Newsletter of
The Farnham Geological Society

Volume 27, Number 1, February 2024

Front Cover of the FGS Newsletter, July 1982

The Lindisfarne Stone showing warriors who may be Vikings, Holy Island, Northumbria. Artist: Unknown

Farnham Geological Society

Farnhamia farnhamensis

Founded 1970

A local group within the GA

Volume 27, No. 1 **Newsletter** February 2024
Issue No. 123

www.farnhamgeosoc.org.uk

Editorial

Happy New Year. Welcome to 2024 and a new edition of the FGS Newsletter. I hope you are all fit and well and had a wonderful Christmas and New Year.

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 "live". And don't forget to **Zoom-in** on **Friday, 9 February** at **8:00pm** for **Prof. Emrys Phillips** talk entitled **"What did the last ice age do for us? – Scotland during the last ice age"** which promises to be a fascinating presentation.

Peter Luckham

As you know Peter Luckham has retired as the Society's Treasurer after **50 years in the role** … **a quite remarkable achievement**. Peter describes here how he first became involved with the FGS and why he now feels it's time to hand over the role.

"On the 23rd of February 1972 I paid a Subscription of £1 and a Membership Fee of a new 50p coin to join the recently formed Farnham Society started by a group of enthusiastic, mature students from a WEA Geology Class. On the 1st of January 1974 I volunteered to be the Treasurer of this now vibrant group with no idea of what the future would hold.

Many great friendships and Field Trips later along came COVID, and the Society's aims and ambitions were made to change to adapt to the restrictions on face-to-face meetings and group activities, even outdoors.

Age and the 'steamroller' pace of Banking change has convinced me to retire from office and give another member the opportunity to reap the pleasure from involvement in doing the accounts and ensuring the strength of the Society going forward.

My 50th and final Statement of Accounts was presented at the January 2024 AGM … thanks Mike. Thank you all for all your support over the last 50 Years"

As you will be aware we held our AGM via Zoom on Friday, 12 January 2024. A full report will appear in the next Newsletter but for those who were unable to attend I wanted to let you know that **the resolution to change the month of the AGM to April, together with the reporting of our finances to end-March was carried unanimously**. In addition, the Committee for 2024 was also agreed by the majority of the members present. **Thank you to everyone who was able to attend the AGM, it really does make a difference!**

The success of our Newsletter depends upon you, the Members, providing material. So, if you have been on a Field Trip, visited a site of geological interest, listened to an interesting Zoom talk, webinar or TV programme, or have any other news or views you would like to share or questions you would like to ask, then please feel free to get in touch with the **Newsletter Editor**, **Mick Caulfield** (newsletters@farnhamgeosoc.org.uk).

We are still looking for members to both join the FGS Committee, particularly IT/Sound, as well as help with organising the Societies various activities. Please contact our Chair Mick Caulfield (newsletters@farnhamgeosoc.org.uk) **if you would like to help.**

Contents

Front Cover

This month's Front Cover dips into the archives and reproduces the cover of the FGS Newsletter from July 1982 (https://www.farnhamgeosoc.org.uk/newsletters/1977_1989/v1n17jul1982.pdf).

The drawing is of a 9th-century grave marker found at Lindisfarne Priory on Holy Island in Northumberland, known as the **Viking Domesday stone**, carved on this side with seven armed men brandishing weapons. The stone is displayed in the site museum.

Reference: https://www.english-heritage.org.uk/visit/places/lindisfarne-priory/History/significance/

Farnham Geological Society
Committee 2024

Chair	**Mick Caulfield**
Treasurer	**Mike Millar**
Secretary	**Judith Wilson**
Programme Secretary	**Janet Catchpole**
Membership Secretary	**Sally Pritchard**
Field Trip Secretary	**Tessa Seward**
Newsletter Editor	**Mick Caulfield**
Web Manager	**Bob Rusbridge**
Advertising	**Peter Crow**
IT/Sound	**Mike Millar**
Without portfolio	**Peter Luckham**
Ad Hoc Member	**Liz Aston**

Meeting Programme 2024

Please note The Maltings and Zoom meeting times:
7.30 pm for 8.00 pm start.

What did the last Ice Age do for us? – Scotland during the last Ice Age
Prof. Emrys Phillips Fri, 9 February
BGS

Glacial history of Deeside, Aberdeenshire
Dr. Stuart Archer Fri, 8 March
Harbour Energy

EGM Fri, 12 April

From Chalk to Peat – 100 million years in the Lambourn Valley
Lesley Dunlop Fri, 17 May
Consultant

Peru
Sally Pritchard Fri, 12 July
FGS

The enigmatic Ice Age boulders of the West Sussex Coastal Plain
David Bone Fri, 4 Oct
Consultant

Field Trip Programme 2024

Our programme for this year has yet to be finalised.

Potential trips include:

DAY TRIPS

- The Folkestone Warren Landslide.
- Dryhill Quarry near Sevenoaks.
- Charmouth / Lyme Regis.
- The Etches Collection Museum of Jurassic Marine Life.
- Wyke Regis / The Fleet

RESIDENTIAL TRIPS

- 2024 - Northern Ireland (4 days)
- 2025 - Glamorgan Coast (3 days)

Also investigating potential joint trips with other societies such as Reading.

Please let our Field Trip Secretary, Tessa Seward (wessa2006@hotmail.co.uk), know if you are interested in any of these trips or if you have other ideas for places of geological interest to visit.

Geologists' Association
Lecture Programme 2024

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

Geological drugs and prophylactics — a look at the historical uses of fossils, minerals and rocks in the prevention and treatment of disease
Dr. Chris Duffin, Fri, 2 February
NHM

Reading the Sahara - Stories in the landscapes
Ted Dubowski, Fri, 15 March
GA Hon. Gen. Sec.

Here be sea monsters: new perspectives on fossil marine tetrapods
Dr. Rebecca Bennion, Fri, 5 April
North Craven Life Museum

Reading Geological Society
Lecture Programme 2024

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

Maps, mountains and madness – Charles Lapworth and the Highland Controversy
Prof. Paul Smith Mon, 5 February
Oxford University
Museum of Natural History

Presidential Address
Prof. Alison MacLeod Mon, 4 March
University of Reading

Mountains in the Sea
Prof. Tony Watts, Mon, 8 April
Department of Earth Sciences,
Oxford University

Mole Valley Geological Society
Lecture Programme 2024

http://mvgs.org.uk

Lapis lazuli – the heavenly stone.
Dr. Chris Duffin, Fri, 9 February
NHM

Evidence of Palaeolithic 2022 human cultural mixing revealed from bone artefacts in French caves.
Dr. Claire Lucas, Fri, 9 March
British Museum

Sea Level Change through the Phanerozoic and into the Anthropocene.
Dr. Colin Summerhayes, Sat, 13 April
Scott Polar Research Institute,
Cambridge University.

Horsham Geological Field Club
Lecture Programme 2024

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

Geological and geotechnical hazards of southeast England
Roger Smith, Wed, 21 February
ex-Director of Southern Testing

TBA
Professor Andrew Coates, Wed, 13 March
Department of Space and Climate Physics,
Mullard Space Science Laboratory

Next Lecture

Friday, 9 February 2024

7:30pm for 8:00pm … Zoom Only

What did the last Ice Age do for us? – Scotland during the last Ice Age

Prof. Emrys Phillips, BGS

BSc Hons (Manchester), MSc (Manchester), PhD (Cardiff)

This talk will begin by answering the question "What did the last ice age do for us?" highlighting why the glacial landscape is important. It will then go onto briefly introduce what causes an ice age and provide a few facts

and figures about the last glaciation to have effected Scotland and Northern Britain. Using photographs of classic examples of the glacial landscape in Scotland it will then provide a quick guided tour of the features formed by the cold climates (periglacial), as well as those landforms formed by the ice (glacial) and by the melting ice. The talk will finish by quickly discussing why understanding glacial process is so important.

Prof. Phillips joined the British Geological Survey (BGS) in August 1990 as a member of the Mineralogy and Petrology Group. His primary role at that time was to provide detailed specialist scientific input into BGS' multidisciplinary research and commercial programmes. Consequently, he gained extensive experience in the petrological, mineralogical and structural (macro- and microstructures) analysis of deformed and metamorphosed bedrock terranes, working on a variety of projects throughout the UK landmass, Iceland, Europe (e.g. Poland, Germany), North America (e.g. Canada), Africa (e.g. Botswana, Egypt) and the Middle East (e.g. United Arab Emirates, Oman, Saudi Arabia).

He currently holds an Individual Merit Promotion (Band 3) Research Scientist post at the BGS office in Edinburgh with an expertise in the macro- and microstructural analysis of deformed glacial sediments, and the control of subglacial deformation on ice sheet dynamics and glacier motion.

In 2015 he was awarded an Honorary Professor position in the Department of Geography at Queen Mary University of London.

Lecture Summary

Friday, 10 November 2023

On Friday, 10 November 2023, 23 FGS members were in attendance at The Maltings & at least 20, including other Society members such as Mole Valley GS, via Zoom, welcomed FGS member Mike Millar.

Asteroids and Comets, an introduction

Summary of a lecture by Mike Millar (FGS)

Our solar system began forming about 4.6 Ga (billion years) ago, from a molecular cloud of gas and dust.

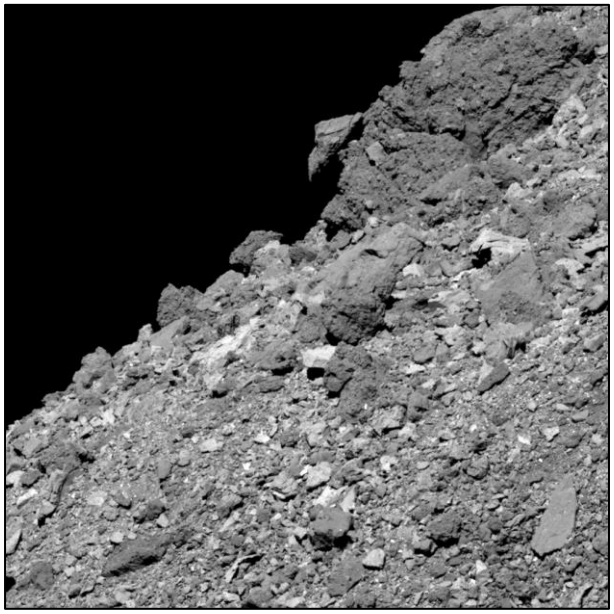
Possibly due to the shockwave of a nearby exploding star, this cloud collapsed to form the solar nebula. The nebula contracted under its own gravity to form an accretionary disk with the proto-Sun at the centre.

While the Sun was forming, the planets and the rest of the Solar System formed from the remainder of the accretionary disk. Within this disk, the dust and ice particles moved about, bumping into each other, and clumping together. Through this process of accretion, these particles formed larger bodies that eventually became planetesimals up to a few kilometres across. The planets formed from further accretion of these planetesimals, into two basic types: **the 'inner' rocky planets** and **the 'outer' gas/ice giants**. Asteroids and comets are a part of the left-over planetesimals.

The **Nice Model** proposes that during the early evolution of the Solar System, the positions of the planets shifted due to their gravitational interactions. Uranus and Neptune probably formed closer to the Sun and migrated outwards. Jupiter may have migrated inwards and then reversed back again due to the influence of Saturn's gravity. The gravitational disruption caused by the outer planets' migrations would have sent large numbers of planetesimals into the inner Solar System, depleting the original belt to its current low mass, and preventing a fifth rocky planet forming.

This also caused numerous impacts by planetesimals on the inner planets in an episode called the **Late Heavy Bombardment** (LHB), which occurred between 4.1 and 3.8 Ga. It also sent icy planetesimals outwards to the outer parts of the Solar System, forming the Kuiper Belt, the Scattered Disk and the Oort Cloud, which are the probable sources of the comets.

Asteroids are thought to be left-over inner solar system planetesimals. Their physical composition is varied and, in most cases, poorly understood. But as most formed within the inner, hotter part of the solar nebula, asteroids are thought to be composed mostly of silicates and metals, however they do appear to contain traces of carbon compounds and water.



This image shows asteroid Bennu's boulder-covered surface. It was taken by the PolyCam camera on NASA's OSIRIS-REx spacecraft on April 11, 2019, from a distance of 2.8 miles (4.5 km). The field of view is 211 ft (64.4m), and the large boulder in the upper right corner of the image is 50 ft (15.4m) tall. When the image was taken, the spacecraft was over the southern hemisphere, pointing PolyCam far north and to the west. (Credit: NASA)
https://en.wikipedia.org/wiki/101955_Bennu#/media/File:Bennu%E2%80%99s_boulder-covered_surface_20190411_bennu_bird_rock_0.png

Some asteroids are still in their original planetesimal form. Some of the larger asteroids may have melted to some degree, allowing them to be partially or completely differentiated (Ceres, Vesta). But some (most?) asteroids are piles of rubble formed from the debris of collisions and held loosely together by their own gravity. Asteroids orbit the Sun mainly in the Ecliptic, and mostly within the inner Solar System, Jupiter's orbit and inwards.

Most asteroids are found in the **Main Asteroid Belt** between the orbits of Mars and Jupiter, at approximately 2 to 4 AU (astronomical unit – c.150 million km). This belt is thought to contain almost 2 million asteroids larger than 1 km in diameter, and millions more smaller ones. Asteroids vary in size from the largest, Ceres at about 940 km diameter, down to the size of pebbles. Only sixteen asteroids have diameters of 250 km or greater. The mass of all the objects of the main asteroid belt is estimated to be only about 4% of the mass of the Moon.

Asteroids are also found as **Trojans.** These shares the orbit of some of the planets, in a stable orbit approximately 60° ahead or behind the main body near one of its Lagrange points L4 and L5. Most known trojans share the orbit of Jupiter and are divided into the Greeks at L4 (ahead of Jupiter) and the Trojans at L5 (trailing Jupiter). There are over 7,000 trojans of 1+ km diameter in Jupiter's orbit, and probably many more to be discovered. Mars, Neptune, and Uranus all have trojans. Earth also has a single trojan, called **2010 TK7**, it is 150m to 500m diameter in the L4 leading position, and was found by the Wide-field Infrared Survey Explorer (WISE) satellite. *(NB a second Trojan is thought to have been recently discovered and named **2020 XL5**).*

The third set of asteroids, **Near-Earth Objects** (NEO), have orbits with a closest approach to the Sun (perihelion) that is less than 1.3 AU. There are over 20,000 known NEOs. If a NEO's orbit crosses the Earth's, and the object is larger than 140m, it is considered a **Potentially Hazardous Object** (PHO). The Planetary Defence Coordination Office at NASA, catalogues, and tracks PHOs, which are larger than 30 to 50m in diameter. This size is pertinent, because the Chelyabinsk meteor (Feb. 2013) was c. 20m across but caused no fatalities, whereas the Berringer Crater in Arizona is about 1 km across and 170m deep and was caused by a nickel-iron meteorite about 50m diameter.

Asteroids are small, quite far away and with low albedo, and are impossible to see by eye; because of this they were first discovered by telescope. Ceres discovered in 1801, was originally considered to be a planet, but was reclassified as an asteroid in the 1850s after many other objects in similar orbits were discovered. As these small bodies appeared as points of light, like stars, rather than as planetary discs, Sir William Herschel suggested that they should be called asteroids, which is Greek for "star-like".

There have been a number of satellite missions to asteroids with some of the most recent being sample return missions. In 2005, JAXA Hayabusa 1 orbited near-Earth asteroid Itokawa, landed and collected samples, which it returned to Earth in June 2010. JAXA Hayabusa 2 surveyed and collected samples from near-Earth asteroid Ryugu in 2018/2019. It returned samples to Earth in December 2020. In Sept 2016, NASA launched the OSIRIS-REx sample return mission to Bennu, which it reached in Dec 2018. It returned samples to Earth in Sept 2023. NASA's Dawn mission orbited both Vesta and Ceres. NASA's DART mission proved it is possible to deflect the orbit of a PHO.

Comets are frozen left-overs from the formation of the solar system, icy planetesimals that formed beyond the frost line. There are about 3,900 known comets orbiting the Sun (NASA), in highly elliptical orbits, for example, comet Halley's orbit ranges from beyond Neptune to inside Venus.

Comets are characterised by their highly elliptical orbits, which are not necessarily in the Ecliptic.

They originate from the outer Solar System (beyond the orbit of Jupiter). They are considered to be "dirty snowballs" or "icy dirtballs", being mainly composed of ices, dust and rock, and some organic compounds. They develop a coma (atmosphere) and tails as they approach the Sun. Comets can be divided into two principal groups based on their orbits: Short Period group, orbit < 200yrs, and Long Period group, orbit > 200yrs.

During their highly elliptical orbits, each time a comet gets close to the Sun they shed millions of tonnes of ices and dust. They can't do this for ever because they will exhaust their ices. So, there must be a fresh supply of 'new' comets. Short period comets are thought to originate from the Scattered Disc. Long period comets are thought to originate from the Oort Cloud.

The Scattered Disc is a distant circumstellar disc in the Solar System that is sparsely populated by icy small solar system bodies, which are a subset of the broader family of trans-Neptunian objects. It was probably created by the outward motion of Neptune during the early evolution of the Solar System (Nice model), but this is not fully understood. It overlaps the Kuiper Belt.

Scattered-disc objects (SDOs) have orbital eccentricities up to 0.8, and inclinations up to 40°. Although the closest SDOs approach the Sun at about 30–35 AU, their orbits can extend well beyond 100 AU.

