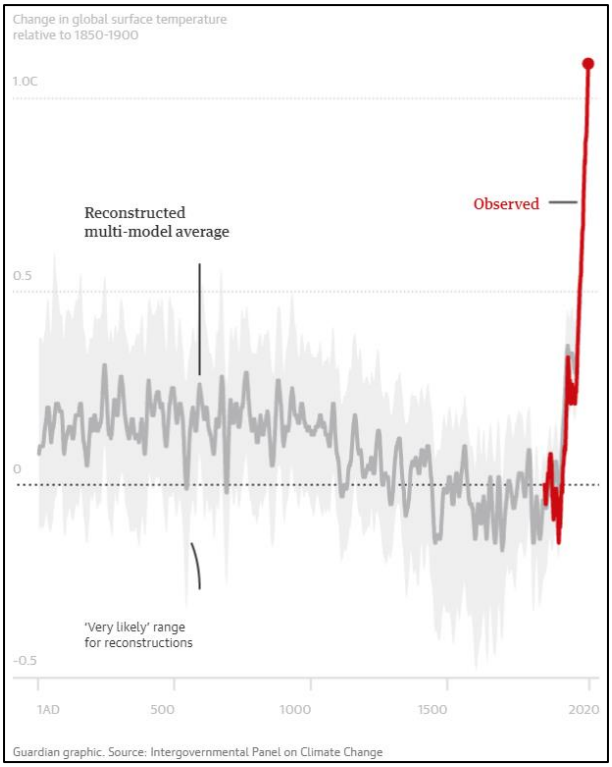
Within the next two decades, temperatures are likely to rise by more than 1.5°C above pre-industrial levels, breaching the ambition of the 2015 Paris climate agreement, and bringing widespread devastation and extreme weather.

Only rapid and drastic reductions in greenhouse gases in this decade can prevent such climate breakdown, with every fraction of a degree of further heating likely to compound the accelerating effects, according to the International Panel on Climate Change, the world's leading authority on climate science.

The comprehensive assessment of climate science published on Monday, the sixth such report from the IPCC since 1988, has been eight years in the making, marshalling the work of hundreds of experts and peer-review studies. It represents the world's full knowledge to date of the physical basis of climate change and found that human activity was "unequivocally" the cause of rapid changes to the climate, including sea level rises, melting polar ice and glaciers, heatwaves, floods and droughts.

World leaders said the stark findings must force new policy measures as a matter of urgency, to shift the global economy to a low-carbon footing. Governments from 197 countries will meet this November in Glasgow for vital UN climate talks, called Cop26.

Each nation is asked to come to Cop26 with fresh plans to reduce greenhouse gas emissions to a level that will limit global heating to no more than 1.5°C above pre-industrial levels, the ambition of the Paris climate agreement and a goal the IPCC emphasised was still possible, but only just.



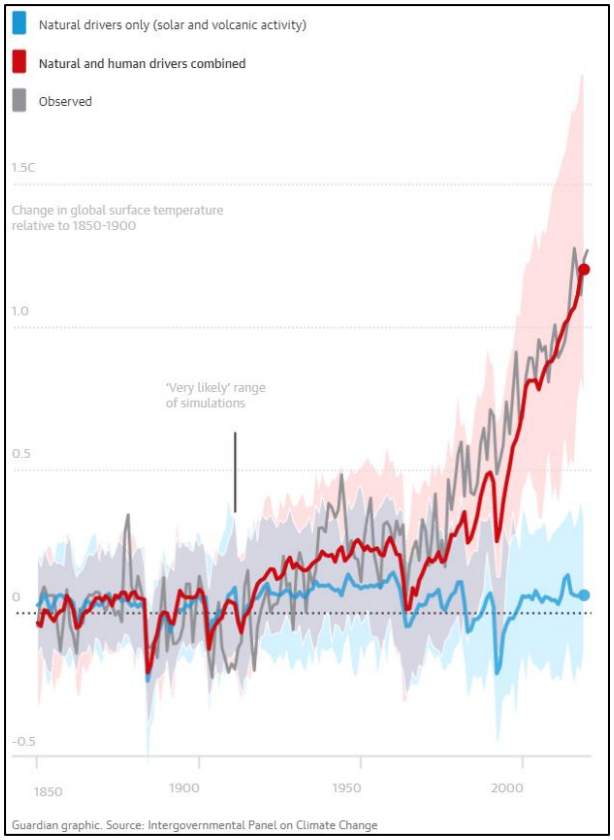
Human influence has warmed the climate at a rate unprecedented in at least the past 2000 years. (Guardian graphic)

