Newsletter of

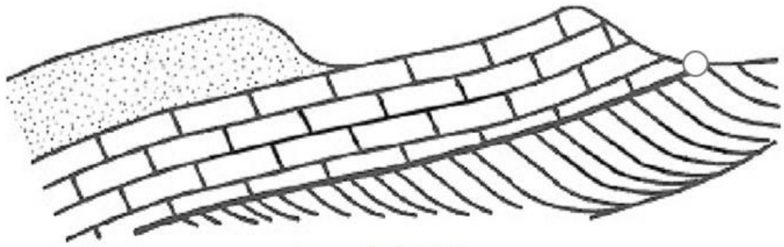
The Farnham Geological Society

Volume 29, Number 1, February 2026

Folding & faulting in the Jura Mountains, France
by
Mick Caulfield, 1987

Farnham Geological Society

Farnhamia farnhamensis



Founded 1970

A local group within the GA

Volume 29, No. 1 | **Newsletter** | **February 2026**

Issue No. 131

www.farnhamgeosoc.org.uk

Editorial

Welcome to the latest edition of the FGS Newsletter. I hope you are all well and had a great Christmas and New Year.

Our next lecture will be ***Zoom only*** on **Friday, 13 February** when we welcome The Open University's **Prof. Bob Spicer** who will be talking to us about **"Lost Landscapes of Tibet and How They Changed the World"** which sounds like it will be an excellent presentation.

This will be followed on **Friday, 13 March** with another ***Zoom only*** talk to be given by **Dr. Doreen van Seenus** who will be bringing us **"The Toba – Super Eruption"** … should be a good one!

On **Friday, 10 April** we will be holding our **AGM** at **The Methodist Hall** on South Street. Following the AGM, FGS Member **Nick Stronach** will be talking to us about "**Pinnacles of Western Australia – A Geological Enigma"**.

The FGS Committee would like to encourage as many members as possible to come along to **The Methodist Hall** to support the excellent speakers assembled by **Janet Catchpole, who take time out of their busy schedules** to travel to Farnham on a Friday evening **to present to the Society.**

I would also encourage members to check out our **field trip section** both in the Newsletter and on our FGS website. **Tessa Seward**, our **Field Trip Secretary**, is working hard to organise interesting and accessible trips and I would urge you to join those that interest you, as well as **pass on any suggested trips** that you would like FGS to organise.

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

If you have visited a site of geological interest, listened to an interesting Zoom talk, podcast, webinar or TV programme, and would like to share with your fellow Members, then please feel free to get in touch with the **Newsletter Editor**, **Mick Caulfield** (newsletters@farnhamgeosoc.org.uk).

Contents

Obituary

Shirley Stephens RIP, died on the 4 November 2025 at the age of 93. She was secretary of the FGS for many years, until around 2011 and a member from the late 1970's. She stopped attending the society some 11 years ago, after the death of her husband David. Our sincere condolences to all her family and friends.

Front Cover

Photo courtesy of Mick Caulfield, FGS Chair and Newsletter Editor.

This month's **Front Cover** shows a road cut in the **Jura Mountains** taken while on a Birkbeck MSc Field Trip in 1987.

Farnham Geological Society

Committee 2026

Chair	**Mick C**
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Membership Secretary	**Sally P**
Field Trip Secretary	**Tessa S**
Newsletter Editor	**Mick C**
Web Manager	**Bob R**
Advertising	**Peter C**
IT/Sound	**VACANT** (Mike M)
Without portfolio	**Peter L**
Ad Hoc Member	**Liz A**

Meeting Programme 2026

Please note The Methodist Hall and Zoom only meeting times:
7.30 pm for 8.00 pm start.

Lost Landscapes of Tibet and How They Changed the World
Fri, 13 February

Prof Bob Spicer
Open University

https://profiles.open.ac.uk/robert-andrew-spicer

The Toba – Super Eruption
Dr. Doreen van Seenus Fri, 13 March

AGM + Pinnacles of Western Australia – A Geological Enigma
Nick Stronach,
FGS Member Fri, 10 April

Geology Of Oman
Andy Wood,
u3a Fri, 8 May

Field Trip Programme 2026

(book via the FGS website)

DAY TRIPS

- **Silcretes in Cobham (Cobham area, Kent)** Wed, 29 April
  Leader: Geoff Downer
- **Ice Age & Jurassic around Buckinghamshire (Coombs Quarry and Buckingham Sand Pit)** Tue, 12 May
  Leader: Dr. Jill Eyres
- **Building Stones walk around Chichester**
  Leader: David Bone Sun, 26 July
- **Brookwood Cemetery**
  Leader: Diana Smith *tba*
- **Building Stones of Guildford**
  Leaders: Maurice Curry & Mick Caulfield *tba*

RESIDENTIAL TRIPS

- **Gloucester Field Trip (Forest of Dean, Wye Valley, Severn Vale)** *Early-mid June*

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

Geologists' Association
Lecture Programme 2026

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

Tales from a Geological Curator
Dr. Emma Nicholls, Fri, 6 February
Oxford University Museum of Natural History

tba Fri, 6 March

tba Fri, 3 April

Reading Geological Society
Lecture Programme 2026

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

Snowballs in the desert – the glacial history of Oman
Dr. Ross Garden, Mon, 2 February
RGS

Presidential Address
Dr. Stuart Black Mon, 2 March
University of Reading

The (Harsh) Life and Times of Maastrichtian Arctic Dinosaurs
Prof. Bob Spicer, Mon, 13 April
Open University

RGS Spring Day Trips
(book via the RGS website https://readinggeology.org.uk/fieldtrips.php)

- **The Albert Memorial in Kensington**
  Sat, 21 March
  Leader: John Cosgrove, Imperial College
- **Dorking Downs periglacial features**
  Sun, 19 April
  Leader: Mark Eller, Mole Valley GS

Mole Valley Geological Society
Lecture Programme 2025

http://mvgs.org.uk

Looking For Life On Mars With The Rosalind Franklin Rover
Prof. A Coates, Thu, 12 February
Mullard Space Laboratory, University College London

Discussion Meeting: The Current State Of The Oil Industry, The North Sea, Ccs, Etc
Dr. M Brown, Mon, 12 March
Former Vice-President Exploration British Gas plc., Past President of the Geological Society of London

Horsham Geological Field Club
Lecture Programme 2026

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

Engineering geology and the geoscience time machine
David Shilston, *Wed, 11 February*
Consultant Engineering Geologist at Atkins

High Speed Rail, Italy: Florence Station
Nick O'Riordan, Wed, 11 March
Geotechnical Group at Arup

Dinosaurs from space
David Martill, Wed, 15 April
Professor of Palaeobiology, University of Portsmouth

West Sussex Geological Society
Lecture Programme 2026

https://www.wsgs.org.uk/

Challenging ground & seismicity for high-speed rail stations in Italy and California
Nick O'Riordan, Fri, 20 March
Geotechnical Group at Arup

ChaSE-ing the chalk: the Chalk Sea Ecosystems Project
James Witt, NHM Fri, 17 April

Lecture Summary

11 July 2025

On Friday, 11 July 2025, 29+ attendees at The Methodist Hall and via Zoom (including members of the Reading Geological Society) welcomed Nick Stronach, FGS Member, in presenting our lecture.

What Makes a Good Reservoir for Carbon Sequestration?

By Dr. Nick Stronach

The following is an overview of the talk presented by Nick Stronach. It is based in part on a webinar presented in 2021 whilst the author was employed at GaffneyCline, but the views here are the author's own.

Introduction

Carbon Capture and Storage (CCS) is now viewed as a major part of strategy by the UK Government (Department for Energy Security and Net Zero) to take the country through the Energy Transition to Net Zero carbon emissions and has figured in announcements for support of various schemes, including disposal of CO_2 from industrial centres in the northeast and northwest of England, and central Scotland. A new scheme was announced earlier in the year to recover CO_2 from cement works in the Peak District, and its disposal in depleted gas fields of the Irish Sea (Ref. 1). CCS is expected to enable continued use of hydrocarbon resources through the Energy Transition and provide longer term sinks for CO_2 generated as part of industrial processes, including power generation, chemicals, cement manufacture and fertiliser.