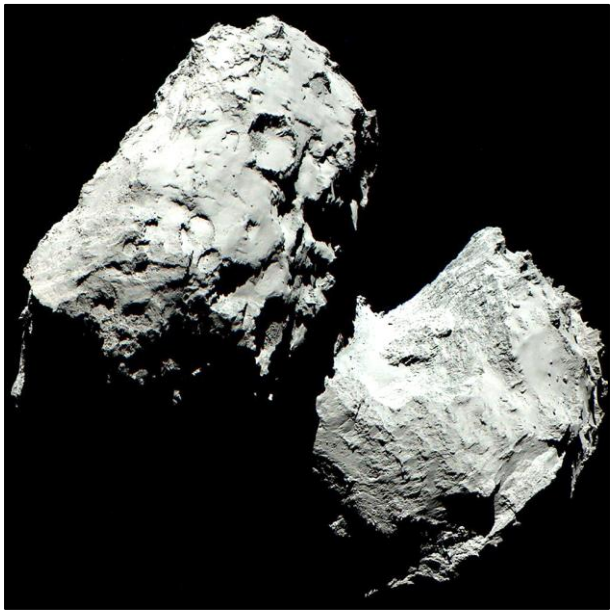
These extreme orbits are thought to be the result of gravitational "scattering" by the gas giants, and the objects continue to be subject to perturbation by Neptune. Because of its unstable nature, the Scattered Disc is thought to be the origin of most short period comets. Perturbations from Neptune and the other giant planets can send them towards the Sun, transforming them into centaurs and then comets.

The Oort Cloud is a theoretical cloud of icy planetesimals proposed to surround the Sun at distances ranging from 2,000 to 200,000 AU, which is beyond the heliosphere and is in interstellar space. The Oort cloud is only loosely bound to the Solar System, and thus is easily affected by the gravitational pull both of passing stars and of the Milky Way itself. These forces occasionally dislodge planetesimals from their orbits within the cloud and send them toward the inner Solar System as potential long period comets.

Comets have two principal components, a **Nucleus** and a **Coma**. The nucleus ranges from a few kilometres to tens of kilometres across. As they get closer to the Sun, they heat

up and some of the ice turns to gas and, with dislodged dust, creates the Coma or atmosphere that can have a diameter larger than a planet. This material can also form tails that can stretch for millions of kilometres.

The nucleus is composed of an amalgamation of water ice, and the ices of carbon dioxide, carbon monoxide, methane, and ammonia, with dust and rock particles. They generally have very low density, probably due to their high porosity. The Deep Impact (NASA) probe found that comet 9P/Tempel was very porous and made of loose aggregates of very fine material.



A colour image of Comet 67P/Churyumov-Gerasimenko composed of three images taken with the Narrow Angle Camera (NAC) of the scientific imaging system OSIRIS in red (centred at 744 nm wavelength), green (536 nm), and blue (481 nm) filters on 6 August 2014 from a distance of 120 kilometres. The image covers roughly 4 x 4 km at a resolution of about 3.9 metres per pixel. (Credit: ESA / Rosetta / MPS for OSIRIS Team MPS / UPD / LAM / IAA / SSO / INTA / UPM / DASP / IDA) https://en.wikipedia.org/wiki/67P/Churyumov%E2%80%93Gerasimenko#/media/File:Comet_67P_True_color.jpg

Deep Impact also found that the 'dust' included clays, carbonates, sodium, and crystalline silicates. In addition, comet nuclei contain a variety of organic compounds, such as methanol, hydrogen cyanide, formaldehyde, ethanol, ethane, and perhaps more complex molecules such as long-chain hydrocarbons and amino acids.

The composition of water vapour from 67P, as determined by ESA's Rosetta spacecraft, is substantially different from that found on Earth. The ratio of deuterium to hydrogen was three times that found for terrestrial water. This makes it unlikely that water found on Earth came from comets such as 67P.

As comets draw closer to the Sun, they receive enough heat for ice to sublimate and the sublimating ice to dislodge dust grains away from their surfaces. This produces a visible atmosphere or coma, and often a tail or two. Although the nucleus of comets is generally less than 60 km across, the coma may be thousands of kilometres across.

The forces exerted on the coma by the Sun's radiation pressure and solar wind cause tails to form. Separate tails form from the dust and the gases, pointing in slightly different directions. The dust tail is left behind in the comet's orbit in such a way that it often forms a curved tail, but the ion/gas tail always points along the streamlines of the solar wind away from the Sun.

Some solid debris outgassed by a comet is too large to be swept away by radiation pressure and the solar wind. When Earth's orbit passes through this trail of debris, it produces a meteor shower. The **Perseid meteor shower**, occurs every year in August, when Earth passes through the orbit of Comet Swift–Tuttle. Halley's Comet is the source of the **Orionid shower** in October. The **Leonids** are a meteor shower associated with the comet Tempel–Tuttle, in November.

Eventually most of the ices contained in the nucleus will be exhausted, and the comet will become a small, dark, inert lump of rock or rubble that can resemble an asteroid. Some asteroids in elliptical orbits are now identified as extinct comets. Roughly six percent of the near-Earth objects are thought to be extinct nuclei of comets, including 14827 Hypnos and 3552 Don Quixote.

The young Earth was so hot it would have driven off much of its volatile content, including water. For the Earth to have so much water today, implies that there must have been later additions. Many comets and asteroids collided with Earth in its early stages, during the Late Heavy Bombardment. These may have brought water to the Earth, and recent research suggests that it is more likely to have been from asteroids than comets.

The **Winchcombe meteorite** that landed in 2021, does contain water that is a close match for that on Earth. This supports the idea that rocks from space brought key chemical components, including water, to the planet early in its history. Water accounts for up to 11% of the meteorite's weight, with a very similar ratio of different types of hydrogen atoms to the water on Earth.

It is thought that impacts of asteroids and comets have, over long time periods, also delivered significant quantities of water to the Moon and Mercury, some of which may have survived in sheltered craters at their poles.

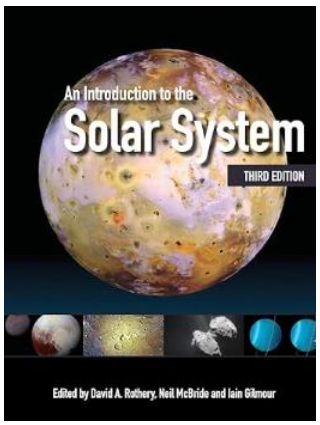
Interstellar dust contains complex organic compounds that were created naturally in the accretion disk surrounding the Sun. These are found in comets and asteroids. Recently, sugar molecules have been discovered in meteorites, suggesting that chemical processes on asteroids can produce some essential organic compounds such as amino acids. The LHB brought organic compounds to Earth, possibly as precursors to life.

In summary, asteroids and comets are part of the left-overs from the formation of Solar System. Early migrations by the giant planets (the Nice Model), probably stopped them forming larger bodies such as plants or dwarf planets. Asteroids are generally rocky or metallic, found in the inner Solar System and have normal orbits. Comets are icy dirt-balls, with the potential for comas and tails, originate in the outer Solar System and generally have eccentric orbits. The Late Heavy Bombardment probably brought water and organics to Earth and may have had some impact on the start of life. Impacts still occur and have the potential for serious effects on Earth.

References:

With grateful thanks to these wonderful information sources:

- An Introduction to the Solar System, 3rd ed. 2018; Edited by David A. Rothery, Neil McBride and Iain Gilmour, The Open University, Milton Keynes.



Online resources:

- Wikipedia - various pages
- NASA and ESA websites.
- OpenStax is a free to download astronomy text box, published through Rice University in Houston, Texas, https://openstax.org/details/books/astronomy-2e
- planetary-science.org/coursehero.com/study-guides/astronomy/
- spacein3d.com

Lecture Summary

Friday, 20 October 2023

On Friday, 20 October 2023, 21 FGS Members were in attendance at The Maltings & at least 15 via Zoom, to welcome Dr. Norman Moles.

Minerals of the Mourne Mountains

Summary of a lecture by Dr Norman Moles (University of Brighton)

The Mourne Mountains are located in the southeast of Northern Ireland, 25 miles south of Belfast, and adjacent to the Irish Sea where, according to Percy French's 1877 song, 'the Mountains of Mourne sweep down to the sea'. Nowadays the area is famous for the **Mourne Wall Challenge**, a twice-yearly 20-mile-long race up and down summits along the line of a boundary wall to the catchment area of reservoirs in the mountains. The Mourne Heritage Trust manage this **Area of Outstanding Natural Beauty** which is now mainly used for recreation but was once the scene of extensive quarrying to make granite kerbstones and other masonry.

Norman introduced his presentation with a geological map showing the five granite intrusions that form the mountains and an 'itinerary for your Mournes fieldtrip'. For nearly a century, magma intrusion was thought to have occurred by 'cauldron subsidence', the sinking of fault-bounded subterranean cylindrical blocks of the sedimentary country rock. Recently, geologists have argued for other mechanisms involving lateral injection with updoming of the roof and/or subsidence of the floor to each magma intrusion. The granitic intrusions took place 55-56 million years ago, a few million years after formation of other central igneous complexes such as the Northern Granite of Arran and the basaltic lava flows of County Antrim and the Scottish Inner Hebrides.

Our first topic was 'drusy granite minerals', drusy cavities being formerly watery fluid-filled vugs in the granite magma. The most well-known locality is 'Diamond Rocks' (Fig. 1) on a mountainous ridge in the Eastern Mournes where gemmy colourless crystals of topaz, up to a centimetre in length, have the appearance of diamonds (Fig. 2). Well-formed crystals of smoky quartz, K-feldspar, albite, a dark mica (siderophyllite?) and green beryl can also be found here. Some of the beryl is the translucent sky-blue variety, aquamarine. Norman recounted the story of Patrick Doran who was originally a quarryman and became a mineral dealer selling Mournes aquamarine crystals to Victorian collectors. Except that Doran developed a reputation as a conman who actually obtained his 'Mournes' crystals from Siberia. A small-scale study by the author of the chemical compositions of beryl crystals from the Mournes and other worldwide sources showed that aquamarine from East Siberia is a better match than Mournes material to Doran's specimens in the Ulster Museum collections. However, recent finds by Stephen Moreton confirm that gemmy aquamarine can be found in the Mournes, albeit of a paler blue colour than the dubious 'Mournes'-derived old-timer specimens.

Figure 1: Diamond Rocks (Credit: N Moles)

Figure 2: Diamond Rocks topaz (NRM Specimen).

We were then taken virtually to a second locality with drusy granite minerals, Lindsay's Leap quarry on Thomas's Mountain near the coastal town of Newcastle, Co. Down (Fig. 3). The mineralogy is similar to that at Diamond Rocks with gemmy smoky quartz and K-feldspar, although aquamarine and topaz are scarce. Instead, some drusy cavities contain crystals of fluorite and stilbite together with other zeolite minerals. Our final drusy granite locality was Spelga Dam in the central Mourne

Mountains where colourless prismatic quartz crystals have been found in cavities in granite downstream of the dam.

Figure 3: Dropping boulders at Lindsey's Leap. (Credit: N Moles)

Next, we visited greisen vein localities, greisen being the product of alteration of granite or country rock by hot vapour emanating from magma. In the northwestern Mournes, some greisen veins contain tiny amounts of tungsten and bismuth minerals. The primary tungsten-bearing minerals are ferberite (iron tungstate, formerly named wolframite) and scheelite (calcium tungstate). However, under electron microscope examination, the crystals show alteration by bismuth- and molybdenum-bearing fluids that generated secondary minerals including russellite (Bi_2WO_6), named after the British mineralogist Sir Arthur Russell. At Pollaphuca, a mile west of Diamond Rocks north of Slieve Bearnagh in the Eastern Mournes, greisen veins contain cassiterite associated with Rare Earth Element (REE)-rich minerals and uncommon arsenic-bearing minerals. Again, these minerals are not obvious to the unaided eye but were found with electron microscopy. The arsenic enrichment appears to be a late-stage overprint from watery fluids circulating through the granite and the nearby country rock, which is revealed by anomalously elevated arsenic concentrations in stream sediment samples analysed in a nationwide Tellus survey.

Norman then introduced the topic of heavy minerals obtained by sluicing and panning stream sediments in the Mourne Mountains. Heavy minerals are those with densities considerably higher than quartz and feldspar, and normally comprise a small part of the total volume of sediment. Quantitative mineralogical analysis by electron microscopy (QEMSCAN) has revealed a remarkable diversity in the proportions of heavy minerals obtained from sampling sites, even in adjacent streams. For example, cassiterite (tin oxide) comprises less than 3% of the heavy mineral sample across two-thirds of the mountain area but reaches concentrations up to 65% at a few sites. As expected, cassiterite is abundant in stream sediment at Pollaphuca, but cassiterite is also quite abundant elsewhere and the bedrock sources for these occurrences are not (yet) known. By contrast, fergusonite, a niobium-rich heavy mineral previously identified in panned stream sediment from the northwestern Mournes, is scarce and largely confined to one catchment area. There are also spatial variations in the grain size of specific heavy minerals such as monazite (REE phosphate): these size variations can be attributed to differences in the type of mineralization in catchment areas in the eastern and western Mournes.

Modern technology such as mobile phones, batteries and 'green energy' production from wind turbines and solar panels, requires supplies of 'critical metals' such as tungsten, niobium and the REE. The Mourne Mountains, being a designated conservation and recreation area, will not be mined for critical metals, but the mineralogical processes that formed mineralization there are relevant to exploration for critical metal resources elsewhere in the world. Our research shows that critical metal enrichment was generated by several processes that varied spatially and temporally, starting with primary magmatic

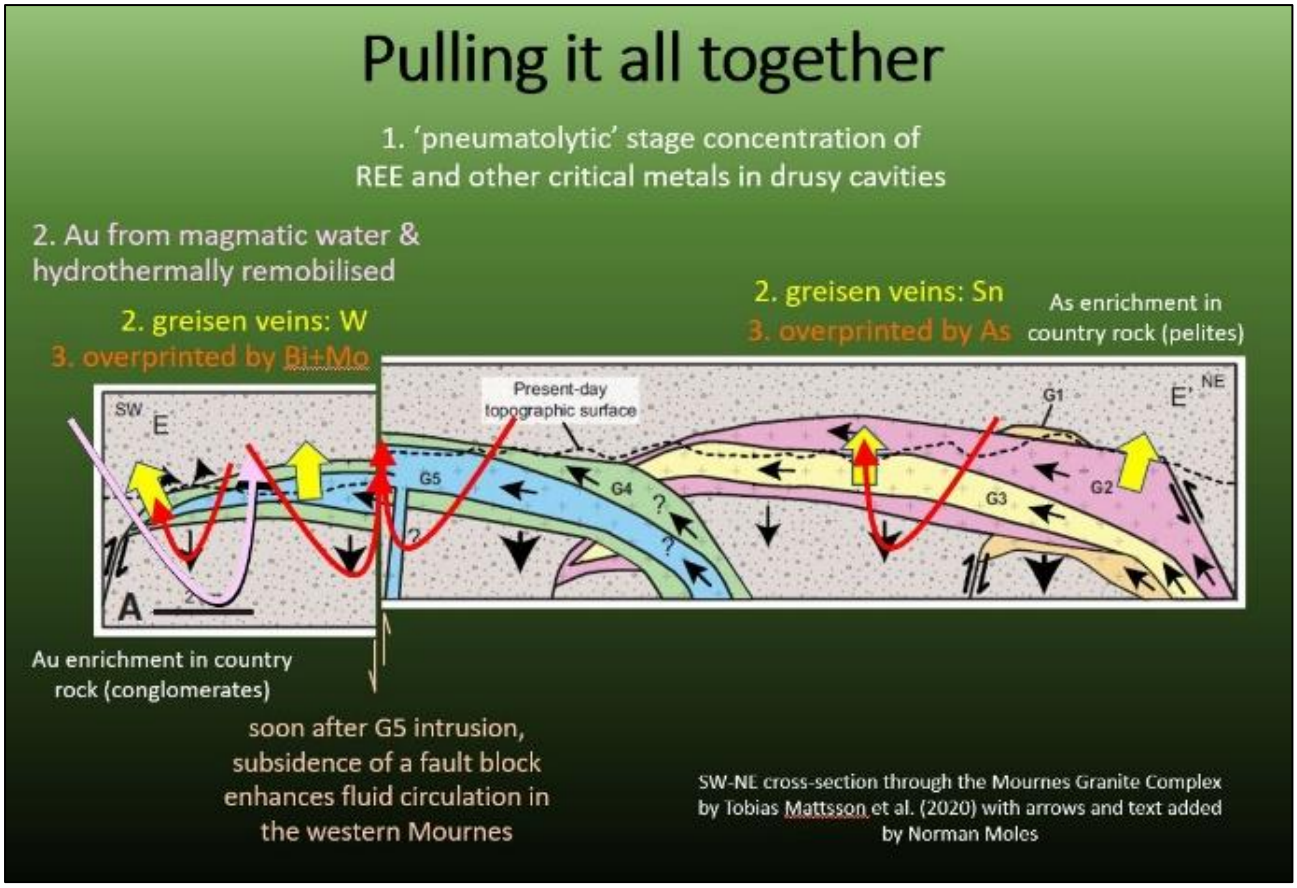


Figure 4: Geological cross section through the Mournes granite. (Credit: N Moles)

crystallisation and concentration of critical metals in the roof zones of granite intrusions. In the northeastern Mournes, circulating hot vapours and watery fluids generated REE–arsenic alteration of pre-existing Sn mineralisation in granite bedrock. In the western Mournes, episodic migration of hydrothermal fluids along post-intrusion faults concentrated REE in allanite, epidote and fergusonite.

The last topic in Norman's presentation was alluvial gold in the western Mournes. This occurrence has been known for a few decades, but we may have just rediscovered what was known to people in the Early Bronze Age (EBA) as there is some evidence that Mournes-derived gold was used in the manufacture of lunulae (crescent-shaped ornaments worn as necklaces) and other EBA artefacts throughout Ireland. The gold occurs as millimetre-sized 'micro-nuggets' in small quantities in heavy mineral concentrates in two areas: the Leitrim and Bann Rivers south of Hilltown, and in the Ballincurry River a small stream southeast of Rostrevor. The angular shape of gold grains from Ballincurry indicate they are from a nearby source whereas the Leitrim-Bann gold grains tend to be flaky and rounded indicating a greater transport distance from their bedrock source. The silver and copper contents of the gold alloy match with EBA artefacts, although Chris Standish used lead isotope compositional analyses to argue that Irish EBA gold artefacts are actually made from Cornish alluvial gold.