António Guterres, the UN secretary general, warned: "[This report] is a code red for humanity. The alarm bells are deafening, and the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet and putting billions of people at immediate risk."

He called for an end to new coal plants and to new fossil fuel exploration and development, and for governments, investors and businesses to pour all their efforts into a low-carbon future. "This report must sound a death knell for coal and fossil fuels, before they destroy our planet," he said.

Boris Johnson, prime minister of the UK, hosts of Cop26, said: "Today's report makes for sobering reading, and it is clear that the next decade is going to be pivotal to securing the future of our planet … I hope today's report will be a wake-up call for the world to take action now, before we meet in Glasgow in November for the critical Cop26 summit."

John Kerry, special envoy to US president Joe Biden, said: "The IPCC report underscores the overwhelming urgency of this moment. The



Climate model simulations show how human factors have contributed to a rise in global surface temperatures. (Guardian graphic)

world must come together before the ability to limit global warming to 1.5°C is out of reach … Glasgow must be a turning point in this crisis."

Temperatures have now risen by about 1.1°C since the period 1850 to 1900 but stabilising the climate at 1.5°C was still possible, the IPCC said. That level of heating would still result in increasing heatwaves, more intense storms, and more serious droughts and floods, but would represent a much smaller risk than 2°C.

Richard Allan, a professor of climate science at University of Reading, and an IPCC lead author, said each fraction of a degree of warming was crucial. "You are promoting moderate extreme weather events to the premier league of extreme events [with further temperature rises]," he said.

Civil society groups urged governments to act without delay. Doug Parr, chief scientist at Greenpeace UK, said: "This is not the first generation of world leaders to be warned by scientists about the gravity of the climate crisis, but they're the last that can afford to ignore them. The increasing frequency, scale and intensity of climate disasters that have scorched and flooded many parts of the world in recent months is the result of past inaction. Unless world leaders finally start to act on these warnings, things will get much, much worse."

Stephen Cornelius, chief adviser on climate change at WWF, added: "This is a stark assessment of the frightening future that awaits us if we fail to act. With the world on the brink of irreversible harm, every fraction of a degree of warming matters to limit the dangers."

Even if the world manages to limit warming to 1.5°C, some long-term impacts of warming already in train are likely to be inevitable and irreversible. These include sea level rises, the melting of Arctic ice, and the warming and acidification of the oceans. Drastic reductions in emissions can stave off worse climate change, according to IPCC scientists, but will not return the world to the more moderate weather patterns of the past.

Ed Hawkins, a professor of climate science at the University of Reading, and a lead author for the IPCC, said: "We are already experiencing climate change, including more frequent and extreme weather events, and for many of these impacts there is no going back."

This report is likely to be the last report from the IPCC while there is still time to stay below 1.5°C, added Joeri Rogelj, director of research at the Grantham Institute, Imperial College London, and an IPCC lead author. "This report shows the closer we can keep to 1.5°C, the more desirable the climate we will be living in, and it shows we can stay within 1.5°C but only just – only if we cut emissions in the next decade," he said. "If we don't, by the time of the next IPCC report at the end of this decade, 1.5°C will be out the window."

Monday's report will be followed next year by two further instalments: part two will focus on the impacts of the climate crisis; and the third will detail the potential solutions. Work on the report has been hampered by the Covid-19 pandemic, which delayed publication by some

months, and forced scientists to collaborate mainly online and through video conferencing.