As its name suggests, CCS involves two separate processes – the **capture** of emissions at or near the point of generation, and the **storage** in geologically secure settings; this note focusses the latter and attempts a geological perspective on the underlying processes that control the long-term storage of CO_2, and also some of the important risk factors that may influence selection of sites and their operation.

Modes of carbon storage

There are four types of CCS scheme that have been implemented or proposed, illustrated in Fig. 1:

1. It has formed part of **Enhanced Oil Recovery (EOR)** via flooding of reservoirs with CO_2 to improve flow of oil in some oil wells. Although this involves injection of CO_2 into the subsurface, arguably it involves more cycling of the CO_2 through the reservoir, rather than permanent storage, and its motivation is improving recovery factor of hydrocarbons, rather than long term disposal of CO_2. It is not considered further here.

2. Injection of CO_2 into **depleted gas or, sometimes, oil fields** after the hydrocarbons have been extracted. This provides forward employment of subsurface locations that would otherwise just be abandoned. Importantly the oil or gas production activities will have gathered and analysed datasets that mean the geology of these locations is well understood. Success relies on the presence of traps containing porous rocks, be they sandstones or carbonates (limestones or dolomites), which can contain and hold CO_2.

3. Injection into porous rocks that are **not** forming part of existing fields, but which extend as other regional reservoir units in the subsurface containing water, not hydrocarbons. These are commonly termed **saline aquifers,** as distinguished from aquifers containing potable water, which would not form suitable sites for CCS. Again, these rely on the presence of subsurface porosity, along with appropriate seals, but the properties and distribution of these might not be so well-described as those in depleted oil or gas fields.

4. Injection into rock masses with which the CO_2 is expected to react, or to be absorbed, directly with reaction with unstable minerals, so called "**mineral carbonation**". Examples of such rocks might be basalts, ultramafics or coals. Although this is an important process and is currently under operation in Iceland, for example by CARBFIX (Ref 2), it will not be considered further here.

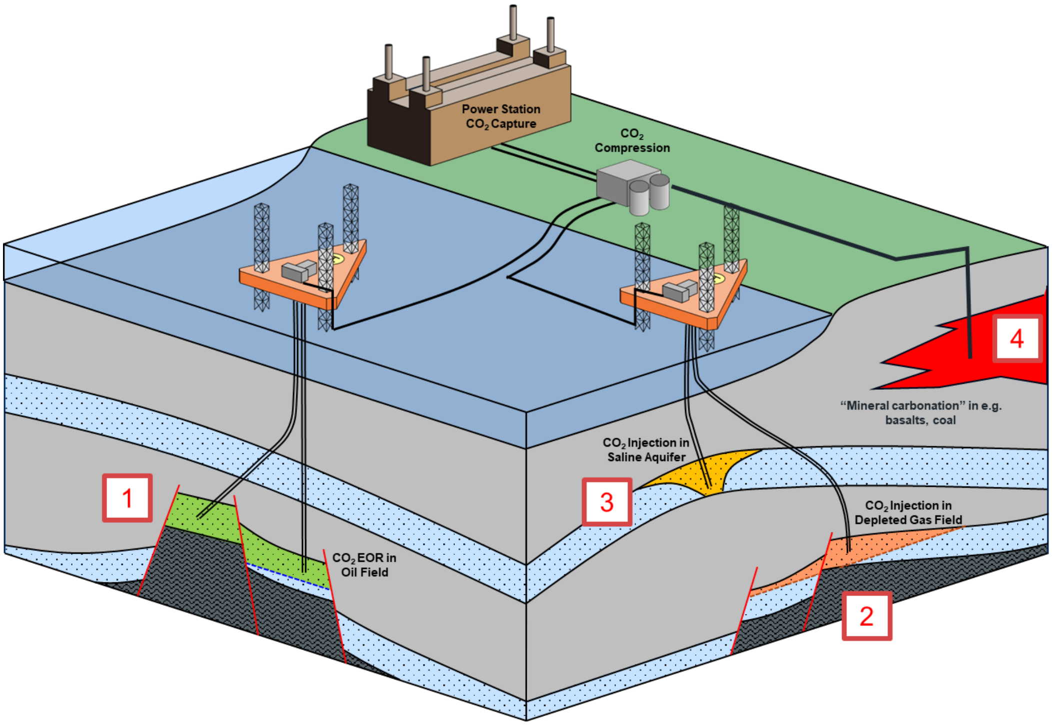

Figure 1: Modes of CO2 storage. Diagram prepared by GaffneyCline, with additional annotation.

State of activity

CO_2 storage is not new and has been operated in the various forms described above for over 50 years.

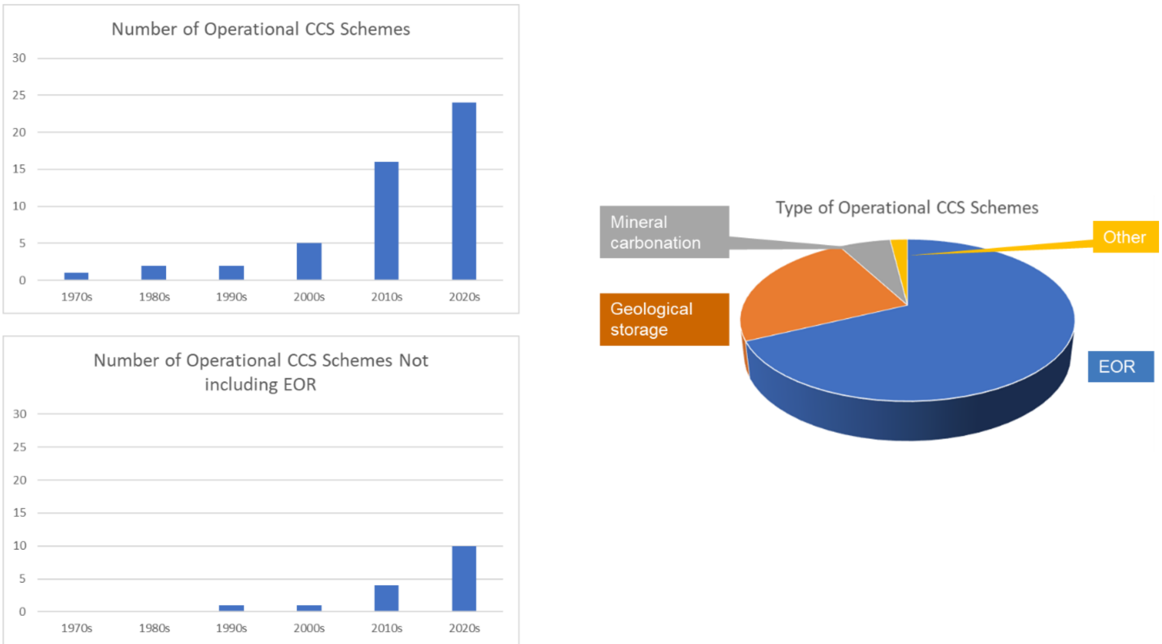

Figure 2: Growth of CCS schemes. Diagram prepared from data in Global CCS Institute (2024) (Ref 3.)

Fig. 2 shows the steady growth of CCS schemes since the 1970s, but most of these have been motivated by **EOR**. The first true CO_2 geological storage scheme (i.e. in **depleted fields** or **saline aquifers**) was initiated in Norway in 1996. There has been modest growth since then, but data (Ref. 3.) suggests a potential explosion of many hundreds of sites over the next two decades. Pilot scale **mineral carbonation** forms a small, but significant component.

Processes

To understand the geological processes behind CCS, it is important to consider the mode of occurrence – the physical phase – of CO_2 in the subsurface. Fig. 3 is a phase diagram showing the state of the substance controlled by pressure and temperature conditions. The key factor is the presence of the "critical point" at 31°C and 72.9 bar. At pressures and temperatures above this point, CO_2 is "supercritical" i.e. it has the viscosity of a gas, but the density of a liquid. This renders the process of injection into the subsurface very efficient. Under "typical" geothermal and pressure conditions, this point corresponds to a depth of approximately 760m, providing an upper depth ceiling to most viable CO_2 injection projects.