Mournes gold has not yet been found in bedrock and there are various theories for where it has come from. One theory is glacial transportation from the Sperrin Mountains located 75 kilometres (c. 50 miles) to the northwest of the Mournes. This can be dismissed as invalid as alluvial gold in these two areas is chemically and isotopically different. Furthermore, if Quaternary glacial transport had taken place, we would expect to find a trail of gold-bearing glacial deposits between the Sperrins and the Mournes, but this does not exist. However, a genetic

association is suggested by the proximity of the main alluvial gold occurrences (and likely bedrock sources) in the upper Leitrim River with a recently-discovered gritstone-conglomerate outcrop within the Silurian country rock adjacent to the Mournes G4 granite. This conglomerate contains pebbles of granite, rhyolite, basalt, chert and vein quartz plus rip-up clasts of shale. It was deposited as an extra-basinal turbidite in a distal channel in the continental slope of the former continental landmass of Laurentia. The turbidite carried into the deeps of the Iapetus Ocean volcanic and plutonic detritus eroded from Ordovician island arcs, quite likely including detritus from gold-bearing mineralization known to be present in the Tyrone volcanic-plutonic complex. As well as the northwestern Mournes gold, other localised occurrences of alluvial gold within the Silurian outcrop of Counties Down, Monaghan and Longford may be derived from Ordovician arc-related magmatic gold mineralization that was eroded and transported south- and south-eastwards into the Iapetus Ocean trough, and subsequently mobilised and recrystallized into mineral veins in the Silurian host rock.

Norman concluded his presentation with a 'pulling it all together' summary diagram based on a geological cross-section through the Mournes Granites and their country rock by Mattsson et al. (2020). The last word was an extract from Percy French's song: *"I just took a hand at this diggin' for gold | but for all that I've found there, I might as well be | where the Mountains of Mourne sweep down to the sea".*

Reference:

2020, Tobias Mattsson; Steffi Burchardt; Karen Mair; Joachim Place. Host-rock deformation during the emplacement of the Mourne Mountains granite pluton: Insights from the regional fracture pattern. ***Geosphere*** (2020) 16 (1): 182–209.
https://doi.org/10.1130/GES02148.1

https://pubs.geoscienceworld.org/gsa/geosphere/article/16/1/182/579683/Host-rock-deformation-during-the-emplacement-of

Article

Purbeck Mining Museum

The Purbeck Mining Museum, near Corfe Castle, Dorset

Mike Millar, with grateful thanks to the Museum website.

The **Purbeck Mining Museum** is a small museum near Corfe Castle focussed on the history of Purbeck ball clay mining. It is located at Norden station on the Swanage heritage railway, near Corfe Castle. It covers clay mining in Purbeck and the experiences of the miners and their families. The museum is run entirely by enthusiastic volunteers and is housed in the last underground mine building that worked in Purbeck.

The clay industry was a major employer in Corfe Castle and the surrounding area from the end of the 18th century until the mid-20th century. Open cast, and later, underground shaft and adit mines appeared wherever the clay was available across north Purbeck. These were connected by a network of narrow-gauge railways.

The museum collection includes mining equipment, as well as images and artefacts of all aspects of associated social and economic history. Outdoor exhibits include a working narrow-gauge railway and various mining working equipment. Indoor exhibits include information about the extensive workings of ball clays that had occurred in the Wareham area. These have resulted in lakes such as the

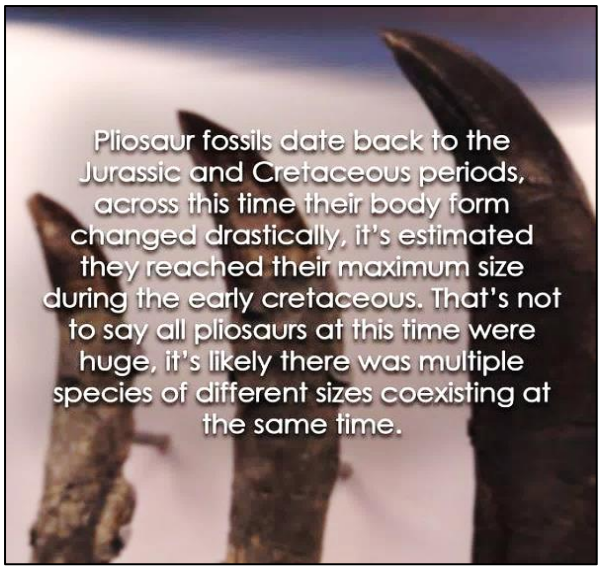
nearby Blue Pool, which are now tourist attractions in their own right.

The ball clay in the Wareham area is part of the Poole Formation, early to mid-Eocene in age. The Poole Formation comprises four stacked depositional sequences, comprising a lower sand unit and an upper kaolinitic clay unit. These sediments were deposited under the prevailing wet, subtropical conditions. The provenance was from deeply weathered uplands in Devon and Somerset, with the sediments transported eastwards by rivers. They were deposited in deltas and lagoons at the edge of the Hampshire Basin. The brackish conditions helped the clay particles to settle quickly before they could be washed on out to sea.

A rare coincidence of geological conditions is required for the formation and preserve the ball clay deposits. There has to be suitable kaolinite-rich source rocks largely free of iron oxides. They have to be deposited into fresh or brackish water for the fine particles to flocculate and settle out before they could be washed out to sea. They need to be left alone from subsequent erosion or deep burial.

For more information, please see

1. www.purbeckminingmuseum.org
2. http://www.clayheritage.org/
3. bgs.ac.uk/lexicon



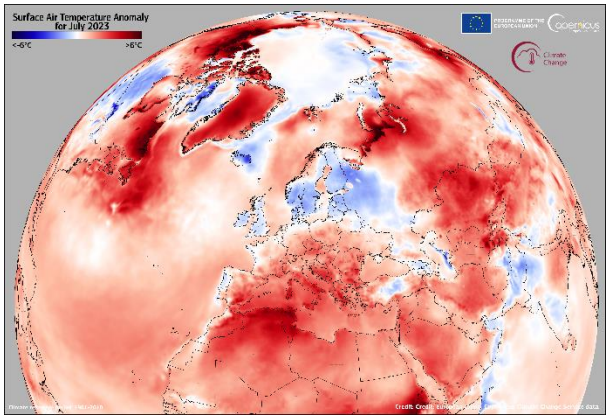
(Credit: The Etches Collection)

Interesting Photos 1

July 2023 was the warmest globally

Date: ***9 August 2023***
Location: ***Northern Hemisphere***

Credit: ***European Union, Copernicus Climate Change Service data***



(Credit: European Union, Copernicus C3S)

This visualisation, based on data from the Copernicus Climate Change Service (C3S), shows the surface air temperature anomaly for July 2023 in Europe.

With a deviation of over 0.7°C from the average of the years 1991 to 2020, July 2023 marks the warmest July ever recorded.

Numerous regions in the Northern Hemisphere, particularly in southern Europe, went through severe heatwaves, with anomalies of +4ºC in Italy, Greece, and Spain. Additionally, North Africa and the Canadian Arctic saw notably high temperatures, reaching peak anomalies of +5 ºC and +7 ºC, respectively.

Reference:

https://www.copernicus.eu/en/media/image-day-gallery/july-2023-was-warmest-globally

One thousand seconds =	**16.67 minutes**
One million seconds =	**11.57 days**
One billion seconds =	**31.71 years**
One trillion seconds =	**31,709.79 years**

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

News

Chancellor Jeremy Hunt says decision over gas drilling disappointing

By Stuart Maisner, BBC News, South East
10 January 2024

Chancellor Jeremy Hunt said he is "bitterly disappointed" after a legal ruling gave the go-ahead to a gas drilling project in his constituency.

UK Oil & Gas (UKOG) had applied to explore a site in **Dunsfold**, in Mr Hunt's Southwest Surrey constituency.

The application had been approved by the government, despite it twice being refused by the local Tory council and opposition from Mr Hunt. The Court of Appeal has now refused permission to appeal the decision.

In a post on X, formerly Twitter, Mr Hunt said: "I am bitterly disappointed to learn that the Court of Appeal has today refused permission for any further appeal against the UKOG planning consent for the **Loxley gas well** outside Dunsfold. I stand ready to provide my assistance and support to local communities in any way possible going forwards."

The Liberal Democrats, the main challenger in the south of England seat, urged the Chancellor to intervene on the project.

The party's environment spokesman Tim Farron called it a "shameful outcome".

"This Conservative Government's policies have resulted in greedy gas barons ripping up the Surrey Hills," he said. "They have railroaded this through the courts despite local outrage at the plans."

Stephen Sanderson, UKOG chief executive, said: "We are pleased that Lord Justice Stuart-Smith has once again dismissed the legal challenge to our project and has confirmed that its planning consent is entirely lawful, as the company and its counsel has maintained."

He said the project would be "beneficial to local and national level energy" and in keeping with national "net zero strategies".

Jennine Walker, from Good Law Project which helped bring the legal challenge, said: "This is an extremely disappointing outcome.

"With the doors left open to UKOG to go ahead with rolling its drilling rigs through Dunsfold, we could now see huge impacts on the local environment, landscape and businesses."

Reference:

https://www.bbc.com/news/uk-england-surrey-67924693

Fossils locked away for 1.75 billion years hold clues about key moment in Earth's history

By Jacklin Kwan, Live Science
8 January 2024

Fossils from Australia provide the first direct evidence that photosynthesis was happening at least 1.75 billion years ago.

The Great Oxidation Event saw oxygen levels on Earth rise dramatically around 2.45 billion years ago. (Image credit: Kriswanto Ginting/Getty Images)

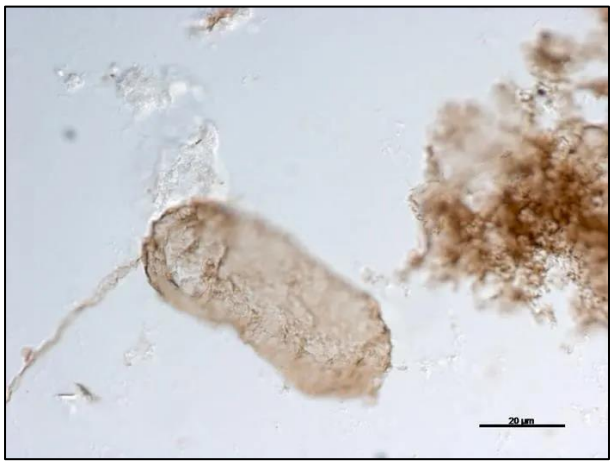
The earliest direct evidence of **photosynthesis** has been discovered in fossils dating back to 1.75 billion years ago.

Scientists collected fossils from Australia, Canada and the Democratic Republic of Congo and found the samples from Australia and Canada contained evidence of **cyanobacteria**, the oldest known lifeform on Earth. Scientists believe that cyanobacteria first emerged 2 to 3 billion years ago, before evolving to be capable of oxygen-producing, or oxygenic, photosynthesis.

In a study published Jan. 3 in the journal **Nature**, researchers revealed these cyanobacteria fossils featured photosynthetic structures, known as thylakoid membranes, which contain pigments like chlorophyll that convert light into chemical energy via photosynthesis.

The cyanobacteria were preserved in a mud clay that was compacted over time to become rock. The researchers used a technique called transmission electron microscopy (TEM) to see the membranes and other tiny details preserved in the fossils.

Instead of using light to image objects, TEM uses electrons, which have a much smaller wavelength than light, allowing us to see much finer details down to the atomic level. Scientists bombard a sample with an electron beam. Some electrons will pass through while some will be absorbed or scattered off more dense parts of the object.



The microfossil that provides evidence of photosynthesis 1.75 billion years ago. (Image credit: Emmanuelle Javaux)

"Finding these membranes tells us that [these cells] are indeed cyanobacteria that are performing oxygenic photosynthesis," lead author Emmanuelle Javaux, a paleobiologist from the University of Liège in Belgium, told *Live Science*. "This pushes back the fossil record of such membranes by 1.2 billion years."

Javaux said identifying the exact time in which cyanobacteria evolved the ability to produce oxygen is an important milestone in Earth's natural history.

The concentration of oxygen in Earth's atmosphere rose dramatically around 2.45 billion years ago, in what is known as **the Great Oxidation Event.**

The rise in atmospheric oxygen transformed life on Earth. It unlocked aerobic respiration for many lifeforms and increased the rate at which minerals weathered and provided nutrients to different environments.

However, scientists don't know whether the Great Oxidation Event was triggered by the evolution of oxygenic photosynthesis, or whether other ecological or geological events occurred first.

The exact biological and physical drivers of the Great Oxidation Event are deeply debated amongst scientists. Though cyanobacterial photosynthesis is generally accepted as the key reason why oxygen concentrations increased, drivers like volcanic eruptions or a decreased level of iron in the oceans may have also played a part.

"If oxygenic photosynthesis evolved very early, but oxygen levels only accumulated in the atmosphere much later, that suggests that there are other processes at work like the burial of organic carbon," Greg Fournier, a geobiologist at the Massachusetts Institute of Technology who was not involved in the study, told *Live Science*.

Fournier said that the age of the fossilized structures in the new study fits well into the bounds of current theories of when cyanobacteria with thylakoid membranes emerged.

The researchers' use of electron microscopy potentially paves the way to reanalyse older, existing fossil samples with the same imaging

technique to identify exactly when cyanobacteria first evolved thylakoid membranes.

"We could potentially time these evolutionary innovations and connect them to the history of the biosphere," Fournier said.

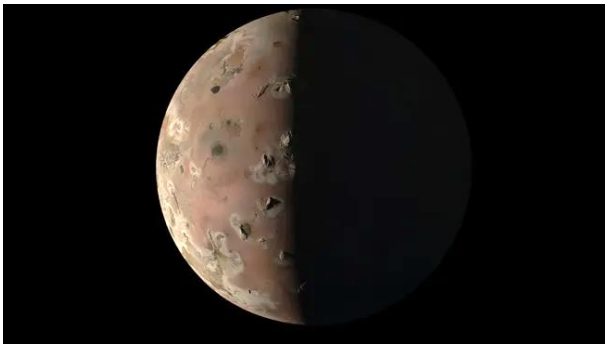
Reference:

https://www.livescience.com/planet-earth/plants/fossils-locked-away-for-175-billion-years-hold-clues-about-key-moment-in-earths-history?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=BF1CE355-C691-425D-B933-5E9BC59641E5&utm_source=SmartBrief

NASA Juno spacecraft reveals Jupiter's volcanic moon Io like never before in spectacular new images

By Robert Lea, Live Science
2 January 2024

Juno ended 2023 in style, coming closer to the volcanic moon on Dec. 30 than any mission has for 20 years.



A stunning image of the volcanic moon Io as seen by Juno on Dec. 30, 2023 (Image credit: NASA/SWRI/Image Processing by Kevin McGIll)

During its 57th flyby of Jupiter, NASA's Juno spacecraft came closer to the planet's moon **Io** than any other mission has in the last two decades.

Passing within around 930 miles (1,500 kms) of Io, ***the most volcanic body in the solar system***, on Saturday, Dec. 30, 2023, Juno was able to capture stunningly detailed images of the Jovian moon. The only time a spacecraft has come closer to Io was in 2001, when NASA's **Galileo** spacecraft passed 112 miles (181 kms) above Io's south pole.

Juno, which launched on August 5, 2011, and reached Jupiter and its system of moons on July 4, 2016 — after a 1.7 billion-mile (2.8-billion-km) journey — captured six views of Io to cap off 2023 in style. Some are black and white while others are in colour. The purpose of the close passage wasn't just to take some incredible images, however, but also to collect important data about Io and its volcanism.

"By combining data from this flyby with our previous observations, the Juno science team is studying how Io's volcanoes vary," Scott Bolton, Juno's principal investigator and a scientist at the Southwest Research Institute, said in a statement issued prior to the flyby. "We are looking for how often they erupt, how bright and hot they are, how the shape of the lava flow changes, and how Io's activity is connected to the flow of charged particles in Jupiter's magnetosphere."

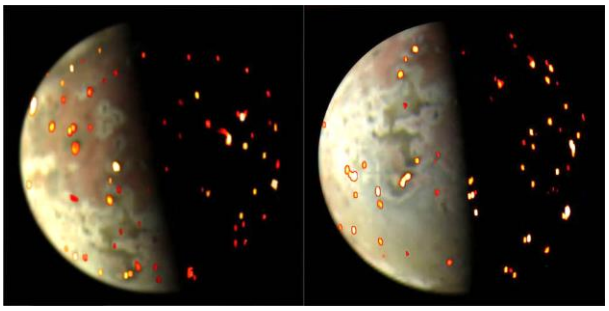
NASA shared some of the incredible Io images on its 'X' feed. In relation to a striking monochrome image of the highly volcanic moon, the space agency wrote: "The JunoCam instrument aboard our #JunoMission acquired six images of Jupiter's moon Io during its close encounter today."

Io gets its status as the solar system's most volcanic body as a result of the immense gravity of Jupiter, the most massive planet in the solar system, in addition to the gravitational influence of the other large Jovian moons — Europa, Ganymede and Callisto.

Together, the Jovian moons and Jupiter pull and push on Io, generating tidal forces. These tidal forces are so immense they can cause the surface of Io to flex intensely enough to can

rise and drop by extremes as great as 330 feet (100m).

As a result, the surface of Io, a body roughly the same size as Earth's moon, is covered in hundreds of active volcanoes that spew lava as high as dozens of miles above Io.



Volcanos on the surface of Io. (Image credit: NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM)

Some of these particles escape the thin, waterless atmosphere of the Jovian moon and are then trapped by the magnetic fields of Jupiter, forming a hot torus of plasma around the gas giant planet. And this is just one way that the volcanism of Io can impact the whole Jovian system, exemplifying why the data that the Juno spacecraft has been collecting is so valuable to planetary scientists.

It won't be long before Juno makes another close approach to Io. The spacecraft will once again pass to within around 930 miles (1,500 km) of the volcanic surface of this Jovian moon on Feb. 2, 2023.

And, in fact, that won't be the last time Juno makes a close approach to Io, but these flybys will get subsequently more and more distant, beginning with a passage around 6,830 miles (11,000 km) away from Io and culminating with a final flyby at around 62,100 miles (100,000 km).

After the final approach to Io, Juno will reach the end of its extended mission (its primary mission concluded in July 2021) in Sept. 2025. At this time, the spacecraft will be intentionally crashed into the atmosphere of Jupiter, concluding its 9-year study of the gas giant and its moons.