Reference:

https://www.theguardian.com/science/2021/aug/09/humans-have-caused-unprecedented-and-irreversible-change-to-climate-scientists-warn

Slowdown of Earth's spin caused an oxygen surge

More daylight helped oxygen escape from microbial mats

By Mindy Weisberger, Senior Writer
2 August 2021

Here's a new spin on how Earth became an oxygen-rich planet: as our planet's rotation slowed, microbes were bathed in longer stints of sunlight that revved up their release of oxygen into the atmosphere.

A burbot fish rests on rocks covered in purple and white microbial mats, inside the Middle Island Sinkhole in Lake Huron. (Image credit: Phil Hartmeyer, NOAA Thunder Bay National Marine Sanctuary)

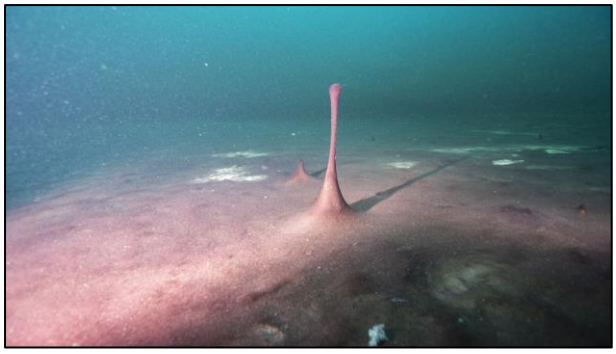
Every breath you take is possible because billions of years ago, dense mats of cyanobacteria — the first life on Earth — began churning out oxygen as a by-product from photosynthesis. But scientists still didn't know for sure what triggered two transformative oxygenation events that turned Earth from a low-oxygen planet into an oxygen-rich world where complex organisms could evolve and diversify.

Now, researchers have identified an important factor that could have spurred the release of microbial-generated oxygen: slowdowns in Earth's rotation beginning about 2.4 billion years ago. Earth spun more quickly when it was a new-born planet, completing a turn in just a handful of hours, but it gradually decelerated over hundreds of millions of years. Once the length of a day reached a certain threshold — possibly during those key oxygenation periods — longer stretches of sunlight may have enabled more oxygen molecules to hop from areas of high concentration (inside the bacteria mats) to areas of lower concentration (the atmosphere), according to a new study.

Scientists recently found clues to this link in a sinkhole at the bottom of Lake Huron. Bordered by Michigan in the United States and by Ontario in Canada, Lake Huron is one of the biggest freshwater lakes in the world. The lake's Middle Island Sinkhole measures 300 feet (91 m) in diameter and lies about 80 feet (24 m) below the surface. There, sulfur-rich water nourishes colourful microbes that thrive in a low-oxygen environment, much like Earth's earliest forms of bacteria did.

In the sinkhole's chilly depths live two types of microbes: sunlight-seeking purple cyanobacteria, which produce oxygen through photosynthesis, and white bacteria, which consume sulfur and instead release sulfate. The microbes jockey for position throughout the day, with the sulfur-eating bacteria covering their purple neighbours in the morning and evening hours, blocking the purple microbes' access to the sun. However, when daylight is strongest, the white microbes shun the light and migrate deeper into the sinkhole, leaving the purple cyanobacteria uncovered and thereby able to photosynthesize and release oxygen.

There might have been similar competitions between communities of microbes billions of years ago, with oxygen-producing bacteria's sunlight exposure hampered by their microbial neighbours, the researchers wrote in the study. Then, as days on Earth became longer, the oxygen-makers gained more time in the



Purple microbial mats in the Middle Island Sinkhole in Lake Huron, June 2019. Small hills and "fingers" like this one in the mats are caused by gases like methane and hydrogen sulfide bubbling up beneath them. (Image credit: Phil Hartmeyer, NOAA Thunder Bay National Marine Sanctuary)

sunlight — and released more oxygen into the atmosphere.