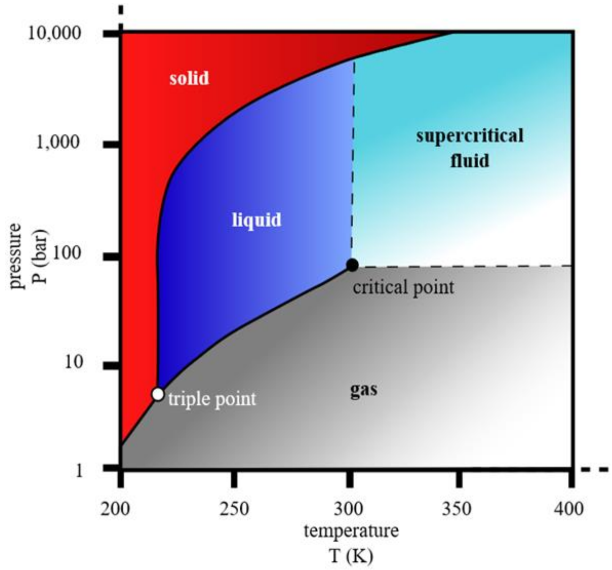

Figure 3. Phase diagram for CO2. Open access data Ref. 4.

CO_2 is injected from one or more wells into porous and permeable reservoir rocks, bounded by seals lacking any capacity for fluid flow. Whether we are dealing with injection into the vicinity of depleted fields or into open aquifers, there are common processes that control the storage of CO_2, illustrated in Fig. 4. Note the depth and thickness scales indicated on Fig. 4. In this case the reservoir is depicted as a simple sandstone unit sealed by overlying mudstones. Other reservoirs (e.g. carbonates) and seals (e.g. evaporites, tight carbonates) and other trapping configurations are of course possible.

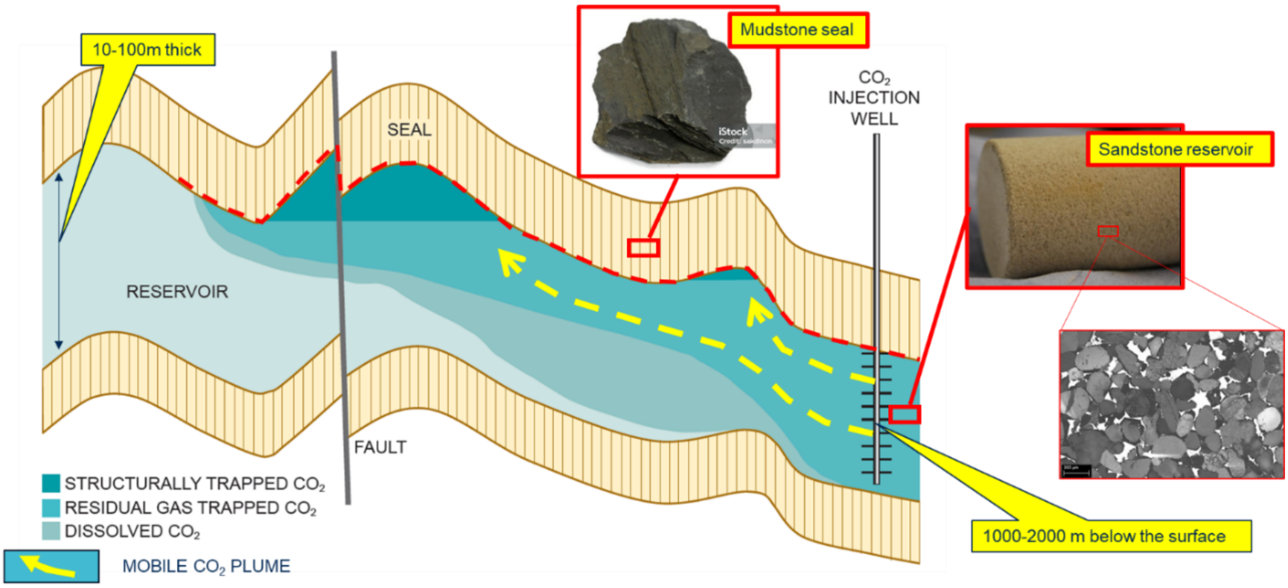

Figure 4. Habit of CO_2 in the subsurface. Base diagram from National Petroleum Council (2021), (Ref. 5). (Credit: Open Access, with additional annotation)

- Close to the injection well, the CO_2 exists as a mobile phase, moving through the pores containing water in response to the balance of buoyant and capillary forces.
- As it flows upwards and laterally, it may be trapped below seals by anticlinal folds or fault blocks where further vertical or lateral migration is retarded or impossible.
- Importantly the CO_2 will leave behind as residual saturations in reservoirs through which it has passed.
- In aqueous solution.

The residence of CO_2 in these forms is governed by a number of distinct processes, operating on widely varying timescales, which can be understood and modelled.

Ultimately, the reservoir system into which the CO_2 is injected must be capable of sealing, most importantly preventing leakage to surface, or into shallow potable aquifers. **Trapping** at the ultimate primary seal is controlled by the same processes that determine hydrocarbon trapping, but in the aquifer situation, rather than in an existing depleted oil or gas field, these will not have been proven effective and also must pertain over large areas. Local closures in the top aquifer surface, which may or may not be pre-existing hydrocarbon accumulations, may form CO_2 accumulation points, where sealing relationships are critical.

CO_2 exists as a **residual saturation** within the pore space, left by the passage of the migrating CO_2 plume, and as small volumes of fully saturated reservoir where local conditions of pore geometry and capillary forces result in the inability of the fluid to move. Residual saturation is hard to predict, as it depends on the detail of the reservoir rock and the migration pathway. At one extreme, if fluid is migrating in a highly porous, permeable and homogeneous unit, there is direct vertical conduit to the top of the unit, then this does not promote exposure of a large pore volume to migration pathways, and development of residual saturation. Heterogeneity, without the presence of actual barriers within the reservoir is favourable, as this leads to a dispersal of the injected CO_2 plume, and its being locked in relatively “tight” areas, as a residual phase.

Dispersal of the fluid through as wide a volume as possible also reduces the chance of local concentrations developing at the top seal of the reservoir. It also increases the contact of the CO_2 with the connate aqueous phase and **dissolution**. It is estimated that some 10-25% of the CO_2 injected is dissolved on contact with water, which then increases slowly because of the convection of dense, CO_2-saturated brine, and diffusion of CO_2 into the aquifer.

In general terms the aim of any storage scheme is to steward the CO_2 from injection, through the more risk-prone stages, to those where sequestration over many years can be safely relied upon. This is essentially the transition from mobile and trapped CO_2 to dispersed residual saturation in the reservoir and dissolved CO_2. Whilst the CO_2 is still mobile, it is important in this phase of the project to have adequate monitoring (geological, geophysical or geochemical) to alert if any potential leakage pathways may be active.

Although **mineral reactivity** as a large-scale storage mechanism is not considered here, it is also and especially relevant to the injection of CO_2 and the processes immediately around the injection well bore. Here it is encountering a very small interface between well and reservoir and changes here are critical. Chemical equilibria are complex and involve the solution of silicates, aluminosilicates and carbonates, for example:

- ***$CO_2 + H_2O \leftrightarrow H^+ + CO_3^{2-}$*: *Generation of acidic solution.***
- ***$CaAl_2Si_2O_8 + 8H^+ \leftrightarrow Ca^{2+} + 2Al^{3+} + 2H_4SiO_4$*: *Dissolution of reactive silicate minerals to create metal ions and aqueous silica.***
- ***$CaCO_3 + H^+ \leftrightarrow Ca^{2+} + HCO_3^-$*: *Carbonate dissolution.***

Reaction rates are generally slow but may, for example, involve the solution of feldspars over periods on the order of 10's-100's of years (see illustration in Fig. 5). Because of the buffering via a number of related equilibria, the net result is expected to be the occlusion of pore and fracture space by precipitated carbonate and amorphous silica. This is likely to be most important in and around the injection wellbore area, where changes in reservoir mineralogy and property affect the rates at which CO_2 can be disposed.