The full catalogue of the spacecraft's Dec. 2023 raw images of Io are available on the Juno mission website.

References:

https://www.space.com/nasa-juno-spacecraft-jupiter-moon-io-photos?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=58E4DE65-C57F-4CD3-9A5A-609994E2C5A9&utm_medium=email&utm_content=05FDE8D9-8FD9-43F2-A886-30ECD2475270&utm_source=SmartBrief

Japanese earthquake on Jan. 1 shifted coastline over 800 feet, satellite photos show

By Samantha Mathewson, Live Science
11 January 2024

Satellite images captured striking changes in the coastline of Japan's Noto Peninsula following a massive earthquake on New Year's Day.

A **7.6 magnitude earthquake** struck Japan on Jan. 1 around 07:10 a.m. GMT (4:10 p.m. local time in Japan), prompting orders for residents to evacuate affected coastal areas that experienced significant uplift. Satellite imagery of the area before and after the quake shows that the intense uplift extended the coastline by up to 820 feet (250m), which is greater than the length of two American football fields.

Images of Japan's Noto Peninsula shared on X (formerly Twitter) by Nahel Belgherze show coastal areas where the seafloor has risen above the water, creating newly exposed beaches. The photos capture the coastline changes after the earthquake and tsunami had already subsided, leaving some ports completely dry and inaccessible to boats.

The earthquake that struck Japan’s Noto peninsula on Monday was so strong that the coastline has moved up to 250m offshore due to significant land uplift.

"During a field investigation along the northwest coast of the Noto Peninsula, we found evidence at 10 locations, from Kaiso to

Akasaki sites, of coseismic coastal uplift related to the Noto Peninsula Earthquake (M7.6)," researchers with the Earthquake Research Institute at the University of Tokyo said in a statement on Jan. 4.

Before the earthquake

After the earthquake

A 7.6-magnitude earthquake struck Japan on Jan. 1, 2024, causing significant uplift in some coastal areas of the Noto Peninsula. (Image credit: Google Earth/GSI, processed by Nahel Belgherze)

"The pattern of estimated coseismic coastal uplift appears to be decreasing southward from Kaiso to Akasaki," they added.

The area near Akasaki port also experienced nearly 14-foot-high (4.2m) tsunamis, according to the university's field investigations that revealed water stains on building walls.

The Japan Aerospace Exploration Agency's (JAXA) Advanced Land Observing Satellite-2 (ALOS-2) also captured the coastal uplift caused by the earthquake. Satellite images compare the coastline from June 2023 to Jan. 2, showing how the shoreline shifted seaward in multiple areas, including Nafune port, Wajima city and Minazuki bay, according to a statement from the **Geospatial Information Authority of Japan**.

While the satellite images capture significant changes following the Jan. 1 earthquake, investigations along the coast are still ongoing, according to the statement.

Reference:

https://www.space.com/japan-earthquake-january-2024-shifted-coastline-photos?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=58E4DE65-C57F-4CD3-9A5A-609994E2C5A9&utm_medium=email&utm_content=EB934E60-2049-4516-BCC7-537FFF481187&utm_source=SmartBrief

Thanks to Liz Aston for suggesting this article.

Thousands in shelters overnight after tsunami warnings in Japan

By Kelly Ng & Ali Abbas Ahmadi, BBC News 1 January 2024

Thousands of people in Japan are spending the night in evacuation centres after a powerful earthquake.

Four people are confirmed to have been killed, the Kyodo news agency reports, and dozens of others have been injured. An unknown number of people are trapped beneath the rubble of collapsed buildings in several towns.

The 7.6-magnitude quake struck at around 16:10 local time (07:10 GMT) on Monday. Tsunami warnings were issued and later downgraded. About 60 tremors have been recorded following the initial quake.

A snowboarder on holiday in Japan's Hakuba Alps said his entire hotel room shook. Speaking to ***Reuters***, Baldwin Chia said he was concerned about avalanches but hadn't received reports of any taking place. He said it was common to hear about earthquakes in Japan, but "you wouldn't expect to actually experience one".

Andy Clark, a Briton in Japan, described to the BBC a "scary afternoon and evening", as he was in the affected coastal city of Toyama when the quake hit. He said he "grabbed the sea wall to stay upright" before heading to a school roof for safety. Mr Clark said it was proving "hard to get some sleep" due to the aftershocks.

Jeffrey Hall, a lecturer at Kanda University, said he felt tremors for about two minutes despite being in Yokohama, on the other side of Japan's main island. He told the BBC the quake was "very, very serious".

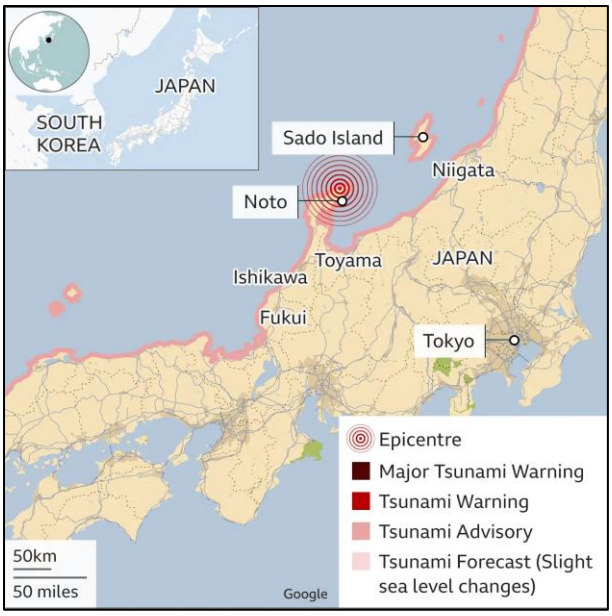
The full extent of the damage is unlikely to be clear until Tuesday morning, but major damage to infrastructure is evident.

Officials in Suzu City in Ishikawa prefecture said several houses and power poles collapsed, according to national broadcaster NHK.

Major highways were closed near the quake's epicentre and more than 36,000 households were left without power, according to utilities provider Hokuriku Electric Power.

The BBC's former Japan correspondent Rupert Wingfield-Hayes - who was reporting from Taiwan - said several hundred metres of the main expressway between the cities of Toyama and Kanazawa had been ripped apart by a landslide.

Video from Uchinada, also in Ishikawa prefecture, showed the surface of a road rippled and cracked. Damage to the Onohiyoshi Shrine in Kanazawa was also pictured.



A map of Japan shows affected areas along the north coastline of the country's central area, where tsunami advisories are in place. Marked on the map are Fukui, Ishikawa, Noto, Toyama, Sado Island and Niigata. Source: BBC / Japan Meteorological Agency)

Initially, a major tsunami warning was issued for the coastal Noto area in Ishikawa - near the quake's epicentre - with authorities saying waves could reach heights of 5m (16ft).

Local reports said this was Japan's first such warning since 2011, when a powerful earthquake tore through the north-east and unleashed waves up to 40m high.

The waves that actually hit the Sea of Japan coastline in Ishikawa on Monday were not much more than a metre high. The major warning was later downgraded to simply a warning, and then an advisory. Nearby Niigata and Toyama prefectures were also on alert.

Japan's allies have sent messages of support to Tokyo in the wake of the disaster.

US President Joe Biden said his country was prepared to offer assistance. "As close allies,

the United States and Japan share a deep bond of friendship that unites our people. Our thoughts are with the Japanese people during this difficult time," he said.

Prime Minister Rishi Sunak said the United Kingdom, too, was "ready to support Japan" following the disaster, and that his thoughts were with "all those affected by the earthquakes in Japan which have caused such terrible damage."

Japan is one of the most seismically active nations on Earth, owing to its location on the so-called **Pacific Ring of Fire**, where many tectonic plates meet. The constant threat of earthquakes has led Japan to develop one of the world's most sophisticated tsunami warning systems.

There are several nuclear power plants in the affected areas, however Japan's nuclear authority said there was "no risk of radioactivity leaking" from the facilities.

South Korea's meteorological agency and Russia also issued tsunami warnings after the earthquake.

The 9.0-magnitude earthquake which hit Japan in 2011 resulted in a tsunami - which tore through the country's north-eastern coastal communities, killing almost 18,000 people and displacing tens of thousands.

Those tsunami waves triggered a nuclear meltdown at the Fukushima power plant, causing the most serious nuclear accident since Chernobyl.

Reference:

1. https://www.bbc.com/news/world-asia-67855990
2. https://www.theguardian.com/world/2024/jan/06/japan-earthquake-death-toll-reaches-100-as-more-survivors-pulled-from-rubble

Iceland: Situation in Grindavík has 'become very bleak' following new eruption

Sascha Pare, Live Science

15 January 2024

A volcano on Iceland's Reykjanes Peninsula erupted on Sunday, cracking open fissures that are extending toward Grindavík and threatening to drown the town in lava flows.

Aerial views shows lava after the fissure eruption located close to Sundhnukagigar, about 4 kilometers northeast of Grindavik town of Reykjanes peninsula, Iceland on January 14, 2024. (Image credit: Iceland Public Defence / Handout/Anadolu/Getty Images)

A volcano on Iceland's Reykjanes Peninsula has resumed erupting after a four-week hiatus, with new fissures opening near the town of Grindavík, the Icelandic Met Office (IMO) announced Sunday (Jan. 14).

The eruption followed an intense series of earthquakes that began around 3:00 a.m. local time in the Sundhnúksgígar area and migrated southwest toward Grindavík. The seismic swarm caused a lava-spewing fissure to open around 8 a.m. to the southeast of the Hagafell mountain, spreading to within just 3,000 feet (900 meters) of the town.

Around midday, a new eruptive fissure opened just north of Grindavík. "Lava flows extruded from this fissure have now entered the town," IMO representatives wrote in a statement.

Seismicity and ground deformation data indicate a magma dike running down the

Reykjanes Peninsula has reached beneath Grindavík. Magma flowing into the dike may have "reactivated" existing faults and fractures in Earth's crust, and likely opened brand new fissures, the statement said.

A map showing the location of the fissure eruption, north of Grindavik. (Credit: IMO / BBC)

Lava is seen edging closer to the outskirts of Grindavík on Jan. 14. (Image credit: HALLDOR KOLBEINS/AFP/Getty Images)

Lava flows from the fissures has slowed significantly since the eruption began. (Image credit: Iceland Public Defence / Handout/Anadolu/Getty Images)

Þorvaldur Þórðarson, a professor of volcanology and petrology at the Icelandic University, told the Iceland Monitor that eruptive activity has shifted from the upper fissure to creep closer to Grindavík, foreshadowing two possible scenarios.

Spectacular helicopter shots show the eruption on the island's coast. (Credit: BBC)

A volcano spews lava and smoke as it erupts, north of Grindavik, Reykjanes Peninsula, Iceland. (Image Source: Icelandic Coast Guard)

The fissure spewing lava is around 2.5 miles long and is close to the Svartsengi power plant. (Image credit: Micah Garen / Contributor via Getty Images)

More fissures could open in the coming days as magma continues to feed the dike, experts told the Iceland Monitor.

"One [scenario] is that if the shift is made, then the activity will continue in the lower fissure," he said. If this is the case, and the eruption continues, lava "will continue to flow towards the town. "The other scenario, which is even worse, is that this is an addition to what is happening in the upper fissure," he said. "This increases the eruption."

It's looking likely that magma will push into the dike and extend it further down the peninsula, Þórðarson said. "It seems to me that the fissure is always getting longer," he said. "The situation has unfortunately become very bleak for Grindavík."

References:

1. https://www.livescience.com/planet-earth/volcanos/iceland-volcano-situation-in-grindavik-has-become-very-bleak-following-new-eruption?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=D004FC91-DE33-4615-86C6-5C3386791953&utm_source=SmartBrief
2. https://www.bbc.co.uk/news/world-europe-67756413
3. https://www.theguardian.com/world/2023/nov/10/iceland-declares-state-of-emergency-over-volcanic-eruption-threat
4. https://www.theguardian.com/world/2023/nov/12/iceland-experts-predict-feared-volcanic-eruption-could-destroy-town-near-reykjavik
5. https://livefromiceland.is/webcams/fagradalsfjall/

What is a Volcano?

A volcano is a vent in Earth's surface where magma, gas, and ash escape. The name is also used for cones of erupted material at the vent. Volcanoes are found on many planets and moons in our solar system.

China earthquake: rescuers scramble to respond after more than 100 killed

Officials said more than 400 people were also injured after the 6.2 magnitude quake in north-west Gansu and Qinghai provinces

Helen Davidson, The Guardian in Taipei. Additional reporting by Chi Hui Lin, Associated Press and Agence France-Presse.
19 December 2023

Rescue workers search a house for survivors after an earthquake in northwest China's Gansu province. (Photograph: AFP/Getty Images)

At least **118 people have been killed** and **more than 500 injured** in an earthquake in China's north-west Gansu and Qinghai provinces, state media has reported.

The strong shallow earthquake struck shortly before midnight on Monday, sending residents fleeing outside, into below freezing temperatures. Thousands of houses have been reported damaged, and state media also said public infrastructure had been damaged "to varying degrees".

The death toll rose on Tuesday morning as rescuers reached affected areas. Gansu authorities said 105 had died in the province, and 397 people had been injured. Qinghai reported 13 dead, 182 injured, and 20 still missing.

It is the deadliest earthquake in China since the 2010 Yushu quake, which also hit Gansu and

Qinghai, which measured 6.9 and killed at least 2,698 people.

China's leader, Xi Jinping, called for "all-out efforts" in the search and rescue work. More than 3,000 firefighters have been deployed or placed on standby, and hundreds of military personnel have been sent to the area. The ministries of finance and emergency management have allocated 200 million RMB (£ 22.1m) in emergency relief funds, according to state media.

Tents, folding beds and quilts were being sent to the disaster area, state broadcaster CCTV said. At least 4,000 firefighters, soldiers and police officers were dispatched in the rescue effort, and the People's Liberation Army Western Theatre set up a command post to direct its work.

Han, the Gansu spokesperson, said rescue work was proceeding in an orderly manner and asked people to avoid going to the quake-hit areas to prevent traffic jams that could hinder the effort.

A video posted by the ministry of emergency management showed emergency workers in orange uniforms using rods to try to move heavy pieces of what looked like concrete debris at night. Other nighttime videos distributed by state media showed workers lifting out a victim and helping a slightly stumbling person to walk in an area covered with light snow.

Footage from the scene showed rescuers working by torchlight, helping people out of collapsed houses.

Photos and videos posted by a student at Lanzhou University showed students hastily leaving a dormitory building and standing outside with long down jackets over their pajamas.

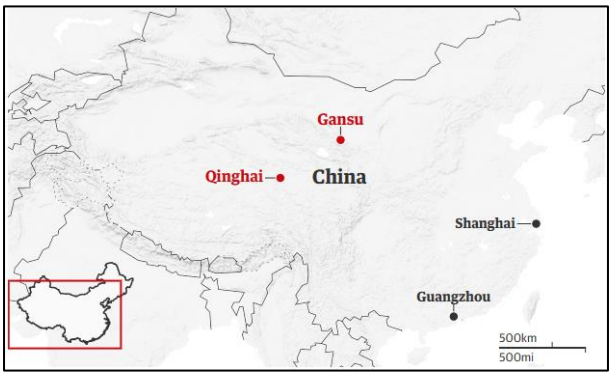
"The earthquake was too intense," said Wang Xi, the student who posted the images. "My legs went weak, especially when we ran downstairs from the dormitory."

"Human beings are really insignificant in the face of natural disasters," said one Gansu resident on Weibo. "I was at the epicentre of the earthquake, and my mother and I couldn't run away. The house was shaking so much that I couldn't even stand up, and things were falling down. It was very cold outside at more than ten degrees below zero. I didn't go back all night and there were constant aftershocks."

The resident later said they had returned to their house but the situation in neighbouring villages, where the houses were very old, were "very serious".

Chinese authorities measured the quake at a **magnitude of 6.2**. The US geological survey (USGS) reported earlier that it was 5.9.

The earthquake struck at a depth of 10km, about 100km south-west of Gansu province's capital, Lanzhou. Much of China is in the midst of a cold wave which swept through last week, and the high-altitude area where the earthquake hit reported temperatures of -14C on Tuesday morning.



Map of the two provinces in China hit by the earthquake. (Source: The Guardian)

Aftershocks continued on Tuesday, with several tremors measuring between 3.0 and 4.5. On Tuesday a separate 5.5 magnitude earthquake struck Xinjiang province, also in the northwest.

Earthquakes are somewhat common in the mountainous area of western Chinam, which rises up to form the eastern edge of the Tibetan plateau.

In August, a shallow 5.4-magnitude earthquake struck eastern China, injuring 23 people and collapsing dozens of buildings.

China's deadliest earthquake in recent years was a 7.9 magnitude quake in 2008 that killed nearly 90,000 people in Sichuan.

The temblor devastated towns, schools and rural communities outside Chengdu, leading to a years-long effort to rebuild with more resistant materials.

Reference:

https://www.theguardian.com/world/2023/dec/19/china-earthquake-death-toll-magnitude-gansu-qinghai

New Royal Mint coins to feature three iconic dinosaurs

By Josh Davis, NHM
14 December 2023

The **Natural History Museum** has teamed up once more with **The Royal Mint** to produce a new coin collection, this time featuring iconic dinosaur species.

The coins are the first time that the dinosaurs Tyrannosaurus, Stegosaurus and Diplodocus feature on UK money. (©The Trustees of the Natural History Museum, London)

The collaboration, involving Museum experts and palaeoartist Bob Nicholls, will be the first time that Tyrannosaurus, Stegosaurus and Diplodocus have featured on UK coins.

The Royal Mint are releasing a new coin collection including 50p coins featuring three of the most iconic species of dinosaurs. From today, people can buy the first of these coins that showcases the mighty *Tyrannosaurus rex.*

Each coin features beautiful images created by palaeoartist Bob Nicholls, who worked alongside the Natural History Museum's Professor Paul Barrett to create the most up-to-date, scientifically accurate artwork possible.

'I have dedicated my life to bringing extinct animals back to life through art, I started drawing dinosaurs as soon as I could hold a pencil - it is my obsession,' says Bob. 'Any project that allows me to work with long-dead animals is a joy but having an opportunity to create collectable coins for The Royal Mint, with royal approval, is very special indeed.'