"We realized that there is a fundamental link between light dynamics and release of oxygen, and that link is grounded in the physics of molecular diffusion," when thermal changes cause molecules to migrate from areas of higher concentration to lower ones, said study lead author Judith Klatt, a research scientist with the Max Planck Institute for Marine Microbiology in Bremen, Germany.

"A shorter day would allow less oxygen to escape a mat, even if the same amount of oxygen is produced per hour," Klatt told *Live Science* in an email.

Spin cycle

Now, Earth completes a full rotation on its axis once every 24 hours, but more than 4 billion years ago, a day lasted only about six hours, the researchers reported. Over billions of years, Earth's ongoing dance with the Moon has slowed the planet's rotation through a process known as tidal friction. As Earth rotates, the pull of the Moon (and the Sun, to a lesser extent) attracts Earth's oceans. This stretches the seas so that they bulge away from Earth's centre, siphoning energy away from the spin and slowing it down, said study co-author Brian Arbic, a professor in the Earth and Environmental Sciences department at the University of Michigan's College of Literature, Science and the Arts.

This deceleration is small, but it added up to hours of additional daylight over hundreds of millions of years; and the slowdown is still going on today, Arbic told *Live Science* in an email.

"Tidal friction continues to slow down the rotation rate — the days will continue to lengthen over geological time," Arbic said.

Breath of fresh air

The researchers modelled scenarios that varied day length and oxygen escape from microbial mats. When they compared their models with an analysis of the competing microbial mats sampled from the Middle Island Sinkhole, they found confirmation of their predictions: photosynthesizing bacteria released more oxygen when days were longer.

This wasn't because the microbes photosynthesized more; rather, it was because longer periods of sunlight meant that more oxygen escaped from the mats in a single day, said study co-author Arjun Chennu, a research scientist at the Leibniz Centre for Tropical Marine Research in Bremen.

"This subtle uncoupling of oxygen release from sunlight is at the heart of the mechanism," Chennu said in a statement.

Earth's atmosphere took shape after the planet formed and cooled, around 4.6 billion years ago, and was mostly made of hydrogen sulfide, methane and carbon dioxide (CO_2) — as much as 200 times the amount of CO_2 as there is in the atmosphere today, according to the Smithsonian Environmental Research Center.

That all changed following the Great Oxidation Event (GOE) about 2.4 billion years ago, followed by the Neoproterozoic Oxygenation Event about 2 billion years later, bringing atmospheric oxygen up to the present-day level of about 21%. Those two oxygenation events have previously been linked to the activity of photosynthesizing cyanobacteria, and this new evidence suggests that another factor could have been daytime on Earth — "a previously largely unconsidered factor" — becoming long enough to trigger the release of even more oxygen from microbial mats,

working "in parallel with the other previously suggested drivers of oxygenation," Klatt said.

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Newly-found ancient human rewrites story of evolution

ARCHAEOLOGY
8 September 2021

A team of researchers have discovered a previously unknown type of ancient human in Israel. The archaeological finds include part of a skull and jaw from an unknown group of hominins who lived alongside our species around 140,000 years ago. The study suggests that this ancient human, called the ***Nesher Ramla Homo***, was the direct ancestor of Neanderthals.

The skull fragments reveal a prominent brow ridge, large teeth, and no chin. (Image: Tel Aviv University)

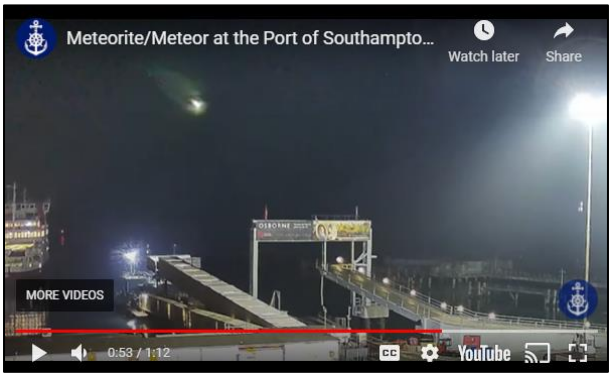
Reference:

https://www.bbc.com/reel/video/p09vcnzv/newly-found-ancient-human-rewrites-story-of-evolution?xtor=ES-213-[BBC%20Features%20Newsletter]-2021September17-[Reel%7c+Copy+2]

Interesting Video

Brilliant meteor lights up sky over southern England coast

By Alexander Cox
11 September 2021



A meteor was caught on camera lighting up the night sky over the southern coast of England on Sunday, 5 September 2021.