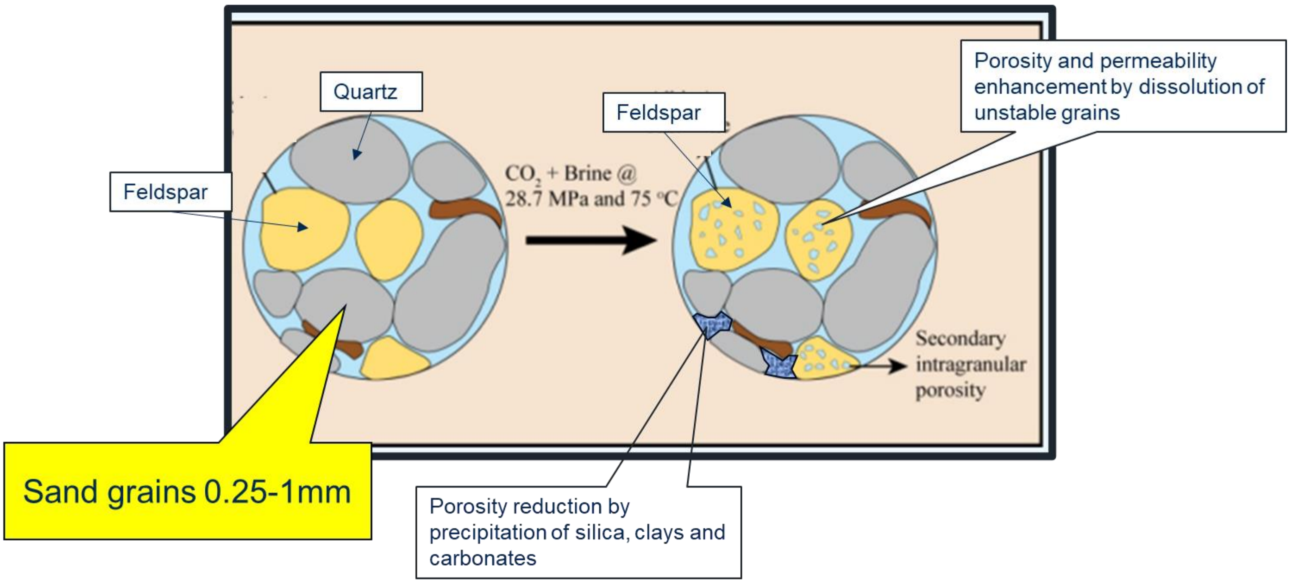

Figure 5. Sketch showing mineral reactions in feldspathic sandstone. Base diagram from Bello et al., (2024), (Ref. 6). (Credit: Open access article, with additional annotation)

What makes a good reservoir?

The understanding of the process described above allows us to determine the best geological situations for CCS.

Fundamentally, the following criteria are important:

- **Injectivity:** Can the CO_2 be reliably injected at the rates required without any future changes to reservoir around the wellbore?
- **Storage:** Via the combination of mechanisms described above, can the short term and long term storage requirements be met?
- **Containment:** Is there a reliable sealing mechanism for the proposed CO_2 reservoir, with no potential weak points?

All of the above criteria have been combined into a summary table that sets the key screening criteria (Table 1), drawing from various published sources. These address the key criteria for selection of storage reservoir, namely **Injectivity**, **CO_2 Storage Capacity,** and **Seal.**

Table 1: Key geological factors affecting CO_2 storage (in part after Ref. 7)

Aspect	Factor	Positive	Rationale / Comment
Injectivity	Depth (Minimum)	>800m	Requirement for supercritical fluid.
	Depth (Maximum)	<2500m	Likely declines in permeability and higher injection pressure required. Also, operational costs increase with depth.
	Permeability	>300mD	Previous experience suggests higher permeabilities required than for equivalent oil or gas reservoir.
	Lithology	Sandstone	Ideally clean sandstone without complexities of mineral reactions, although more variable compositions and carbonates not ruled out.
Storage Capacity	Porosity	>20%	Previous experience suggests higher porosities required than for equivalent oil or gas reservoir.
	Trap geometry	Well defined	Applies both to trap of depleted oil and gas fields and to trapping geometries within saline aquifer unit.
	Heterogeneity	Moderate heterogeneity but not with major barriers and baffles	Promotes higher residual CO_2 saturation – important for long-term secure storage, especially if no large traps are present. However major baffles may close the system and create rapid pressure increase on injection.
	Reservoir thickness	>50m	Creates large potential storage volume.
Seal Integrity	Seal thickness	>100m	Thicker seal more likely to be regionally continuous and with better chance of sealing at faults.
	Depth of seal	>1000m	Below depth of "critical point".
	Number of seals	>1	Secondary seals provide "back-up" in case of leakage.
	Lithology	Mudstone with organic-rich units and/or carbonates	Good seal properties with addition of adsorption if locally breached.
	Faulting	Absent	Faults may cause leakage along fault plane, or by juxtaposition of permeable "thief zones" against reservoir.
	Wells	Sparse	Old wells with uncertain quality of cementation at abandonment may represent critical leakage points in seal.

Details of existing schemes

Table 2 below summarises the main operational schemes, along with two of the first to be implemented in the UK, on which design and performance data are available. All are understood to be schemes that are injecting CO_2 into saline aquifers, with exception of Acorn (*).

Table 2: Selected major CCS schemes (from various published data)

Project	Country	Start	Injection rate	Total	Unit	Age	Lithology	Depth	No of wells
			MT/a	MT				m	
Sleipner	Norway (Offshore)	1996	0.85	19	Utsira	Miocene-Pliocene	Sandstone	1000	1
Snøhvit	Norway (Offshore)	2008	0.7	6.5	Tubåen	Lower Jurassic	Sandstone	2600	1
					Stø	Lower Jurassic	Sandstone	2320-2400	1
Northern Lights	Norway (Offshore)	2024	1.5	-	Johansen	Lower Jurassic	Sandstone	2700	1
Quest	Canada (Onshore)	2015	1.2	5.7	Basal Cambrian	Cambrian	Sandstone	1900	5
Illinois	USA (Onshore)	2017	1	-	Mount Simon	Upper Cambrian	Sandstone	2150	1
Gorgon	Australia (Offshore)	2019	4	11	Depuy	Upper Jurassic	Sandstone	2000	9
In Salah	Algeria	2004-2011	1	3.8	Unnamed	Carboniferous	Sandstone	1850	3
Endurance	UK (Offshore)	2028	4	Up to 1000	Bunter	Triassic	Sandstone	1000	5
Acorn*	UK (Offshore)	2030	0.3-3	?150	Captain	Lower Cretaceous	Sandstone	2500	4

(*) will initially exploit the depleted Goldeneye Field.

It is notable that all the schemes opt for injection into sandstone reservoirs and avoid the complications of carbonate lithologies referred to above.

It is beyond the scope of this short article to cover all of these, but some notes and comparisons are worth making.

- The oldest scheme operational is that at **Sleipner**, in the central Norwegian North Sea. Here CO_2 is extracted from gas produced from a deep Jurassic reservoir and is injected into a Mio-Pliocene sandstone. This unit represents an ideal open system, with high levels of storage efficiency achieved because the injection reservoir is in the shallow part of the basin and is extensive, highly porous and permeable. The only risk factor may result from its shallow depth and the proximity to the critical phase change. If parts of the system contain CO_2 gas rather than supercritical fluid, then this might result in risks of seals being breached, something that has required close monitoring.
- In contrast, the **Snøhvit** scheme in the Norwegian Arctic attempts injection into a deep reservoir closely adjacent to the producing reservoir, in the Jurassic. This initially proved to be a closed and restricted reservoir system, with fault-bounded compartments and limited reservoirs. This

became critical in the early parts of the projects, where reservoir pressures climbed, rendering injection very difficult. A new injection well had to target a more extensive, slightly shallower reservoir in a larger fault block. This overcame the difficulties and injection continues to this day.