This is the third collection in The Royal Mint's **'Tales of the Earth'** series. The first collection featured the first three dinosaurs scientifically named from Britain, while the second collection focused on the scientific discoveries of Mary Anning.

Although the coins will be legal tender, they won't go into circulation. Instead, members of the public will be able to buy the coins, with colour edition of the coins also available.

Icons of the Mesozoic Era

The first of the coins features the indomitable *Tyrannosaurus rex.* As one of the most recognisable dinosaurs and among the largest ever predator to roam the land, *T. rex* needs little introduction. First formally named in 1905, it would have once been stalking the forests and plains of what is now North America some 66 million years ago eating pretty much anything it could get its bone-crushing jaws on.

This will be followed by a coin that showcases *Stegosaurus stenops*. Instantly recognisable by the row of armoured plates along its back and its threatening, spiked tail, Stegosaurus was well defended from any large predator prowling northern America and western Europe some 150 million years ago. The most complete skeleton of Stegosaurus in the world can be seen the Natural History Museum's Earth Hall.

Finally, these two will be joined by the equally iconic *Diplodocus carnegii*. With their long neck and whip-like tail, Diplodocus were the true giants of North America 153 million years ago. Perhaps best known to many as the iconic Dippy that once graced the Natural History Museum's main hall, visitors will be able to see a bronze cast in our newly developed gardens that are opening to the public next year.

Rebecca Morgan, Director of Commemorative Coin at The Royal Mint says, 'We are excited to reveal the roar-some new collectable 50p coins by The Royal Mint, featuring some of the most legendary and mighty dinosaurs of all time - including Tyrannosaurus, Stegosaurus, and Diplodocus.'

'For nearly 200 million years, dinosaurs roamed Earth so it's fitting that they are honoured forever on an official UK coin. Seeing these dinosaurs on a 50p coin we hope it will delight and inspire both current and budding palaeontologists for years to come.'

The coins are available to buy or pre-order from The Royal Mint's website.

Reference:

https://www.nhm.ac.uk/discover/news/2023/december/new-royal-mint-coins-to-feature-three-iconic-dinosaurs.html

Ancient plant species revealed to be fossilised baby turtles

By James Ashworth, NHM
11 December 2023

A case of mistaken fossil identity has been resolved after 20 years.

New research reveals that the plant *Sphenophyllum colombianum* is actually an ancient fossil turtle, which researchers have nicknamed after the **Pokémon Turtwig.**

The mystery of a fossil plant's unusual age has been solved after it was revealed it wasn't actually a plant at all.

Back in 2003, two five-centimetre-wide fossils covered in leaf-like markings were described as a new species of an ancient group of plants, known as *Sphenophyllum*. This was quite surprising, as all known members of the group had died out more than 100 million years before the fossil was buried.

To see if the fossils were really plants , a team of researchers re-examined them and discovered that the markings weren't the veins of leaves after all, but the ribs of tiny turtles.

While the fossil has marking that look like leaf veins, they turned out to be the ribs of a baby turtle. (Images © Fabiany Herrera and Héctor Palma-Castro, and drawing © Edwin-Alberto Cadena and Diego Cómbita-Romero)

Dr Edwin-Alberto Cadena, a co-author of the study, says, 'These are remarkable specimens, not just because of their story, but because they are small hatchlings. It's really rare to find hatchlings of fossil turtles in general, as the bones in their shells are so thin they can be easily destroyed.'

'These turtles were likely the relatives of other Cretaceous species that grew to around 4.5 metres long, but we don't know much about how they grew to such giant sizes. These fossils will help to add to our understanding of that.'

The findings of the study were published in the journal ***Palaeontologia Electronica***.

Vegetable, animal or mineral?

For a period of around 110 million years, *Sphenophyllum* would have been a common sight in wetlands across the world. These plants looked similar to modern horsetails, but died out around 250 million years ago during the Triassic.

This made it quite the surprise when a new species, *Sphenophyllum colombianum*, was described from Colombian rocks dating to just 120 million years ago during the Early Cretaceous. While it's not unheard of for some species to cling on long after their relatives have become extinct, it's very unusual.

To try and resolve the mystery once and for all, the researchers tracked down the original fossils in the collections of **National University of Colombia**. While they certainly looked leaf-like, a few things didn't add up.

Though Sphenophyllum colombianum might not be a true plant, other members of the species have been found in many regions of the world. (Images © Falconaumanni, licensed under CC BY-SA 3.0 via Wikimedia Commons)

The shape and margin of the leaf, for instance, didn't seem to match up with the leaves of other *Sphenophyllum* fossils, while what had been described as leaf venation looked suspiciously like growth marks in bone.

When they compared the fossils to museum specimens of living turtles, they were left in no doubt that the fossils were not plants after all. While there's not enough evidence to assign the fossils to a particular species, the turtle's botanical origins have been recognised in a new nickname.

Héctor Palma-Castro, a PhD student at the National University of Colombia who led the study, says, 'Discovering that these plant fossils were actually a baby turtle made me immediately think of Pokémon, where the concept of combining two or more elements together is common.'

'We nicknamed the fossils after **Turtwig**, which looks like a baby turtle with a leaf attached to its head. Finding such a fossil was truly surprising and goes to show how your imagination and capacity to be amazed are always being put to the test in palaeontology.'

A closer look at the 'Turtwigs' revealed that they were very young at their time of death and were probably less than a year old. Within a few weeks of their death, the turtles would have ended up being buried and started their journey to becoming fossils.

The scientists hope that the reassessment of these plant fossils will inspire more researchers to delve into Colombia's fossil plant collections, and help to answer some of botany's larger questions.

Dr Fabiany Herrera, another co-author of the study, says, 'We may have resolved a small palaeobotanical mystery, but more importantly, this study shows the need to re-study historical collections in Colombia.'

'The Early Cretaceous is a critical time in land plant evolution, particularly for flowering plants and conifers. Our future job is to discover the forests that grew in this part of the world.'

Reference:

https://www.nhm.ac.uk/discover/news/2023/december/ancient-plant-species-revealed-fossilised-baby-turtles.html

Steve Etches has the skull. Now he wants the rest of the animal's body. (Image Source: BBC / Tony Jolliffe)

Pliosaur discovery: Huge sea monster emerges from Dorset cliffs

By Jonathan Amos and Alison Francis
BBC News, Science

Additional reporting by Rebecca Morelle and Tony Jolliffe
10 December 2023

The skull of a colossal sea monster has been extracted from the cliffs of Dorset's Jurassic Coast.

It belongs to a pliosaur, a ferocious marine reptile that terrorised the oceans about 150 million years ago.

Artwork: Pliosaurs had the speed and power to take down other big marine reptiles. (Image Source: BBC Studios)

The 2m-long fossil is one of the most complete specimens of its type ever discovered and is giving new insights into this ancient predator.

The skull will be featured in a special **David Attenborough programme** on BBC One on New Year's Day.

"Oh wow!" There are gasps as the sheet covering the fossil is pulled back and the skull is revealed for the first time. It's immediately obvious that this pliosaur is huge and beautifully preserved.

There isn't a specimen anywhere else to match it, believes local palaeontologist Steve Etches.

"It's one of the best fossils I've ever worked on. What makes it unique is it's complete," he tells BBC News. "The lower jaw and the upper skull are meshed together, as they would be in life. Worldwide, there's hardly any specimens ever found to that level of detail. And if they are, a lot of the bits are missing, whereas this, although it's slightly distorted - it's got every bone present.

The skull is longer than most humans are tall, which gives you a sense of how big the creature must have been overall.

You can't help but focus on its 130 teeth, especially those at the front. Long and razor sharp, they could kill with a single bite. But look a little closer - if you dare - and the back of each tooth is marked with fine ridges. These would have helped the beast to pierce the flesh and then quickly extract its dagger-like fangs, ready for a rapid second attack.

The pliosaur was the ultimate killing machine and at 10-12m long, with four powerful flipper-

Experiments show the grooves really do aid incision and withdrawal. (Image Source: BBC / Tony Jolliffe)

like limbs to propel itself at high speed, it was the apex predator in the ocean.

"The animal would have been so massive that I think it would have been able to prey effectively on anything that was unfortunate enough to be in its space," says Dr Andre Rowe from Bristol University. "I have no doubt that this was sort of like an underwater T. Rex."

Bite force comparison

Meals would have included other reptiles such as its long-necked cousin, the plesiosaur, and the dolphin-like ichthyosaur - and fossil evidence reveals that it would have even feasted on other passing pliosaurs.

How this fossil skull was recovered is extraordinary. It started with a chance find during a stroll along a beach near Kimmeridge Bay on southern England's famous World Heritage Jurassic Coast.

Steve Etches' friend and fellow fossil enthusiast **Phil Jacobs** came across the tip of the snout of the pliosaur lying in the shingle. Too heavy to carry, he went to fetch Steve and the pair rigged a makeshift stretcher to take the fossil fragment to safety.

But where was the rest of the animal? A drone survey of the towering cliff face pinpointed a likely location. The problem was the only way to excavate it was to abseil down from the top.

Removing fossils from rock is always painstaking, delicate work. But to do this while dangling on ropes from a crumbling cliff, 15m above a beach, requires another order of skill.

The courage, dedication, and the months spent cleaning up the skull, have certainly been worth it. Scientists from across the globe will be clamouring to visit the Dorset fossil to gain fresh insights into how these amazing reptiles lived and dominated their ecosystem.

Jurassic pliosaur skull: 'It's got all its bones'

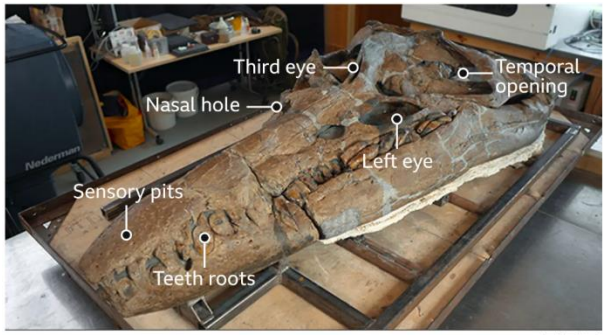


Image credit: BBC Studios

Palaeobiologist Prof Emily Rayfield has already examined the large circular openings at the rear of the head. They tell her about the size of the muscles operating the jaws of the pliosaur, and the forces generated as its mouth snapped shut and crushed its prey.

At the top end, this comes out at about 33,000 newtons. For context, the most powerful jaws in living animals are found on saltwater crocodiles, at 16,000 newtons.

"If you can generate a really powerful bite, you can incapacitate your prey; it's less likely to get away. A powerful bite means you're also able to crunch through tissue and bone quite effectively," the Bristol researcher explained.

"As for feeding strategies: crocodiles clamp their jaw shut around something and then twist, to maybe twist a limb off their prey. This is characteristic of animals that have expanded heads at the back, and we see this in the pliosaur."

This newly discovered specimen has features that suggest it had some particularly acute, and very useful, senses. Its snout is dotted with small pits that may have been the site of glands to help it detect changes in water pressure made by prospective prey. And on its head is a hole that would have housed a parietal, or third, eye. Lizards, frogs and some fish alive today have one of these. It's light-sensitive and might have helped in locating other animals, especially when the pliosaur was surfacing from deep, murky waters.

Steve Etches will put the skull on display next year at his museum in Kimmeridge - the Etches Collection. It has some vertebrae poking out at the back of the head but trailing off after just a few bones. They are a tantalising clue that more of the fossil might still be in the cliff. Steve is keen to finish what he started.

"I stake my life the rest of the animal is there," he tells BBC News. "And it really should come out because it's in a very rapidly eroding environment. This part of the cliff line is going back by feet a year. And it won't be very long before the rest of the pliosaur drops out and gets lost. It's a once in a lifetime opportunity."

Reference:

1. https://www.bbc.com/news/science-environment-67650247
2. https://www.smithsonianmag.com/smart-news/fossil-hunters-uncover-prehistoric-sea-monster-skull-at-a-uk-beach-180983423/?fbclid=IwAR3vAfosDizGu5SB-xJDwAr7BpFuC-8zQicigUjCrjnK8bplMfMZwJ62T4E
3. **How I discovered the Giant Sea Monster** ***By Philip Jacobs*** https://www.bbc.co.uk/programmes/articles/2WtwsKJqGXtF2NJ17pZtJ0v/how-i-discovered-the-giant-sea-monster?fbclid=IwAR37IptN0-iqpKYgGZXuBIwloLVR0BE6vJeXU43xderCe_mZ_GpT3-wP_4I

Prehistoric fast food: fossil reveals final meal of young tyrannosaur

Rare, preserved stomach contents show young dinosaur feasted on drumsticks of speedy turkey-sized creature

Nicola Davis, The Guardian Science correspondent
8 December 2023

A remarkable fossil preserving the last meal of a young tyrannosaur has been discovered in **Canada**, revealing the dinosaur had a taste for prehistoric fast food.

While tyrannosaurs were some of the most fearsome dinosaurs to roam the planet, with adults boasting massive bodies, huge heads and bone-crushing bites, juveniles were rather more puny, with long, skinny legs, blade-like teeth and narrow skulls.

The transformation has long been thought to be associated with a shift in diet as the tyrannosaurs matured and required more energy: while evidence including bite marks on bones has suggested adults hunted and feasted upon enormous herbivores, such as duck-billed and horned dinosaurs, youngsters did not have the dental apparatus to tackle such prey. But just what the juveniles did munch on has been something of a mystery.

Now a spectacular fossil featuring the preserved stomach contents of a young tyrannosaur has offered a rare insight into their diet.

“This is really the first solid evidence that we have of what the diet or feeding behaviour was in a juvenile tyrannosaur,” said Dr Darla Zelenitsky, the co-author of the study at the University of Calgary.

Thought to date to about 75 Ma years ago, the fossil of the young *Gorgosaurus libratus* was discovered in the badlands of Dinosaur Provincial Park, Canada, in 2009 by Darren Tanke, a technician working at the Royal Tyrrell Museum of Palaeontology.

Dr Darla Zelenitsky and Dr Francois Therrien with the full tyrannosaur fossil. (Photograph: Royal Tyrrell Museum of Palaeontology)

The team say the young tyrannosaur had weighed about 350kg, with analysis of growth rings in the fossilised bones suggesting it died young, at five to seven years old. But it didn’t die hungry.

“It was during the preparation process in late 2010 that Darren noticed small knuckle bones that were protruding out of the ribcage of the tyrannosaur,” said Dr François Therrien, the curator of dinosaur palaeoecology at the Royal Tyrrell Museum and co-author of the research.

Writing in the journal **Science Advances**, the team report that inside the ribcage they discovered the remains of two juvenile citipes: turkey-sized creatures with a parrot-like head that would have been speedy on their feet, rather like an emu.

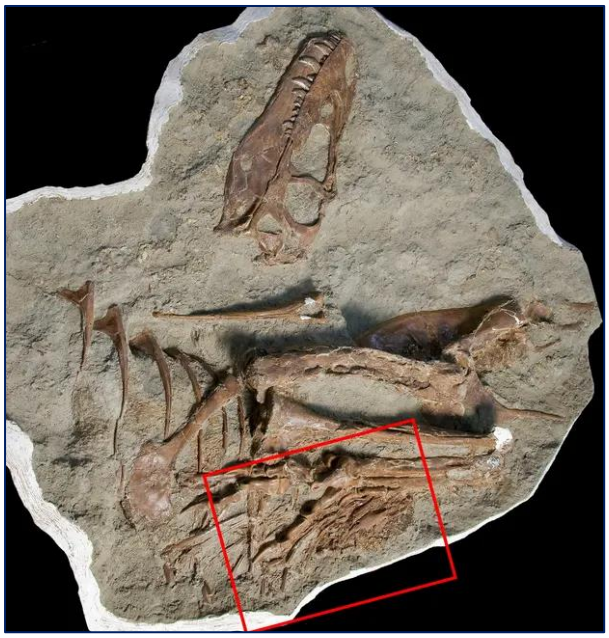
Differences in the extent of stomach acid damage suggested the citipes were consumed in two separate sittings. However, the remains were largely limited to the hind legs, suggesting the young tyrannosaur did not eat all of its prey.

“This juvenile tyrannosaurus seems to have had an appetite for drumsticks of citipes,” said Zelenitsky, adding that one possibility is that the legs were the meatiest part of the prey, with the skull of the young gorgosaurus enabling precision feeding.

While the team said it was unclear how the tyrannosaur died, it appears to have perished within a week of its last meal.

The discovery is the first time the fossil of a tyrannosaur has been found with the contents of its stomach preserved. And there is another bonus to the find.

“The legs present in the stomach represent the most complete citipes skeleton known,” said Therrien.



A fossilised skeleton of a juvenile gorgosaurus, with the photo highlighting the location of the preserved stomach contents – the hind limbs of a citipes. (Photograph: Royal Tyrrell Museum of Palaeontology/Reuters)

Prof Stephen Brusatte, a palaeontologist at the University of Edinburgh, who is not involved in the work, said the fossil was direct evidence of what a tyrannosaur was eating.

“Not guesswork or a series of assumptions based on interpretation of bite marks or coprolites – fossil faeces – but actual direct in-the-gut evidence,” he said. “This is a tyrannosaur’s last meal, preserved in stone.”

Brusatte said the fossil supported the idea that tyrannosaurs changed their diets as they got older, shifting from small to huge prey.

While Brusatte added the insights make intuitive sense, he said it was not inevitable, noting an alternative possibility was that young tyrannosaurs simply feasted on prey killed by adults.

“But that doesn’t seem to be the case here – the little tyrannosaurs ate little prey, so they probably actively hunted their own food and changed the prey they targeted as they got bigger,” he said. “This means that tyrannosaurs filled different roles in the food web as they grew up, which is pretty neat.”