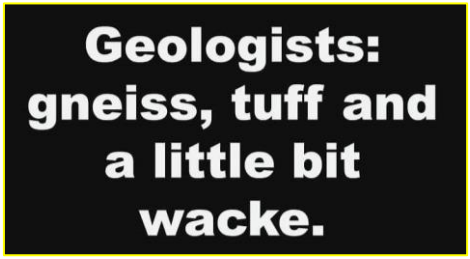
In the video, viewers can see a bright, fireball-like object shooting across the sky over the Red Funnel Ferry Terminal in Southampton.

The footage was taken Sunday night around 10:45 pm BST and uploaded to Solent Ships YouTube channel - a channel that normally releases content about boats and ships off the coast of Southampton, England.

Thanks to Liz Aston for this article.

Reference:

https://www.space.com/meteor-over-southern-england-sept-5-2021?utm_source=SmartBrief&utm_medium=email&utm_campaign=58E4DE65-C57F-4CD3-9A5A-609994E2C5A9&utm_content=4F3F4CF2-4EA5-4854-981C-CDDB2832A0C8&utm_term=dca9b4e6-e972-4b05-b6b8-1d3993db5655



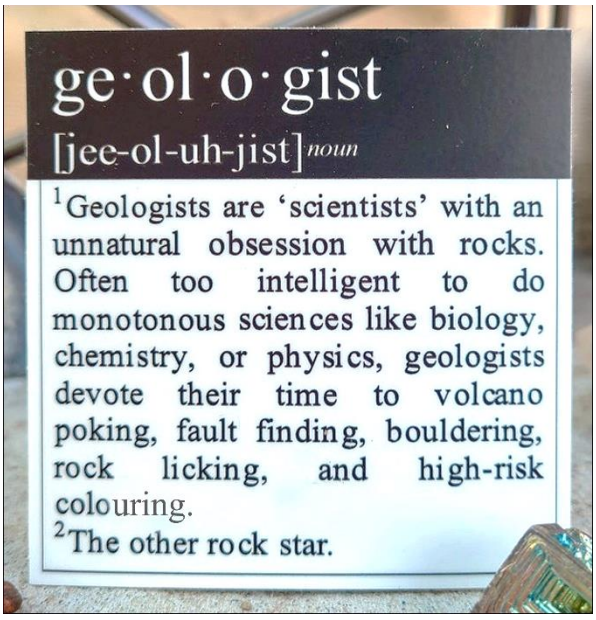
Letters to the Editor

Earth's liquid hot interior is 'swallowing up' more carbon than thought

Harry Cockburn, The Independent
28 July 2021

FGS Newsletter, August 2021, Page 22

Dear editor,
This is a very interesting report and concept - but I am worried about the science - most of the C is held in CO3 and by the time the plate and thus any shells arrive at the subduction zone, nearly all the CaCO3 will have been dissolved back into the seawater (at the calcite compensation depth ~3.5km) due to the pressure at the bottom of the oceans. So, there will be no calcareous shells - it will be CO3 in igneous minerals (not a significant amount I would have thought) or in the seawater within the slab pores that will be taken down into the trench. Most / much of that will be released into the asthenosphere as seawater I would argue and into a melt - so not a lot will get down to or be stored at the CMB. But I guess the volume of slab rock which is subducting is pretty significant and any little extra will help - as Tesco says in its advert.
Liz Aston



(Credit: MineDesignCreations.com)

Interesting Places 2


Santorini viewed from orbit

Thomas Pesquet: I love the look of Santorini from space, is it about to take a large bite and swallow the Tholos Naftilos volcano whole? The boat on the left looks like it was traveling very fast towards the natural harbour.