- The two planned UK schemes offer two distinct geological strategies. **Endurance** targets the Bunter Sandstone in the Southern North Sea in a closed structure relating to an underlying salt swell. This is an analogous situation to nearby gas fields, but one which never acquired a hydrocarbon charge, so there is ready-made structure, very likely to be competently sealed, awaiting injection and filling by CO_2. The rocks are very similar to those illustrated below (Fig. 6), Permo-Trias aeolian and fluvial sandstones. Their uniformity in the expected trap will allow very efficient filling and usage of the storage space. This site thus uses simple trapping in a uniform reservoir sand as the means of achieving CO_2 storage.

- In contrast, although the **Acorn scheme** is to initially target a depleted oil and gas field, the long-term potential relies on injection into a more extensive aquifer. In this case there is no trap and the storage of CO_2 relies on other processes. In this case the rock unit comprises alternating and variable sandstones and mudstones deposited as turbidites in a deep-water setting. Although these particular units do not outcrop, they are likely similar to those illustrated (Fig. 7).

  The vertical and lateral heterogeneity promotes variable and complex flow paths of the injected CO_2 and its storage as residual saturations in the tortuous reservoir pathways. Thus, the geology to be exploited here is distinctly different to that envisaged at Endurance, but both potentially lead to successful low-risk storage sites.

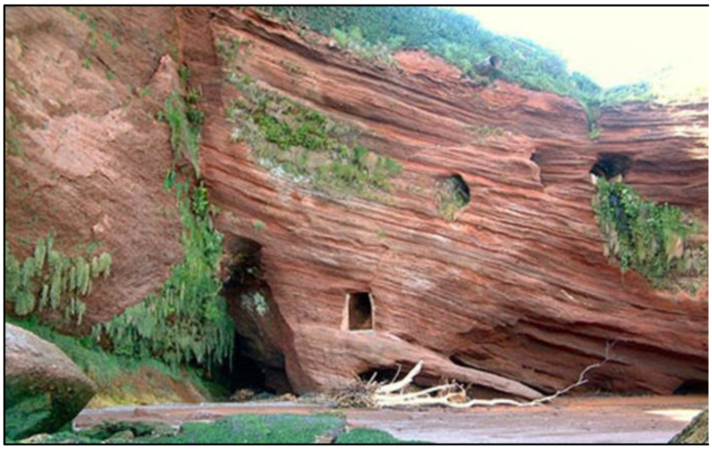

Figure 6: Permo-Triassic sandstones, possible analogues to Endurance project (Ref 8).

Figure 7: Proximal turbidite sandstones, possibly analogous to the Acorn reservoir (Ref 9).

Conclusions

So, to answer the basic question posed; **hat makes a good sequestration reservoir for CO_2?**

- Supercritical depths, but not excessive.
- Sandstone, ideally quartzose, especially at the injection points into the reservoir.
- Multiple primary or secondary cap rock seals.
- Porous and permeable, but with some heterogeneity to promote dispersal of the CO_2 plume, and generation of residual saturations of CO_2.

- Presence of carbonates or organic-rich layers in the caprock.
- No, or stable fault systems affecting seal capacity.

Brief review of the existing or planned schemes shows that none is in an ideal situation, and that each has some potentially significant risk factors. This underlines the need for accumulation of robust datasets, complete characterisation and modelling of the physico-chemical behaviour of the CO_2 fluid in both reservoir and caprock, and ongoing monitoring schemes that keep track of future performance.

The UK is well endowed with geological sites which would lend themselves to CO_2 storage. Achievement of the potential depends on comprehensive geological study and assessment and mitigation of risk but also working in a political and economic space that allows the necessary investments to be made with confidence.

References

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8. Tunnel in cliffs at Horse Cove © Ray Girvan (source Geograph.org.uk). Creative Commons Attribution-ShareAlike 2.0 license. https://www.geolsoc.org.uk/science-and-policy/100-great-geosites/outcrops/permian-red-sandstone-dawlish
9. https://commons.wikimedia.org/wiki/File:Silurian_Proximal_Turbidites_New_Quay_Wales_2 2024913.jpg

NJS December 2025

A very interesting & informative talk from Nick Stronach

Nick Stronach is a retired petroleum geologist who spent his career working on oil and gas exploration and development for operating and contracting companies, most recently with GaffneyCline. Projects were in a number of countries around the world, ranging from regional petroleum exploration to analysis of individual wells and fields.

His original PhD was obtained in Calgary, Canada, working on the sedimentology and palaeontology of Jurassic rocks in the Rocky Mountains.

In retirement, he volunteers in "citizen science" mapping of landscape and archaeology, and also with the Geological Society in London. He is also pleased to be a member of the FGS, where he is reigniting his interest in aspects of geology beyond those relevant to petroleum.

Lecture Summary

Friday, 10 October 2025

On Friday, 10 October, 31 attendees at The Methodist Hall and via Zoom welcomed Alison Ure in presenting our lecture.

Discovery of Kas Bay Meteorite Impact Crater off the coast of Turkey

By Alison Ure, Citizen Scientist

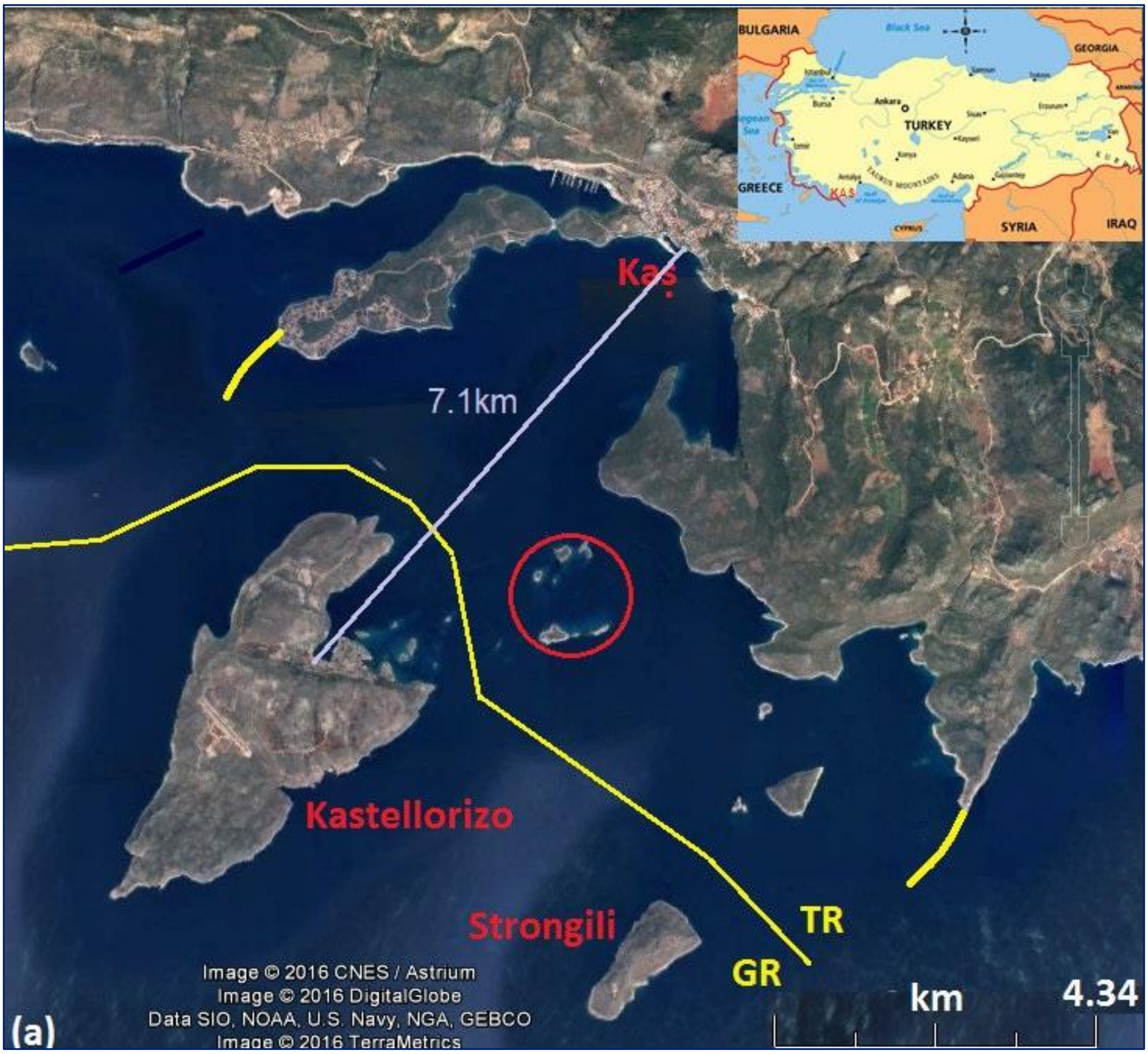

Figure 1: Google map image of Kaş Bay 2016, indicating the initial suggested crater rim, yellow curved lines. The unbroken yellow line demarcates the border between Greece and Turkey. Red circle shows the islands marking the central uplift.