Reference:

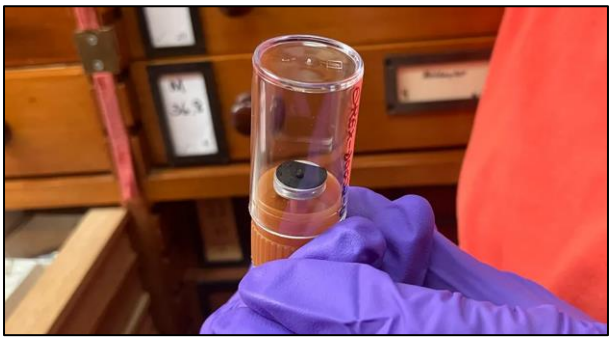
1. https://www.theguardian.com/science/2023/dec/08/prehistoric-fast-food-fossil-reveals-final-meal-of-young-tyrannosaur
2. https://www.bbc.com/news/science-environment-67642374

Nasa delivers 'teaspoonful of asteroid' Bennu to UK

28 November 2023
Jonathan Amos, BBC Science correspondent

Fragments from the asteroid US space agency Nasa has described as the most dangerous rock in the Solar System have arrived in the UK for study.

The tiny pieces of rock and dust from the object known as **Bennu** will be subjected to a battery of tests at the Natural History Museum, and the Open, Manchester and Oxford universities.



This fragment, little more than 1mm across, is packed full of information waiting to be extracted. Credit: BBC)

It is a small donation but ample, says the NHM's Prof Sara Russell. "One hundred milligrams of beautiful" was how she described it to BBC News.

The sample was scooped up from the surface of 500m-wide **asteroid Bennu** in 2020 by

Nasa's **Osiris-Rex spacecraft**, and then delivered by capsule to the Utah desert two months ago.

The US agency wants to learn more about the mountainous object, not least because it has an outside chance of hitting our planet in the next 300 years.

But more than this, the sample is likely to provide fresh insights into the formation of the Solar System 4.6 billion years ago.

This new knowledge will be found in the Bennu material's chemistry, which has remained largely unchanged over time.

Hundreds of scientists around the world are taking part in the investigation.

The NHM team, for example, has particular expertise in X-ray diffraction techniques (XRD). These will reveal the types of minerals present, and their abundance.

"We're unusual in that we have an XRD set-up that allows us to do experiments that others maybe can't," explained the museum's Dr Ashley King. "We also have an incredible minerals collection which means we have all the standards and can do the comparisons that will help us with our calculations."

Dr King has a number of instruments at his disposal at the west London institution, but he'll also be employing the biggest XRD machine in the country - the **Diamond Light Source** in Harwell, Oxfordshire.

The size of a football stadium, Diamond produces brilliant beams of X-rays to provide that next level of sensitivity and resolution.

Early analysis conducted at Nasa - assisted by Dr King - showed the black, extra-terrestrial Bennu material to be full of carbon and water-laden minerals.

That's a great sign. There's a theory that carbon-rich (organic), water-rich asteroids similar to Bennu may have been involved in delivering key components to the young Earth system. It's potentially how we got the water in our oceans and some of the compounds that were necessary to kick-start life.

The 100mg given to the UK doesn't sound like a lot. The largest fragments are less than 2mm in diameter; some of the smallest are barely visible to the naked eye.

"It's only a teaspoonful, but if you imagine a teaspoon of sugar and how many individual grains there are in that - we are going to be looking at this material grain by grain," said Prof Russell, who leads the planetary materials group at the museum. "It could be a lifetime of work ahead of us."

Nasa has much more in reserve. Quite how much, it's not really sure. It hasn't yet been able to open fully the Osiris-Rex sample container. An enclosing plate can't be unscrewed. The agency's curation team at the Johnson Space Center in Texas is having to qualify new tools to complete the job.

The UK's 100mg was sourced from 70g that had spilled from the container as it was being encapsulated for return to Earth. Seventy grams is actually 10g more than the minimum required of the mission when it was funded, so there is no rush to free the rest which may add a further 200g or so to the total.

Scientists in Britain and across the world hope to report on their early work at the **Lunar and Planetary Science Conference (LPSC)** in March. Two major overview papers are also expected to be published at the same time or shortly after in the journal **Meteoritics & Planetary Science.**

Nasa plans to put most of the Bennu sample straight into the archive to preserve for future generations - for scientists who may not even have been born yet, to work in laboratories that don't exist today, using instrumentation that still awaits invention.

Reference:

https://www.bbc.co.uk/news/science-environment-67545539

See also "Further Reading" items 9 and 10, page 49.

Isle of Wight: Enormous fossil ammonite dug out from boulder

27 November 2023
BBC Science

The huge fossil is thought to be a rare Epicheloniceras ammonite. (Image Source: Wight Coast Fossils)

A giant fossil ammonite has been recovered from a fallen boulder on a beach. The edge of the creature's shell was spotted in the block by fossil collector Jack Wonfor on the Isle of Wight's southwest coast.

Fossil enthusiasts from across the island came together to painstakingly extract the fossil, which weighs over 150kg (24 stone), from the boulder.

It was hauled up from the remote beach via a make-shift sled and rope system. It took several attempts for Mr Wonfor, along with friends and fellow fossil collectors, to get the weighty fossil off the beach, up onto the clifftop and into a car.

The 23-year-old palaeontology student at the University of Portsmouth and fossil guide at Wight Coast Fossils said he was "super happy to have it off the beach safely and saved from the destruction of the sea".

Wight Coast Fossils said the "near on perfect example" was thought to be a "huge and rare *Epicheloniceras ammonite*".

Once it has been fully cleaned up it will be donated to the **Dinosaur Isle Museum in Sandown.**

Ammonites are closely related to modern-day squid, cuttlefish and octopuses. They lived during Jurassic and Cretaceous times. They became extinct at roughly the same time as the dinosaurs disappeared.

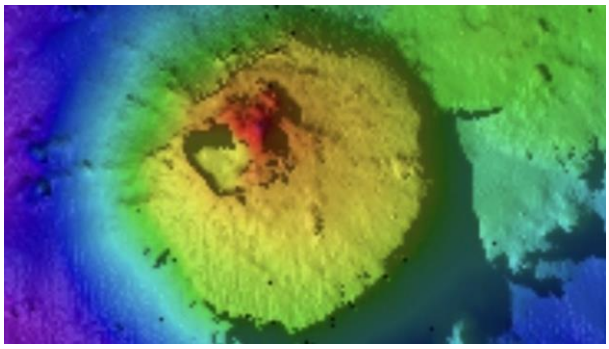
Reference:

https://www.bbc.co.uk/news/uk-england-hampshire-67541396

Seamount twice the size of world's tallest building discovered 'hidden under the waves'

By Sascha Pare, Live Science
23 November 2023

Scientists aboard the Falkor (too) research vessel have documented, for the first time, an extinct volcano towering 5,250 feet above the seabed in international waters in the Pacific Ocean.



Researchers detected the seamount using multibeam sonar aboard the vessel Falkor (too). (Image credit: Schmidt Ocean Institute)

Ocean explorers mapping the seabed off the coast of Guatemala have discovered a mountain twice as high as the Burj Khalifa, the world's tallest building, hiding deep beneath the waves.

The **5,250-foot-tall** (1,600m) formation is a seamount — a large, underwater geological feature typically formed from an extinct volcano. Scientists discovered the cone-shaped seamount 7,870 feet (2,400m) below sea level during an expedition organized by the **Schmidt Ocean Institute** this summer, according to a statement shared with ***Live Science***.

"A seamount over 1.5 kilometers tall which has, until now, been hidden under the waves really highlights how much we have yet to discover," Jyotika Virmani, the executive director of Schmidt Ocean Institute, said in the statement.

The towering feature covers 5.4 square miles (14 square kms) and sits in international waters in the Pacific Ocean, 97 miles (156 kms) from Guatemalan waters. The researchers detected the seamount using multibeam sonar mapping during a six-day crossing from Costa Rica to the East Pacific Rise — the boundary between six tectonic plates, including the Pacific plate to the west and the North American plate to the northeast.

Seamounts provide crucial rocky habitats for deep-sea corals, sponges and a host of invertebrates, as hard substrate can be difficult to come by in the ocean, with the majority of the seabed covered in loose, muddy sediment.

"Seamounts can be too steep for mud to stick to, and some animals really thrive on the sides," **Jon Copley**, a professor of deep-sea ecology and ocean exploration at the **University of Southampton** in the U.K, previously told *Live Science*. "When one sticks up, it creates strong currents for filter feeders to grow up into the water and catch food."

Satellite data suggest there are more than 100,000 unexplored seamounts that will come to light through continued seafloor mapping. "A complete seafloor map is a fundamental element of understanding our ocean," Virmani said. "It's exciting to be living in an era where technology allows us to map and see these amazing parts of our planet for the first time!"

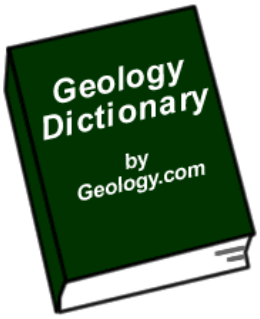
In April, a research team on a Schmidt Ocean Institute mapping expedition aboard Falkor (too) revealed three new hydrothermal vent fields on the Mid-Atlantic Ridge. In August, they announced the existence of a hidden underworld filled with sea creatures on the East Pacific Rise. Scientists aboard the same vessel also recently discovered two uncharted seamounts and pristine coral reefs near the Galápagos Islands.

The latest find is **"yet another breathtaking discovery,"** Jamie McMichael-Phillips, the director of the **Seabed 2030 project**, which aims to map the entire seafloor by the end of the decade together with the Schmidt Ocean Institute and other partners, said in the statement.

Reference:

https://www.livescience.com/planet-earth/geology/seamount-twice-the-size-of-worlds-tallest-building-discovered-hidden-under-the-waves?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=73D766D4-B530-4667-B0E3-62F1DF896FAB&utm_source=SmartBrief

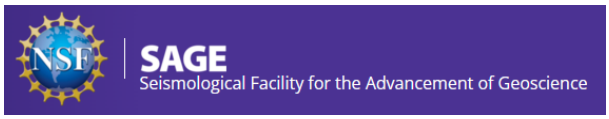
Online Resources



Geology and Earth Science Terms and Definitions

Reference:

https://geology.com/geology-dictionary.shtml



A very interesting online resource providing lessons on a variety of geological concepts including 3D Seismic Data and Basic Seismic Interpretation, Direct Hydrocarbon Indicators (DHI), Risk Analysis, Introduction to Petroleum Exploration and Plotting Earthquake Epicentres has been suggested by **FGS Member Angela Snowling.**

The site can be filtered for Novice, Intermediate, Advanced and Expert levels and for the Resource Type, e.g., Fact-Sheet, Poster, Video or Course, as well as a variety of different languages.

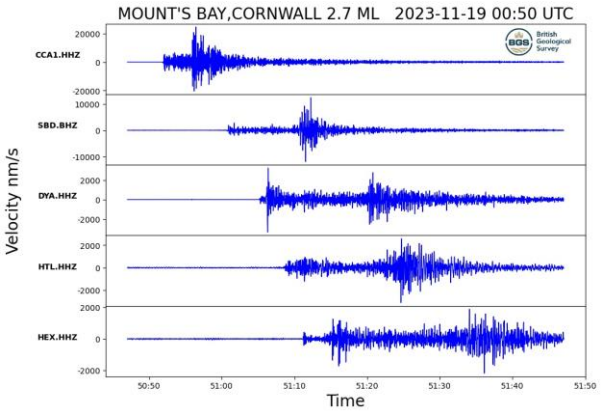
Feedback on the site would be appreciated.

Reference:

https://www.iris.edu/hq/inclass/search#type[]=4&language[]=1

Cornwall shaken by 2.7 magnitude earthquake

Jonathan Morris, BBC News Online
18 November 2021



The earthquake was recorded by the British Geological Survey at 00:50 GMT. (Image Source: British Geological Survey)

At a glance

- The earthquake was recorded by the British Geological Survey at 00:50 GMT on Sunday.
- The epicentre was in the Mounts bay area, but the tremor was felt from St Just to Redruth.
- People described hearing a rumbling sound like thunder and feeling their houses and ornaments shake

An earthquake has shaken parts of Cornwall, with people saying it felt like an explosion or avalanche.

Seismologists at the British Geological Survey recorded the 2.7 magnitude quake at 00:50 GMT.

Its epicentre was in the Mounts Bay area in south Cornwall, with people woken up by a loud bang from St Just in north Cornwall to Redruth.

Experts said the tremor was within what is expected for the area and is among hundreds in the UK every year.

Linda Dwan, from Mousehole in south Cornwall, said: "There was a rumbling, like thunder and the house shook for about two or three seconds. It felt like an explosion or an avalanche. My glass ornaments were shaking in the window."

Dr David Hawthorn, a seismologist with the British Geological Survey, said: "We have 2-300 quakes a year, but about 30 are felt and this was at the lower end of those quakes. This was quite small by global standards.

"In the UK we have a phenomenally complicated geology and that's particularly true in Cornwall and sooner or later that stress weakens and we get an earthquake."

He appealed for anyone affected to get in touch. "We are still getting data in, so please give us a description because we want to know how much it shakes the ground in any given location" he said.

Reference:

1. https://www.bbc.co.uk/news/articles/c724le759lro
2. http://www.earthquakes.bgs.ac.uk/earthquakes/recent_events/20231119005043.html#page=summary

Supervolcano 'megabeds' discovered at bottom of sea point to catastrophic events in Europe every 10,000 to 15,000 years

By Hannah Osborne, Live Science
15 November 2023

Four huge deposits from supervolcano eruptions over the last 40,000 years have been discovered at the bottom of the Mediterranean Sea.

Huge "megabeds" from ancient supervolcano eruptions are hiding at the bottom of the Mediterranean Sea, researchers have found. Their discovery points to a **cycle of catastrophic events** that appear to hit the region every **10,000 to 15,000 years**.

Megabeds are huge submarine deposits that form in marine basins as a result of catastrophic events like volcanic eruptions.

The researchers found the beds while investigating deposits at the bottom of the **Tyrrhenian Sea**, near the coast of Italy, close to a large underwater volcano. Previous research into geohazards in the area using sediment cores and imaging indicated something was hidden beneath the ocean, but the resolution was not high enough to see the megabeds, lead study author Derek Sawyer, associate professor of Earth sciences at The Ohio State University, told ***Live Science***.

Scientists have discovered "megabeds" at the bottom of the ocean that appear to have been formed by ancient supervolcano eruptions. (Image credit: Vershinin-M/Getty Images)

In a new study published Aug. 10 in the journal ***Geology***, Sawyer and colleagues went back to the site to create higher-resolution images of the layers of sediment and discovered a succession of four megabeds, each between 33 and 82 feet (10 to 25 meters) thick, and each separated by distinct layers of sediments. Cores drilled from the site showed the megabeds were made of volcanic material.

The oldest layer was around 40,000 years old, the next oldest was 32,000 years, the third 18,000 years, while the youngest formed about 8,000 years ago.

The team then looked at known volcanic activity in the region to determine the source of the megabeds. The region where the beds formed is extremely active volcanically and includes the **Campi Flegrei supervolcano**, which has been rumbling recently.

The oldest megabed formed after a huge eruption from Campi Flegrei 39,000 years ago — one of the biggest known eruptions on Earth. The same eruption may also have created the second bed, as the layer between the two is just 3.2 feet (0.98m) — indicating a relatively short interval between

The scientists think the 18,000-year-old megabed formed in the wake of the Neapolitan Yellow Tuff supereruption of Campi Flegrei about 15,000 years ago, while the youngest megabed was deposited by another, less energetic eruption at Campi Flegrei.

The eruptions occurred roughly every 10,000 to 15,000 years. However, they are refining the eruption dates to get a more precise picture of the cycle and potential risk for the future. "It's not as constrained as we would like it to be," Sawyer said.

The findings, Sawyer said, will help researchers understand the risk posed by volcanoes in the region. "That whole field is still active, there's still a lot of concern about the future of that, so it's certainly potentially possible that it could happen again," he said.

Reference:

https://www.livescience.com/planet-earth/volcanos/supervolcano-megabeds-discovered-at-bottom-of-sea-point-to-catastrophic-events-in-europe-every-10000-to-15000-years?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=8A86A2D3-677B-462F-801F-E6AADB45E1EE&utm_source=SmartBrief

Japan gets a new island after undersea volcano erupts

New landmass about 100 metres across pops up above the waves near Iwoto island after eruptions began last month

Justin McCurry, The Guardian in Osaka
9 November 2023

New island emerges off Japan after volcanic eruption. (Credit: The Guardian)

Japan has gained another island to add to its already impressive collection, after an undersea volcanic eruption 1,200km (745 miles) south of Tokyo created a new landmass.

Experts said the tiny island emerged after a series of eruptions that began in October near Iwoto island, part of the Ogasawara island chain in the western Pacific.

Fukashi Maeno, an associate professor at Tokyo University's earthquake research institute, said he had confirmed that **phreatomagmatic eruptions** – a type of explosive eruption that results from magma interacting with water – had occurred about a kilometre off Iwoto, forming a landmass of about 100 metres in diameter.

Maeno, who flew over the site at the end of October, told the Kyodo news agency that plumes of smoke and ash of more than 50 metres high rose every few minutes during the eruptions.

He also witnessed large rocks hurtling through the air and bands of brown pumice stones floating in the sea, which had changed colour as a result of the eruption, Kyodo reported.

Iwoto – the scene of one of the bloodiest battles of the Pacific war and one of 111 active volcanoes in Japan – is located near another new island that was formed after an eruption in 2021. **Iwoto** island was previously known as **Iwo Jima** but was renamed by Japanese authorities in 2007.

The area is accustomed to dramatic bursts of volcanic activity. Japan's meteorological agency said similar eruptions had been observed near Iwoto between July and December last year and in June this year.

Maeno said the recent island formation was proof that magmatic activity had returned to the area. The new island could grow larger and change shape if the eruptions continue, but it could also disappear beneath the waves. Islands formed in a similar way in the area in 1904, 1914 and 1986 all disappeared due to erosion.

New islands made up of ash and rock fragments could struggle to resist constant battering by waves, but continued volcanic activity could produce lava flows that eventually form a harder, more durable surface.

In 2013, weeks of volcanic activity formed an island that merged with an existing island to create a new landmass that for a while bore a resemblance to the cartoon dog ***Snoopy***.