An age-old volcanic eruption here could have been the inspiration for the myth of Atlantis, one theory goes. After its eruption a whole civilisation might have been lost to the sea, when you see it like this, it is an interesting theory, and all the more interesting that the eruptions made this natural harbour.

Credits: ESA/NASA-T. Pesquet/W. Harold
Larger image Santorini from space (credit: ESA)


Fires in Peloponnese as seen from space

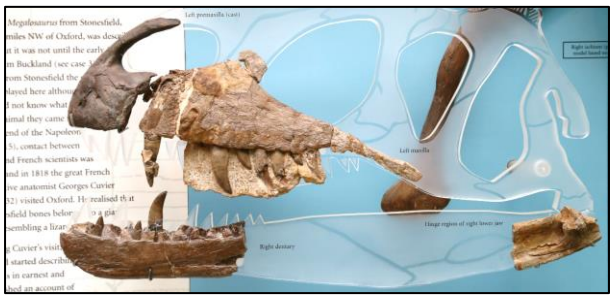
11 August 2021: Fires in Peloponnese, Greece in the Mediterranean. *(Credit: ESA/NASA-T. Pesquet)*

Oxford University Museum of Natural History holds an internationally-significant collection of natural history specimens and archives in a stunning example of neo-Gothic architecture. It is home to a lively programme of research, teaching and events focused on the sciences of the natural environment.

The Oxfordshire Dinosaurs

Oxfordshire is home to the discovery of the first dinosaur to be scientifically described: *Megalosaurus bucklandii*. On display with Megalosaurus are three other species of dinosaur discovered in Oxfordshire, as well as exact replicas of dinosaur skeletons from around the world, including *Tyrannosaurus rex*.

On display in the centre court are the fossilised remains of the first dinosaur ever to be described by scientists – *Megalosaurus bucklandii*. The jawbone of Megalosaurus, a nine-metre-long Jurassic carnivore, was discovered in the late 18th century in the small village of Stonesfield about 15km north of the Museum.



Bones from the skull of Megalosurus bucklandii on display. (Credit: Oxford University Museum of Natural History)

Over the next two decades, several more enormous bones were found at Stonesfield. In 1818, the University of Oxford's first Reader in Geology, William Buckland, showed the collection to the renowned French comparative anatomist Georges Cuvier. The two scientists realised that the bones belonged to a giant lizard-like animal. Buckland went on to describe the bones in 1824, naming it *'Megalosaurus'*, meaning 'great lizard'. The specimens in the Museum's display include most of the material he used in this ground-breaking work.

A sequence of Megalosaurus footprints can be seen on the lawn in front of the Museum. The 60-metre-long trackway is made up of casts of fossilised prints discovered at Ardley Quarry, Oxfordshire in 1997.

Megalosaurus is not the only dinosaur to have been discovered in Oxfordshire. The Museum's displays include three other species found in the area: *Cumnoria, Eustreptospondylus* and *Cetiosaurus*. All these dinosaurs date from Middle-Late Jurassic (around 170–150 Ma ago), when the area which is now Oxfordshire had a much warmer climate. As well as dinosaurs, the land was home to pterosaurs and small mammals.

Tyrannosaurus rex replica skeleton *(Credit: Mick Caulfield)*

Reference:

https://www.oumnh.ox.ac.uk/#/

Photographic Competition

"What geology means to me!"

As part of our 50th Anniversary Celebrations we were planning a Photographic Competition. However, like many other aspects of our lives over the past 18 months the competition was postponed.

We would now like to revise the competition in time for our **11 March 2022** meeting.

If you would like to enter a photograph(s) on the theme of **"What geology means to me!"** please submit **A4 copies** of the photographs in black & white or colour. **The rules for the competition are attached with this newsletter.**

Entry closing date is 28 February 2022.

Entries will be displayed at the meeting and the winner will receive a prize.

Good luck!