My story starts in 2004 when I bought a property in Southwest Turkey in a town called Kaş (Fig. 1). I was a keen diver and could often be found on the dive boat in the popular dive site of Five Islands, (Fig. 2). This was a group of islands that formed a circle roughly a kilometre in diameter and inside the islands it had a dish shaped profile down to 20 metres in the centre but was only 5 or 6 metres around the edge (Fig. 3). This was ideal for beginner divers but if you went outside the islands there was a steep drop to about 80 metres, good for advanced divers. This was indeed an underwater inverted cone, and I assumed it was an extinct volcano.

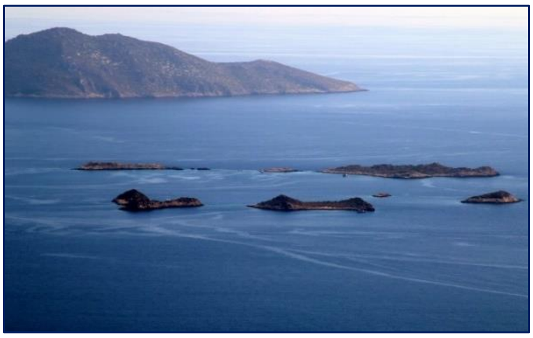

Figure 2: Five Islands dive site.

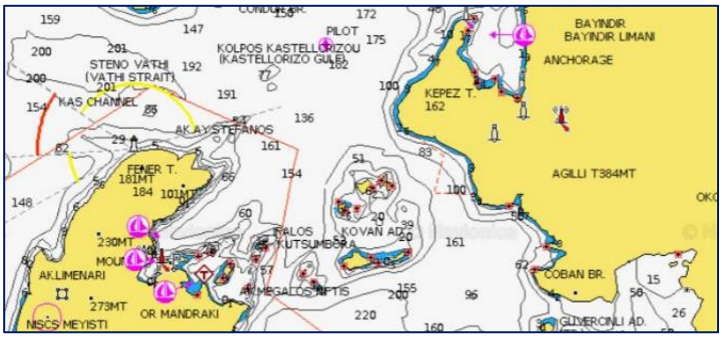

Figure 3: Bathymetric map of Five Islands dive site.

In 2009 I began my degree in Earth and Environmental Science with the Open University (OU) and soon joined the Open University Geological Society, Southeast Branch. I volunteered as events organiser and decided to run a trip to Turkey in 2012. I began doing recce's in 2011 which included finding a geological map of the area. I discovered that where Kaş was located on the Teke peninsula, the southern point of the Bey Daglari Formation (Fig. 4) turned out to be Cretaceous and Miocene limestone (Fig. 5).

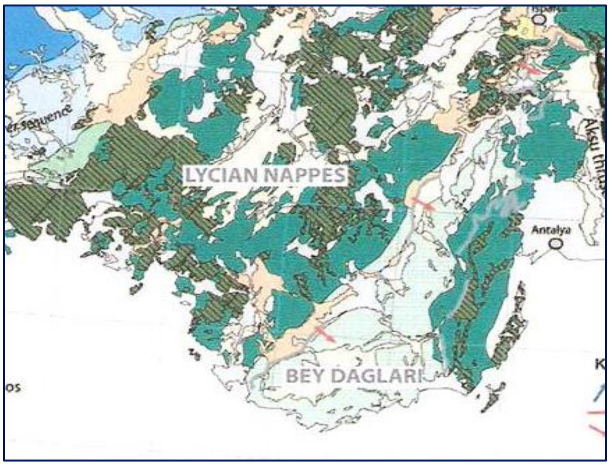

Figure 4: Geological map of the Teke Peninsula.

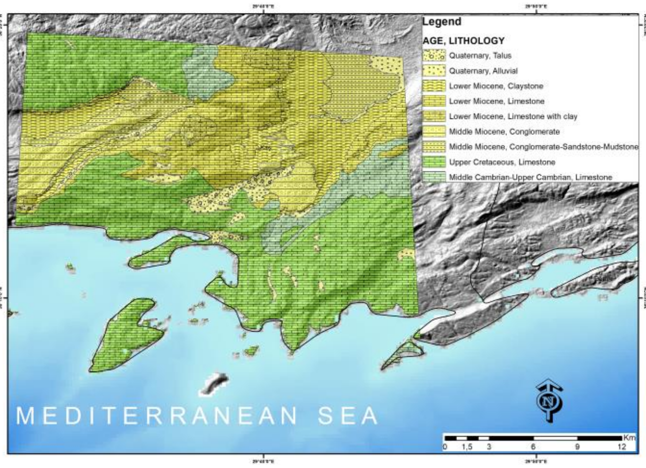

Figure 5: Geological map of the project area.

Five Islands could therefore not be an extinct volcano as this was clearly the wrong type of rock. I asked myself what other natural geological processes produce round shapes; most geology is in straight lines. A google map view of Kaş showed the area to the east of the bay was concentric in contrast to further out where the general geomorphology was linear in a SW – NE direction (Fig. 6).

At the time the second-year module I was doing, was titled Near Earth Objects. This included meteorites and the evidence they left on the earth. Whilst doing this module I felt that I had seen some of what was being described. Could Kaş Bay be a meteorite impact site? It seemed a rather crazy idea. However, meteorite craters over 1.5 kilometres in diameter, known as a complex crater, have a central peak which is an inverted cone. Under 1.5 kilometres the crater is a simple crater which is basically just a bowl-shaped hole in the ground (Fig. 7). The best-known example of the latter is the Barringer Crater in Arizona. The distance across Kaş Bay to the Greek island of Kastellorizo on the far side was 7.5km (Fig. 1), so could this be a complex crater?