Earlier this year, geographers said the Japanese archipelago, previously thought to comprise four main islands and about 6,000 much smaller and mostly uninhabited ones, was actually made up of twice as many. Using digital mapping technology, the **Geospatial Information Authority of Japan** said it had identified a total of **14,125 islands** – 7,273 more than previously thought.

While it gains new islands, Japan occasionally loses them. Esanbe Hanakita Kojima, which was located 500 metres off the coast of Hokkaido, is thought to have slipped beneath the waves unnoticed in 2018.

No one realised it had disappeared until the author Hiroshi Shimizu visited the area to write a sequel to his picture book on Japan's "hidden" islands.

Reference:

1. https://www.theguardian.com/world/2023/nov/09/japan-gets-a-new-island-after-undersea-volcano-erupts
2. https://www.livescience.com/planet-earth/volcanos/new-island-that-emerged-from-the-ocean-off-japan-is-now-visible-from-space?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=1D584F99-3BA9-448A-863C-53889A5A5A43&utm_source=SmartBrief

Most Martian meteorites are curiously young in age

By Josh Davis, NHM
27 October 2023

The vast majority of meteorites from Mars are shergottites, but the difficulty in ageing these rocks created something of a paradox. (©The Trustees of the Natural History Museum, London)

Putting Martian meteorites in a nuclear reactor has confirmed their curiously young age.

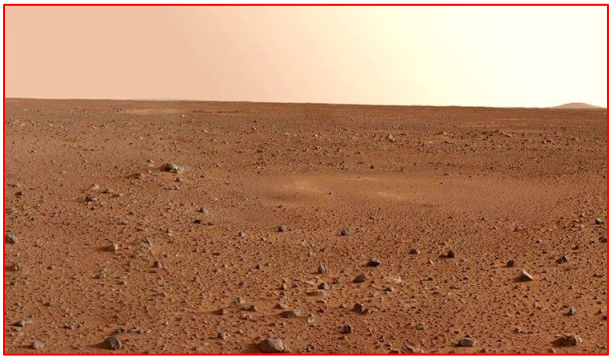
Most meteorites from Mars **are just a few hundred million years old**, and likely come from relatively recent volcanic events such as the eruptions on the largest volcano in the solar system, **Olympus Mons**.

Earth is occasionally hit by little pieces of Mars. These bits of Martian rock are incredibly rare, but can tell us a lot about the geological history of the red planet. One of the biggest issues for scientists studying these meteorites, however, has been a difficulty in dating them. Different techniques have come back with different ages, making it hard for researchers to pin down where on Mars the rocks originated.

But a new paper published in **Earth and Planetary Science Letters** has solved this problem.

Dr Ben Cohen, a volcanologist at the University of Glasgow, has been working with colleagues at the Natural History Museum, the University of Edinburgh, and researchers in the USA to figure out once and for all how old Martian meteorites actually are.

'We know from certain chemical characteristics that these meteorites are definitely from Mars,' explains Ben. 'They've been blasted off the red planet by massive impact events, forming large craters. But there are tens of thousands of impact craters on Mars, so we don't know exactly where on the planet the meteorites are from.'



The young age of the shergottite meteorites seemingly did not match with the typically ancient surface of Mars. (©NASA/JPL/Cornell)

'One of the best clues you can use to determine their source crater is the samples' age.'

The Shergottite Age Paradox

While over 70,000 meteorites have been identified on Earth, only roughly 358 of these are thought to have originated on Mars. Impact events kicked up Mars' surface rocks and threw them into space. These incredibly rare rocks then swirled around the Solar System before crashing down onto Earth millions of years later.

Martian meteorites are typically grouped into three main categories, with a fourth for those currently 'unclassified'. **Chassignites** are the rarest of these rocks, with only two ever having been discovered. Next are the **nakhlites**, which formed about 1.3 billion years ago during volcanic eruptions on Mars. The most common type of meteorites are those known as **shergottites**.

Around three-quarters of all Martian meteorites are classed as shergottites. They are also thought to have formed in roiling lavas of **Martian volcanoes** but have formed something of a conundrum for scientists studying the red planet too.

This is because most of Mars' surface is extraordinarily old. Using the abundance of **impact craters**, researchers know that the majority of the planet's surface is between three and four billion years old. But when scientists came to age the shergottite meteorites, they got a huge range of ages, from four billion years old to less than 200 million years old.

This created a problem - if the surface of Mars is, on average, billions of years old, then how were shergottite meteorites coming back with ages of just a few hundred million years old? This mismatch became known as the ***Shergottite Age Paradox***.

'One of the ideas was that impact events hitting Mars could be 'resetting' the methods that geologists use to determine the age of rocks,' explains Ben. 'That was used to say that the meteorites were actually four billion years old, and all the younger numbers were because the rocks were being either fully or partially reset by the heat and pressure of these impacts.'

But as more and more meteorites were studied by different techniques, the bulk of the results obtained were curiously young, with evidence that the ages were not reset by impact. Clearly, something was not quite right.

How to date Mars

Martian meteorites have historically been dated using a range of methods, typically giving a spread of ages. One of these is what is known as the **'argon-argon' method**. In the simplest of terms, this measures the rate of decay of the isotope potassium-40 to argon-40. Potassium is an abundant element, making this method very versatile. It can be used to measure the age of a variety of rocks, from the eruption of Mount Vesuvius to the start of the Solar System itself.

This is useful for rocks that have formed on Earth, as scientists are able to account for contamination of additional argon making its way into the rocks which might skew the age. But things are a little trickier for rocks that have been whizzing around in space for millions of years.

Scientists use the number of impact craters on the surface of Mars to estimate the age of rocks. (©NASA/JPL-Caltech/Univ. of Arizona)

'There are five potential sources of argon that can be contained within shergottite meteorites,' says Ben. 'That compares to rocks on Earth, where there are only three.'

'The fact that there're these two extra sources of argon in Martian samples is what's making the argon-argon system get complicated for the shergottites.'

By going back and looking at the argon-argon method with modern equipment and technology, Ben and his colleagues were able to reassess seven **Martian meteorites**. This included sticking very small pieces of them into a research-only nuclear reactor to measure the argon concentrations as accurately as possible, and then seeing what ages they came back with.

By looking more precisely at the chemistry of the meteorites they were able to account for any argon the rocks gained while in space. They were also able to correct for how much

contamination there had been from both the Martian and Earth atmosphere.

‘Once we did that, the argon-argon ages came out as being young and matched perfectly with other methods, like Uranium-Lead,’ explains Ben.

Professor Caroline Smith is the Head of Collections at the Museum and coauthor of the new paper. She says, ‘Exciting science like this using samples from the Natural History Museum’s collections is helping unravel the history of the planets in our Solar System.'

‘This work also links to our ongoing meteorite research program and our continued Mars research using meteorites and with space exploration missions such as Mars 2020 (Perseverance rover), Mars Science Laboratory (Curiosity rover) and ExoMars.’

While this new research meant that the various dating methods now lined up, it still left the problem of the Shergottite Age Paradox.

The best explanation for this is that the frequent bombardment of Mars has created a layer of crumbly rock on the surface known as regolith. Over time, as there have been more and more impacts, this layer of regolith has accumulated, while at the same time fresh volcanic eruptions brought newer rocks to the surface. This meant that for every new impact, the likelihood of the older rock being kicked up and ejected into space was reduced.

‘The older the sample, the thicker the regolith, and the thicker the regolith the harder it is to blast the underlying rock off the surface of Mars,’ explains Ben. ‘And that would explain why around three-quarters of the Martian meteorites are the ‘young’ shergottites, with comparatively fewer of the older types of Martian meteorites.’

Reference:

https://www.nhm.ac.uk/discover/news/2023/october/most-martian-meteorites-are-curiously-young-in-age.html

The remains of an Ancient Planet lie deep within Earth

Lori Dajose, Caltech News
01 November 2023

In the 1980s, geophysicists made a startling discovery: two continent-sized blobs of unusual material were found deep near the center of the Earth, one beneath the African continent and one beneath the Pacific Ocean. Each blob is twice the size of the Moon and likely composed of different proportions of elements than the mantle surrounding it.

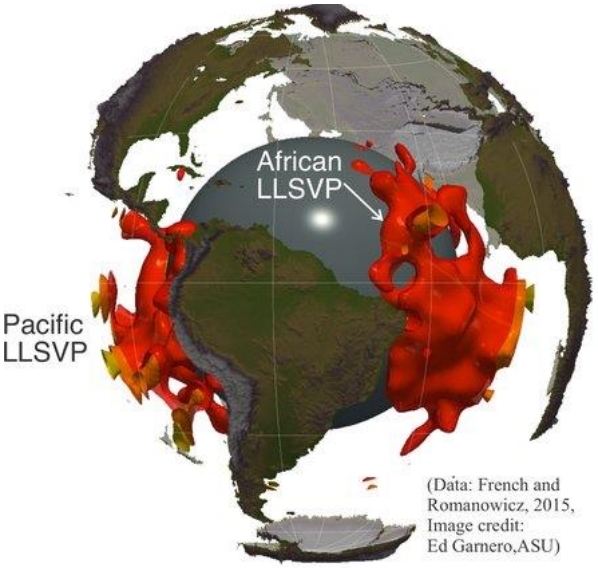


Illustration of the location of the two large, dense "blobs" of iron-rich material near the Earth's core. One is underneath the African continent while the other is across the globe beneath the Pacific Ocean. Each blob is nearly twice the size of the Moon. Earth's core is illustrated as a gray sphere. (Credit: Edward Garnero)

Where did these strange blobs—formally known as **large low-velocity provinces** (**LLVPs**)—come from? A new study led by **Caltech researchers** suggests that they are remnants of an ancient planet that violently collided with Earth billions of years ago in the same giant impact that created our Moon.

The study, published in the journal **Nature** on November 1, also proposes an answer to another planetary science mystery.

Researchers have long hypothesized that the Moon was created in the aftermath of a giant impact between Earth and a smaller planet dubbed ***Theia***, but no trace of Theia has ever been found in the asteroid belt or in meteorites. This new study suggests that most of Theia was absorbed into the young Earth, forming the LLVPs, while residual debris from the impact coalesced into the Moon.

The research was led by Qian Yuan, O.K. Earl Postdoctoral Scholar Research Associate in the laboratories of both Paul Asimow (MS '93, PhD '97), the Eleanor and John R. McMillan Professor of Geology and Geochemistry; and Michael Gurnis, the John E. And Hazel S. Smits Professor of Geophysics and Clarence R. Allen Leadership Chair, director of Caltech's Seismological Laboratory, and director of the Schmidt Academy for Software Engineering at Caltech.

Scientists first discovered the LLVPs by measuring seismic waves traveling through the earth. Seismic waves travel at different speeds through different materials, and in the 1980s, the first hints emerged of large-scale three-dimensional variations deep within the structure of Earth. In the deepest mantle, the seismic wave pattern is dominated by the signatures of two large structures near the Earth's core that researchers believe possess an unusually high level of iron. This high iron content means the regions are denser than their surroundings, causing seismic waves passing through them to slow down and leading to the name "large low velocity provinces."

Yuan, a geophysicist by training, was attending a seminar about planet formation given by Mikhail Zolotov, a professor at Arizona State University, in 2019. Zolotov presented the giant-impact hypothesis, while Qian noted that the Moon is relatively rich in iron. Zolotov added that no trace had been found of the impactor that must have collided with the Earth.

"Right after Mikhail had said that no one knows where the impactor is now, I had a 'eureka moment' and realized that the iron-rich impactor could have transformed into mantle blobs," says Yuan.

Yuan worked with multidisciplinary collaborators to model different scenarios for Theia's chemical composition and its impact with Earth. The simulations confirmed that the physics of the collision could have led to the formation of both the LLVPs and the Moon. Some of Theia's mantle could have become incorporated into the Earth's own, where it ultimately clumped and crystallized together to form the two distinct blobs detectable today at Earth's core–mantle boundary today; other debris from the collision mixed together to form the Moon.

Given such a violent impact, why did Theia's material clump into the two distinct blobs instead of mixing together with the rest of the forming planet? The researchers' simulations showed that much of the energy delivered by Theia's impact remained in the upper half of the mantle, leaving Earth's lower mantle cooler than estimated by earlier, lower-resolution impact models. Because the lower mantle was not totally melted by the impact, the blobs of iron-rich material from Theia stayed largely intact as they sifted down to the base of the mantle, like the colored masses of paraffin wax in a turned-off lava lamp. Had the lower mantle been hotter (that is, if it had received more energy from the impact), it would have mixed more thoroughly with the iron-rich material, like the colors in a stirred pot of paints.

The next steps are to examine how the early presence of Theia's heterogeneous material deep within the earth might have influenced our planet's interior processes, such as plate tectonics.

"A logical consequence of the idea that the LLVPs are remnants of Theia is that they are very ancient," Asimow says. "It makes sense, therefore, to investigate next what consequences they had for Earth's earliest evolution, such as the onset of subduction before conditions were suitable for modern-style plate tectonics, the formation of the first continents, and the origin of the very oldest surviving terrestrial minerals."

The paper is titled **"Moon-forming impactor as a source of Earth's basal mantle anomalies."** Qian Yuan is the first author. In addition to Yuan and Asimow, the additional Caltech coauthor is Yoshinori Miyazaki, Stanback Postdoctoral Scholar Research Associate in Comparative Planetary Evolution. Additional coauthors are Mingming Li, Steven Desch, and Edward Garnero (PhD '94) of Arizona State University (ASU); Byeongkwan Ko of ASU and Michigan State University; Hongping Deng of the Chinese Academy of Sciences; Travis Gabriel of the U.S. Geological Survey; Jacob Kegerreis of NASA's Ames Research Center; and Vincent Eke of Durham University. Funding was provided by the National Science Foundation, the O.K. Earl Postdoctoral Fellowship at Caltech, the U.S. Geological Survey, NASA, and the Caltech Center for Comparative Planetary Evolution.

Reference:

https://www.caltech.edu/about/news/the-remains-of-an-ancient-planet-lie-deep-within-earth

Net zero boost as carbon storage licences accepted

North Sea Transition Authority
15 September 2023

- **21 licences shared by a total of 14 companies**
- **Almost 10% of total UK greenhouse gas emissions could be stored in new licence locations**
- **Bacton could be Energy Transition Hub – home to carbon storage, offshore wind, and hydrogen production**

The North Sea Transition Authority (NSTA) today (15 September 2023) announced the list of companies which have accepted licences following the UK's first-ever **carbon storage licensing round**.

A total of 14 companies have been awarded 21 licences in depleted oil and gas reservoirs and saline aquifers which cover around 12,000sq km – an area equivalent to the size of Yorkshire.

The locations could store up to 30 million tonnes of CO2 per year by 2030, approximately 10% of UK annual emissions which were 341.5 million tonnes in 2021.

Shell, Perenco and ENI have all been awarded licences off the coast of Norfolk in sites which could form part of the **Bacton Energy Hub** – a carbon storage, hydrogen and offshore wind project, which could provide low-carbon energy for London and the South East for decades to come and help in the drive to net zero greenhouse gas emissions.

Other locations include sites off the coasts of Aberdeen, Teesside, and Liverpool.

Stuart Payne, NSTA Chief Executive, said: "Carbon storage will play a crucial role in the energy transition, storing carbon dioxide deep under the seabed and playing a key role in hydrogen production and energy hubs.

"It is exciting to award these licences and our teams will support the licensees to bring about first injection of carbon dioxide as soon as possible. We will also continue to work with industry and government to enable further licensing activity and back the UK's drive to net zero emissions."

It is estimated that as many as 100 storage licences will be needed to meet the requirements for reaching net zero and the volume of applications received for the first round demonstrated the industry's desire for further opportunities.

The NSTA will assess the response and the quality of opportunities in locations across the UK before deciding when to run a second round.

Six licences have already been granted by the NSTA and the Government recently announced £20bn funding for the progression of these existing projects. Two locations, Hynet and the East Coast Cluster, have been selected as **Track 1**, while Acorn and Viking CCS projects have been chosen as the **Track 2** clusters.

The cluster sequencing process was set up to give industry the certainty it requires to deploy carbon storage at pace.

Ruth Herbert, Chief Executive at the Carbon Capture and Storage Association, said:
"The CCSA welcomes the acceptance of carbon storage licences, a significant step towards achieving net zero. These licences mark a substantial milestone towards widespread deployment of CCS.

"With the potential to store almost 10% of the UK's greenhouse gas emissions in these new locations, starting to develop these sites paves the way for a cleaner and more sustainable future. The next step is a carbon capture deployment plan to enable us to fully exploit our future CO2 storage capacity."

Lord Callanan, Minister for Energy Efficiency and Green Finance, said:
"The UK has one of the largest potential carbon dioxide storage capacities in Europe, putting us in prime position to be world leaders in carbon capture – which is why we've committed an unprecedented £20 billion to develop the early stage development of carbon capture, usage and storage (CCUS).

"These new licences confirmed today will be vital to realising our CCUS potential, playing a key role in the energy transition to help boost our energy security and achieve our net zero targets, while also bringing in private investment and supporting thousands of jobs."

The NSTA, The Crown Estate (TCE) and Crown Estate Scotland (CES) are working in close collaboration to help meet the UK Government's ambitious carbon storage targets of 20-30 million tonnes of CO2 emissions per year by 2030, and over 50 million tonnes by 2035, and make a significant contribution to net zero.

Reference:

https://www.linkedin.com/pulse/net-zero-boost-carbon-storage-licences%3FtrackingId=qGfoMjInSJ5W%252BVeSUpJCSw%253D%253D/?trackingId=qGfoMjInSJ5W%2BVeSUpJCSw%3D%3D

Moon is 40 million years older than we thought, tiny crystals from Apollo mission confirm

A new analysis of zircon crystals from the Apollo 17 mission has revealed that the moon formed around 40 million years earlier than past geological evidence suggested. However, our cosmic companion may be even older than that.

By Harry Baker, Live Science
23 October 2023

The moon is at least 40 million years older than we once thought, a new study reveals. Scientists confirmed our cosmic companion's new minimum age after reanalyzing tiny impact crystals from lunar samples taken by NASA's Apollo 17 mission in 1972.