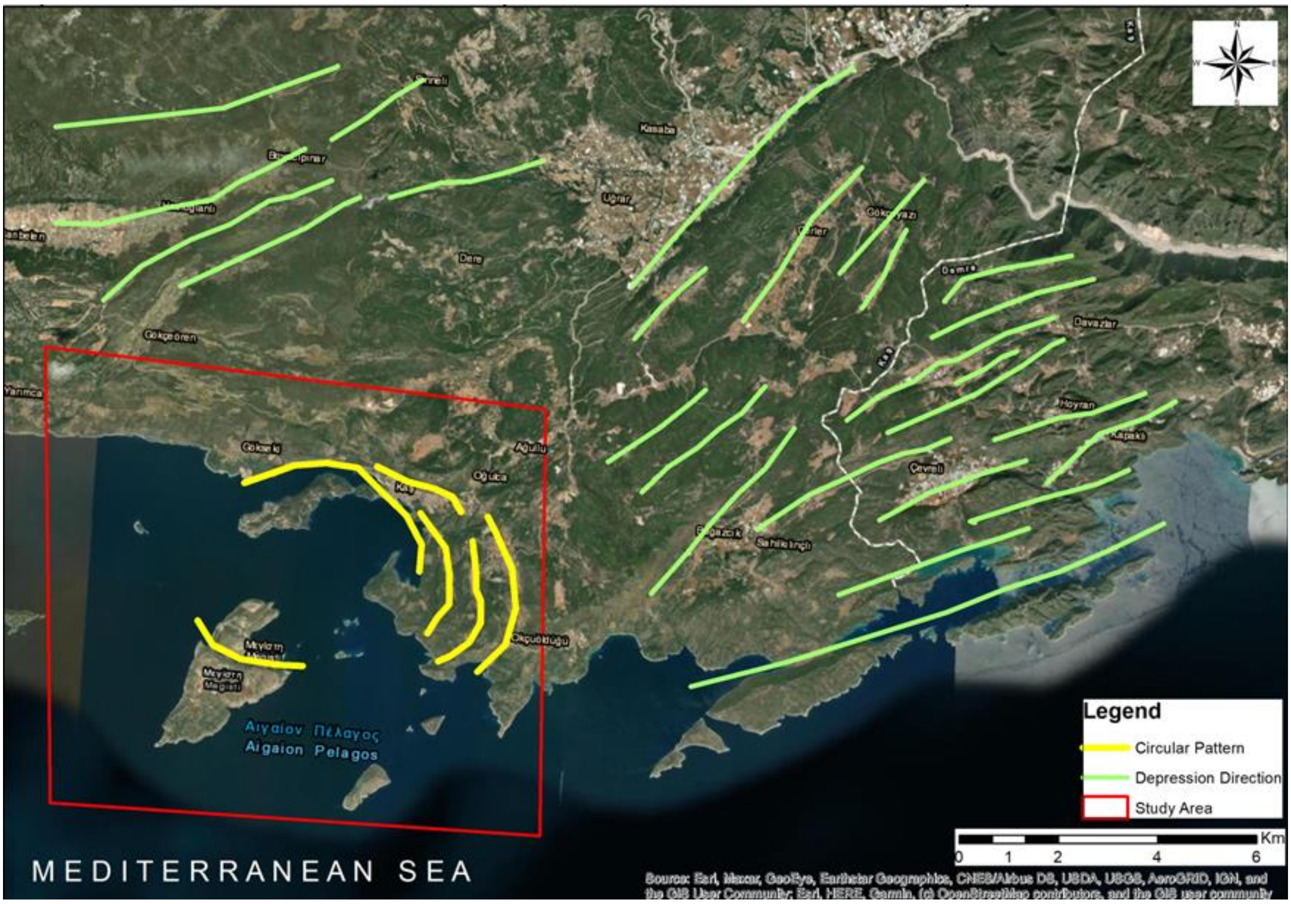

Figure 6: Concentric geomorphology around the project site.

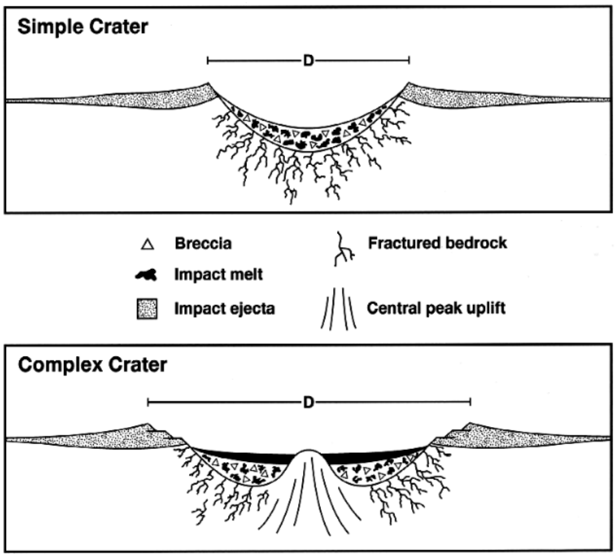

Figure 7: Simple and Complex crater.

As it happened, I had met the author of the module on a field study during the summer, Professor Simon Kelly, so I emailed him explaining my question, and asked how would I be able to prove if it was a meteorite impact structure? Simon emailed back and said I would need to get thin sections made from samples. I thanked him and wondered how I would manage to do this.

In 2012 we ran the trip, but it was slightly disappointing as the English-speaking Turkish guide pulled out at the last minute and was substituted for a very nice and knowledgeable guide who didn't speak any English! Serdar was determined for us to learn - he drew excellent diagrams, and luckily chemical symbols are universal. The trip was a success, though still left unanswered questions, so I decided to run it again in 2014 using English leaders to make life easier. A colleague suggested I contact Professor David Bridgland which I did, and he said yes, he would lead it if he could do so with his colleague Dr. Rob Westaway. David and Rob were both based in Durham, so I went to meet them at the University in 2013 with an ulterior motive. I wanted my samples made into thin sections. I explained my crazy idea, neither were phased, and Rob agreed to get the thin sections made. This he duly did, and I sent them to Simon, he came back and said they were very nice fossiliferous limestone!

I was disappointed that I hadn't proved my impact crater theory in one blow but soon realised they were just the wrong samples. We ran the trip in 2014 successfully and Rob and Dave agreed to lead another trip in 2016. They decided also to do some field work the week before that trip on an inland valley where there were some interesting river terraces. Between 2014 and 2016 I continued my research in Turkey and brought back more samples which Rob got made into thin sections. I also had some samples analysed through x-ray fluorescence (XRF) in the Durham University laboratory though I wasn't really sure what I was looking for. I graduated with a 2.1 Honours degree in 2015 and went to Durham that October to meet Rob and Dave to plan for the 2016 trip. I felt I'd gone as far as I could with my crazy impact idea. Rob introduced me to his PhD student, Brigitta, who was doing something related to evidence from impacts and discussed possibly taking the impact project on. I had also noticed there was a postgraduate bursary available from the Open University, the Ian Gass Bursary; Ian had founded the earth science sector of the Open University. I downloaded an entry form which might have been written in Chinese because I couldn't understand a word! I showed it to Rob who did understand it, and he helped me fill it in. I sent it off thinking that they would laugh me out of the room. A couple of months later I heard from Brigitta who had decided to change tack with her PhD so would not be taking my project on, and a week later, I heard from the bursary committee. They had awarded me the bursary! Now I had to be a real scientist. This meant proper research and field work with a write up at the end as well as budgeting the £1000 they had awarded me.

Rob, Dave and I went out to Turkey in the Spring of 2016 a week before the trip, and having never done much field work during my degree I learned from the best during that time. I was chief cook and bottle washer, driver, stone counter, picnic maker, etc. I learned how to use a GPS, take dips and strikes, keep accurate notes, and not be afraid of writing down ideas or changing one’s mind rather than knowing the end result and trying to prove it. What was important was the evidence and what that pointed to. On my return from Turkey, I decided to go to Germany and visit the Steinham and Reis craters as I felt actually seeing a real impact crater might help me know what I was actually looking for. Up until now, the only evidence that I knew would prove an impact crater or that an impact had occurred, was to do with silica. This would be in the form of shocked quartz with planar deformations (PDF's) in the quartz (Fig. 8) diaplectic glass, or polymorphs of quartz in the form of stishovite or coesite. This information wasn't helpful to me as my project area was carbonate. I asked the curator of the Reis Crater museum what I should look for in the absence of silica, and he said I might be able to find shatter cones (Fig. 9), which had been discovered at the Steinham crater, which was carbonate, and these were generally found around the central peak. One problem, most of the area around the central peak of the Kaş Bay crater was underwater, and limestone dissolves in water, so the chances of me finding any shatter cones were very slim.

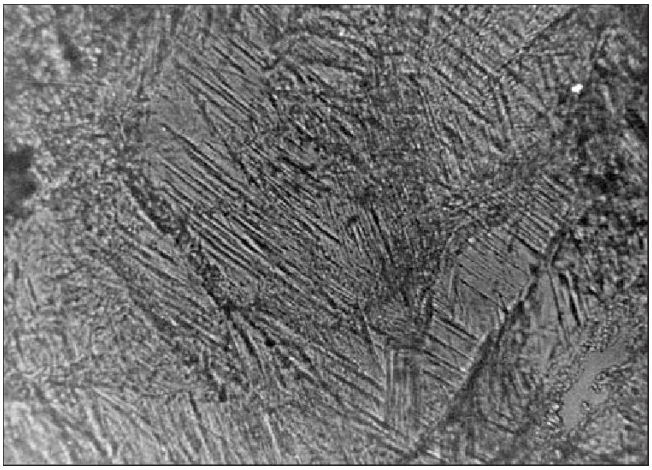

Figure 8: Planar Deformotions (PDF’s) in quartz.

Figure 9: Shatter cone from the Steinham crater.