In a 2021 study, researchers first analyzed the lunar gems, known as **zircon crystals** — microscopic rocks created under intense heat and pressure that, on Earth, are used to date objects such as impact craters. The lunar grains were left behind when the moon formed following a colossal collision between Earth and a Mars-size planet, named Thea. The analysis, which involved measuring the decay rate of different versions, or isotopes, of uranium and lead in the crystals' outer layers, revealed that the samples could be up to 4.46 billion years old.

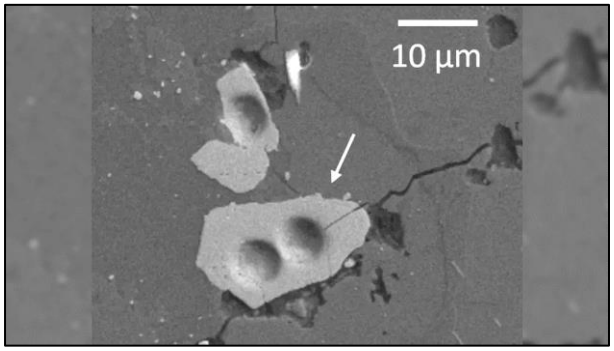
However, the 2021 study authors noted that there was a large amount of uncertainty in their dating method. As a result, the oldest confirmed lunar zircon crystals remained a group that was part of a separate Apollo 17 sample that was analyzed in a 2009 study, which put the moon's earliest possible birth date at around 4.42 billion years ago.

The new study, published Monday (Oct. 23) in the journal **Geochemical Perspectives Letters**, reanalyzed the crystals from the 2021 study, paying close attention to how the lead atoms clustered within the crystals. This confirmed that the crystals are indeed around **4.46 billion years old**.

"These crystals are the oldest known solids that formed after the giant impact," study author Philipp Heck, a planetary scientist at the University of Chicago and director of research at the Field Museum, said in a statement. "And because we know how old these crystals are, they serve as an anchor for the lunar chronology."

Earth is approximately **4.54 billion years old**. So based on the newest study, the zircon crystals were formed around 80 million years after our planet formed. However, the collision that birthed the Moon could have actually happened even earlier.

After the Earth-Thea crash, the infant moon's surface would have been covered by a magma ocean due to the intense energy of the collision. Therefore, the lunar zircon crystals could only have properly solidified into their current state once the magma ocean had cooled down.



Grains of lunar zircon crystals viewed under the microscope. (Image credit: Photo courtesy of Jennika Greer)

In a 2017 study, researchers created a computer model based on data from multiple lunar zircon samples to predict how long the magma cooling process may have taken and, as a result, when the collision actually took place. This revealed that the moon could be up to 4.51 billion years ago, Live Science's sister site ***Space.com*** reported.

But although the 2017 study contains some "great work," the method used by the researchers was an "indirect approach" that lacked a "direct age determination," Heck told ***Live Science*** in an email. As a result, the newest study represents the best current estimate of the moon's age, he added.

Our understanding of the moon's history and geological evolution is constantly changing with new discoveries.

In July, researchers revealed that the "man in the moon" is 200 million years older than previously thought. And in November 2022, lunar samples collected by China's now-defunct Chang'e 5 rover revealed that volcanic eruptions occurred on the moon as recently as 2 billion years ago, which is around 1 billion years later than we realized.

Therefore, there is every chance that the moon's official birth date will be revised again at a later date.

Reference:

https://www.livescience.com/space/the-moon/moon-is-40-million-years-older-than-we-thought-tiny-crystals-from-apollo-mission-confirm?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=99C8F233-401C-4298-B580-CF8DF1C6C222&utm_source=SmartBrief

Interesting Animation

The Power of Nature: Pompeii – 24 August 79 AD

Reference:

https://www.youtube.com/embed/dY_3ggKg0Bc

As suggested by Janet Catchpole

Interesting Photos 2

Terminal & Lateral Moraine

Date: ***6 August 2013***
Location: ***South of Kennecott, Alaska in the Wrangell-St. Elias National Park***

(Credit: Richard Droker, wanderflechten)

Reference:

https://www.flickr.com/photos/wanderflechten/10997875076/in/photostream/

https://www.flickr.com/photos/wanderflechten/10997800925/?fbclid=IwAR0wOsqFmAZ8rV1Twf5gttaIQdOpSk_ZS0CY_ySXyYlNBvlTABfx3l5Pbks

https://education.nationalgeographic.org/resource/moraine/

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

https://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle/page3451.html#m

TV review

Attenborough and the Giant Sea Monster review – quite possibly the most deeply joyous show ever made

As Sir David realises he's helped unearth a new pliosaur, the years fall away until the 97-year-old is a schoolboy fossil hunter once more. Talk about truly exciting television (available on BBC iPlayer).

Lucy Mangan, The Guardian
1 January 2024

Attenborough and the Giant Sea Monster is a programme about happiness. I mean, ostensibly it's a programme about the discovery, extraction and examination of the intact (in 150Ma old fossil terms) skull of a pliosaur from a cliff face along the Jurassic coast. But really, it's a study in joy.

Joy is everywhere. "Is there anything more beautiful than that?" says Attenborough in his introduction, while he cleaves a rock in two like he used to as a schoolboy fossil hunter ("You're supposed to wear glasses these days") to reveal an ammonite.

The pliosaurus was embedded about 11 metres from the ground on the Dorset coastline, making it 'very difficult to reach and even harder to work on', Attenborough said. (Photograph: BBC Studios)

Joy and disbelief mingle in the phone footage of the original discovery ***by Philip Jacobs*** on the beach at **Kimmeridge Bay** of the snout of the pliosaur skull, and in every lineament of **fossil expert Steve Etches** as the realisation

dawns of the likelihood that the rest of the skull is above them, embedded somewhere in the towering cliff.

So it proves. All he and his team have to do now is get it out. How do you do that? Well, quickly, before the seasonal storms come and the treasure is lost for ever. And by rappelling down the cliff face and chipping your way round the huge specimen, protecting the exposed bits as you go with tinfoil and superglue. “I thought stupidly it wouldn’t be as hard as it is,” says Etches as they work their way with a combination of brute force and incredible dexterity round their half-tonne jewel. But he is only talking of a deeper joy.

Meanwhile, Attenborough talks joyfully to experts about information already gleaned from the snout: the sensory pits that could detect changes in water pressure brought about by oncoming prey, the variety of tooth shapes that maximised grip and the signs that new ones came in when the old ones broke, giving the beast longevity as well as extraordinary hunting prowess.

After more than three weeks of vertical digging, the skull is free from its surrounding stone. All they have to do now is get it up to terra firma. Fortunately, farmer and self-taught engineer Rob has spent the time (possibly even more happily than either Attenborough or Etches has) inventing a device that will allow them to do just that. It is a wooden crate on metal skis which pivots to enable it to stay horizontal no matter what angle it has to be brought up or down the cliff. If you can’t envision that – well, that is why people like Rob exist, and should be revered as gods. And if you are not filled with joy as the whole thing works like a dream and the skull comes safely to rest in Etches’ restoration workshop, then who hurt you? Two of Etches’ team go so far as to hug him. “Now, now,” he says. “None of that.”

Then Etches embarks on a year of cleaning the millions of years off the fossilised bone, the delicacy increasing the closer he gets to the beast. **Paleontologist Dr Judyth Sassoon** comes to visit and determines that it is likely to be a new species of pliosaur to add to the eight already known. Attenborough’s face lights up. “This is truly exciting.” The years fall away and you can still see the schoolboy beneath. Not fossilised. Still there.

‘About the size of a double-decker bus’: David Attenborough with the restored pliosaur skull in the workshop of the Etches Collection in Kimmeridge, Dorset. (Photograph: BBC Studios)

The schoolboy and the 97-year-old naturalist visit paleobiologist **Dr Andre Rowe** to discuss convergent evolution, the likely strength, size and habits of the new pliosaur, **Professor Emily Rayfield**, a paleontologist specialising in skeletal mechanics to talk about – well, its skeletal mechanics and **Dr Luke Muscutt** in his hydrodynamic lab to see how the marine reptile with its rare four flippers instead of two used them and how fast it could go.

It is all bad news for ichthyosaurs, basically, but all very good for us, the viewers. There is nothing like watching passionate, informed people share their knowledge, and their enthusiasm – their joy – to chip away the accrued layers of protective cynicism and excavate the tender soul once more. Look at what we can do, look at what we can come to know. Look at what we can feel, appreciate, bring back to life with the power of imagination (and a little well-placed CGI). An hour is nowhere near long enough. I could watch an entire hour, an entire series, on every aspect mentioned.

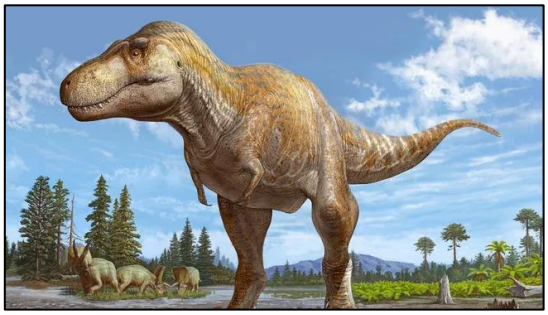
In the closing moments, Attenborough urges us to keep on. “There is still so much to learn about these extraordinary animals,” he says. “And I for one will never tire of discovering more.”

Reference:

1. https://www.theguardian.com/media/2024/jan/03/calls-for-dinosaur-attenborough-and-the-giant-sea-monster-to-be-named-after-amateur-fossil-hunter-bbc
2. https://www.theguardian.com/tv-and-radio/2024/jan/01/attenborough-and-the-giant-sea-monster-review-quite-possibly-the-most-deeply-joyous-show-ever-made
3. https://www.theguardian.com/tv-and-radio/2023/dec/09/david-attenborough-film-tells-of-risky-mission-to-excavate-t-rex-of-the-seas-from-dorset-cliff
4. https://www.dorsetecho.co.uk/news/23943168.dorset-fossil-subject-david-attenborough-documentary/?ref=socialflow&fbclid=IwAR1z9VLBYm0XX7YmO8iEI3h93Rn0fLS-81tjVlcsXC6kR_3eSXlCzHBmj5U

Further Reading

1. **Newfound T. rex relative was an even bigger apex predator, remarkable skull discovery suggests**



https://www.livescience.com/animals/dinosaurs/newfound-t-rex-relative-was-an-even-bigger-apex-predator-remarkable-skull-discovery-suggests?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=9B4C656A-B2B8-45CC-8777-64F52539F5C3&utm_source=SmartBrief

2. **Factchecked: the UK government's claims about North Sea oil and gas**

https://amp-theguardian-com.cdn.ampproject.org/c/s/amp.theguardian.com/environment/2024/jan/08/factchecked-the-uk-governments-claims-about-north-sea-oil-and-gas

3. **Megalodon tooth found on unexplored seamount 10,000 feet below the ocean's surface**

https://www.livescience.com/animals/extinct-species/megalodon-tooth-found-on-unexplored-seamount-10000-feet-below-the-oceans-surface?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=2E9AC67D-DA9A-48E6-8B0C-DC12C39E1E44&utm_source=SmartBrief

4. **Ventnor cliffs at risk of further movement after landslide**

https://www.bbc.com/news/uk-england-hampshire-67689522

5. **Tonga volcano eruption was fueled by two merging chambers that are still brimming with magma**

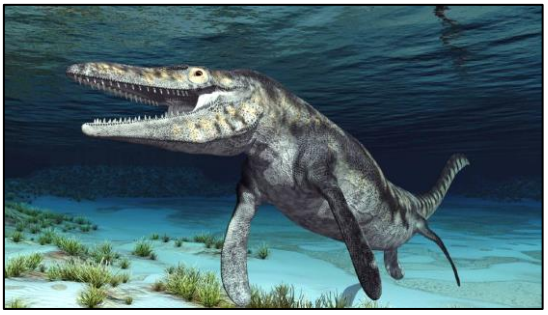
https://www.livescience.com/planet-earth/volcanos/tonga-volcano-eruption-was-fueled-by-2-merging-chambers-that-

are-still-brimming-with-magma?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=CD9A8A89-74BF-4485-8625-4498F9AAF14A&utm_source=SmartBrief

6. **Challenging assumptions: The 8.5-year rhythm of Earth's inner core**

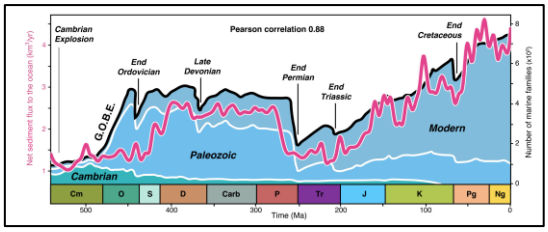
https://phys.org/news/2023-12-assumptions-year-rhythm-earth-core.html?fbclid=IwAR2l74WtOClmeGmX8sNtK-rIhephffihYFiOcYPCqGJP5u0R6pN5ZWRLQQY

7. **72 million-year-old 'blue dragon' unearthed in Japan is unlike anything we've ever seen, experts say**



https://www.livescience.com/animals/extinct-species/72-million-year-old-blue-dragon-unearthed-in-japan-is-unlike-anything-weve-ever-seen-experts-say?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=FE2ABC80-7BEB-4A1D-9CB4-7729C442C7B8&utm_source=SmartBrief

8. **New unified theory shows how past landscapes drove the evolution of Earth's rich diversity of life**



https://phys.org/news/2023-11-theory-landscapes-drove-evolution-earth.html?fbclid=IwAR0jE6ICdLRaDOws5ZD_aBO7h4e2MKjp3o2apjhihg8hBfIlikV8lqGavmM

9. **NASA finally opens OSIRIS-REx asteroid sample canister after freeing stuck lid**

https://www.space.com/nasa-osiris-rex-asteroid-sample-canister-open?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=58E4DE65-C57F-4CD3-9A5A-609994E2C5A9&utm_medium=email&utm_content=1209E23F-54DD-478E-A8E8-4FD60E14A7DF&utm_source=SmartBrief

10. **'What is that material?': Potentially hazardous asteroid Bennu stumps scientists with its odd makeup**

https://www.livescience.com/space/space-exploration/what-is-that-material-potentially-hazardous-asteroid-bennu-stumps-scientists-with-its-odd-makeup?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-

62503D85375D&utm_medium=email&utm_content=1CBE2296-2591-44DA-A8D3-5EE76F48CAD8&utm_source=SmartBrief

11. **'Stressed jellyfish' reveal dangers of seabed mining.**

https://www.bbc.co.uk/news/science-environment-67486365

12. **Cop28's winners and losers: from fossil fuel firms to future generations**

https://www.theguardian.com/environment/2023/dec/14/cop28-winners-and-losers-fossil-fuel-climate-crisis

13. **COP28's 'historic package': Writing on the wall that spells end of fossil fuel era or new opportunity for gas and LNG players?**

https://www.offshore-energy.biz/cop28s-historic-package-writing-on-the-wall-that-spells-end-of-fossil-fuel-era-or-new-opportunity-for-gas-and-lng-players/?utm_source=offshoreenergytoday&utm_medium=email&utm_campaign=newsletter_2023-12-14

14. **Mount Marapi: Eleven hikers killed as volcano erupts in Indonesia.**

https://www.bbc.co.uk/news/world-asia-67610326

15. **The sun is blinding us to thousands of potentially lethal asteroids. Can scientists spot them before it's too late?**

https://www.livescience.com/space/asteroids/the-sun-is-blinding-us-to-thousands-of-potentially-lethal-asteroids-can-scientists-spot-them-before-its-too-late?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=1D584F99-3BA9-448A-863C-53889A5A5A43&utm_source=SmartBrief

16. **Tonga's strange volcanic eruption was even more massive than we knew.**

https://www.nationalgeographic.com/science/article/tonga-volcano-largest-eruption-pacific-ocean-tallest-plume?cmpid=org=ngp::mc=crm-email::src=ngp::cmp=editorial::add=Compass_EMEA_20231025&rid=2885730A-0BBC-4A57-A6A3-E7D025CB281C

17. **Dust from the dino-killing impact ushered in years of global darkness**

https://www.livescience.com/planet-earth/dust-from-the-dino-killing-impact-ushered-in-years-of-global-darkness?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B

3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=6546D987-47C8-4D38-803D-F62BA5090110&utm_source=SmartBrief

18. **Scientists finally discover 'lost continent' thought to have vanished without a trace**

https://www.livescience.com/planet-earth/geology/scientists-finally-discover-lost-continent-thought-to-have-vanished-without-a-trace?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=6546D987-47C8-4D38-803D-F62BA5090110&utm_source=SmartBrief

19. **Zealandia, Earth's hidden continent, was torn from supercontinent Gondwana in flood of fire 100 million years ago**

https://www.livescience.com/planet-earth/geology/zealandia-earths-hidden-continent-was-torn-from-supercontinent-gondwana-in-flood-of-fire-100-million-years-ago?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=B446BFF1-A67F-4D61-A7D0-41C8A6B27E34&utm_source=SmartBrief

20. **What's inside Earth?**

https://www.livescience.com/planet-earth/geology/whats-inside-earth?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=B446BFF1-A67F-4D61-A7D0-41C8A6B27E34&utm_source=SmartBrief

21. **Fountains of diamonds that erupt from Earth's center are revealing the lost history of supercontinents**

https://www.livescience.com/planet-earth/geology/fountains-of-diamonds-that-erupt-from-earths-center-are-revealing-the-lost-history-of-supercontinents?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=81C8AD54-F7DD-457A-9B0A-686F65751988&utm_source=SmartBrief

National Geographic: Atlantic Ocean Floor 1968

Historic Wall Map Series

This striking portrait of the Atlantic Ocean seafloor was published in October 1968 as a supplemental map of the Atlantic and displays the ocean floor with breathtaking detail.

(©The Geological Society, 2021. This work is licensed under CC BY-NC-ND 4.0)

Reference:

https://www.geolsoc.org.uk/~/media/shared/documents/education%20and%20careers/Resources/Posters/Plate%20Tectonics%20Poster%20KS4%20KS5.pdf?la=en

We need your help in running the IT/Sound for our Zoom and our Maltings meetings.

Can you help?

Please contact Mike Millar (mike.millar27@btinternet.com) if you are interested.