I emailed a few recommended people in different parts of the world asking for their advice but got no reply; I was banging my head against a brick wall. But I had the bursary, and I had to produce something for the committee, so I headed back to Turkey for three weeks in the September of 2016 to do my field work. I drew from my experience with Rob and Dave earlier in the year and took detailed notes of any unusual rocks which I photographed, collected more samples, made GPS notes of their locations, I took dips and strikes and over 3 weeks covered a large area of the Turkish mainland around the bay and the Greek island. In the first of the three weeks I had a colleague with me and we we're both convinced something with a lot of energy had occurred to produce some of the rock formations we were seeing. However, by the time I got home I was wondering if I was seeing it because it was there, or because I wanted it to be there? I needed an expert. I had recently found a website to help, so I wrote to one of the authors, Kord Ernstson. Kord responded within the hour saying my e-mail and photos looked very interesting, he would get back to me. Three days later, as good as his word, he sent me an e-mail having annotated many of the photographs and sending me to sections of his website I hadn't yet discovered, and his last paragraph said he was so sure I'd found a new impact structure that I must publish before somebody nicked my discovery! He suggested the ***Lunar and Planetary Science Conference (LPSC)*** held in Texas every March. The closing date was January 7th, we were already at the end of November. I now had to write a paper, scary, but I knew two people who could help me. I went back to Durham with the news and both Rob and Dave helped me construct the conference paper, which is only 2 pages, and Kord put the finishing touches and sent it in. It was accepted, peer reviewed and published in March 2017. I couldn't believe I was now a published scientist.

The work didn't stop there. Under Kords guidance, I gradually learnt more and more about what I was looking for. By pointing me to different parts of his website, Kord introduce me to a large variety of impact breccia. Monomict breccia, Polymict breccia, Mega breccia (Fig. 10), breccia dykes (Fig. 11), and in particular, breccia-in-breccia (Fig. 12), which is very specific for impacts. This, along with other fracture mechanics, such as fitted fragments and spallation. The former indicates movement in a confined condition, the latter is when a rarefaction wave passes through a rock and leaves it intact but in slices like a cake. Under the microscope we saw multiple sets of micro-twinning which, if a regular size of 1µ, indicate shock metamorphism equivalent to PDFs in quartz, along with accretionary lapilli (Fig. 13), more usually found in a volcanic eruption but also common in impacts. In contrast to silica rocks, carbonate rocks don't quench to form glass. However, under high pressure temperature (P/T) conditions, limestone can melt with subsequent, in part immediate, recrystallization. This can result in decarbonized limestone showing as a white powder along with a melting flow texture. This latter evidence was observed around the project area.

Figure 10: Mega Breccias.

Figure 11: Breccia Dykes.

Figure 12: Breccia in Breccia.

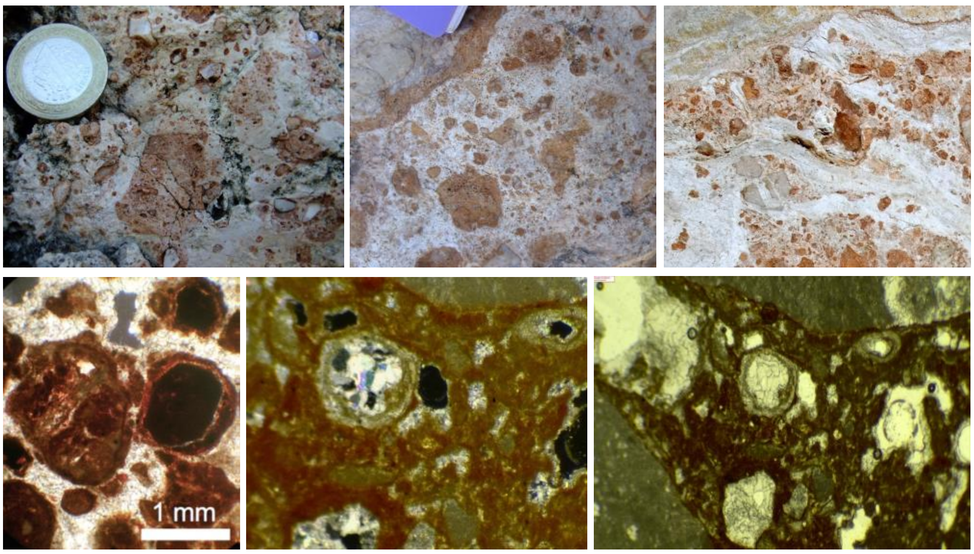

Figure 13: Accretionary lapilli.

Together with Kord, Rob and Dave, a second paper was published in the 2018 LPSC. For the third paper in 2019, Kord wanted to compare the Kaş Bay impact structure with the Rubielos de La Cérida in Spain where he had worked. Both these large structures were carbonate, and the similarities were amazing. From micro to macro under thin section and out in the field they were almost identical. Then the pandemic hit and everything went on hold.

In December 2022, Kord sent me an e-mail saying we ought to do a full paper and that he also thought the structure, which up to then we'd assumed was around 10 kilometres across, was probably twice the size, and he sent me a digital terrain model image annotated to show this (Fig. 14). I had always thought the structure was larger than we originally thought but I wasn't sure it was this big, the only way to find out was to go back to the field. So, with some financial help from the GA, from February 2023 I spent three months in Turkey, researching a much bigger area, and now looking at the rocks both inside and outside the presumed crater rim. Kord was right, the rocks inside the crater rim were all shattered and brecciated showing signs of an impact (Fig. 15). Outside the crater rim on the east was a quarry which was quarrying very large blocks of limestone for the building trade, and these were pure limestone completely unaffected by any kind of impact. To the west were large, tilted boulders, again showing no signs of impact (Fig. 16).

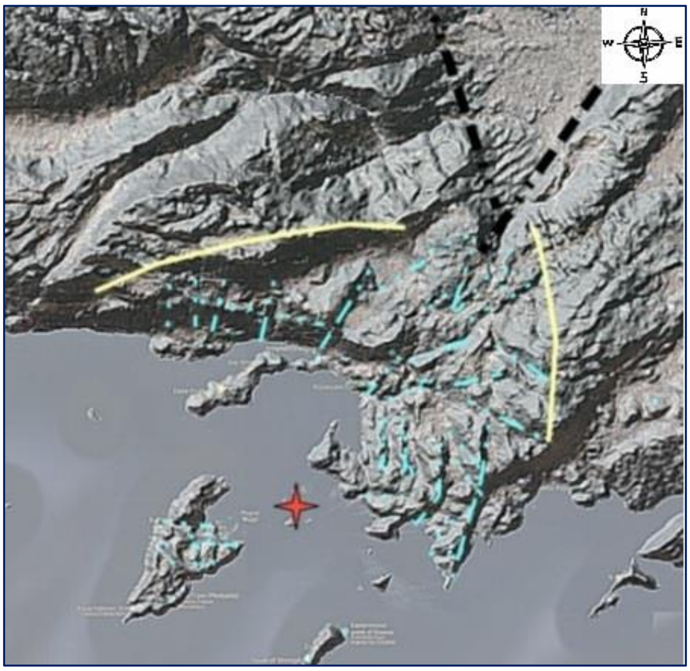

Figure 14: Digital Terrain Model (DTM) of project area.

Figure 15: Shattered brecciated rocks inside the crater rim.

When you look at the project area on a map, it appears a bit skewed. Five islands aren't exactly in the middle where you would expect them to be. This is explained by the presence of three tectonic plates, Aegean, Anatolian and Indian, all moving in different directions at different rates and therefore over the time scale of roughly 2.5 million years, the impact structure was no longer round (Fig. 17).

Figure 16: Quarries and tilting blocks outside crater rim.

We arrived at this approximate age for the impact structure, using uplift and subsidence data, based on the age of a dated fossil layer inland from Kaş, discovered whilst doing the field work in 2016. On the map showing the tectonic plates, it infers that the southern edge of the crater would have been south of the Greek island and had fallen down from the continental shelf into the deeper ocean. Turkey is highly tectonic, and as this part of the crater appeared to have formed on the shelf edge, it would have been unstable and vulnerable to earth movement.

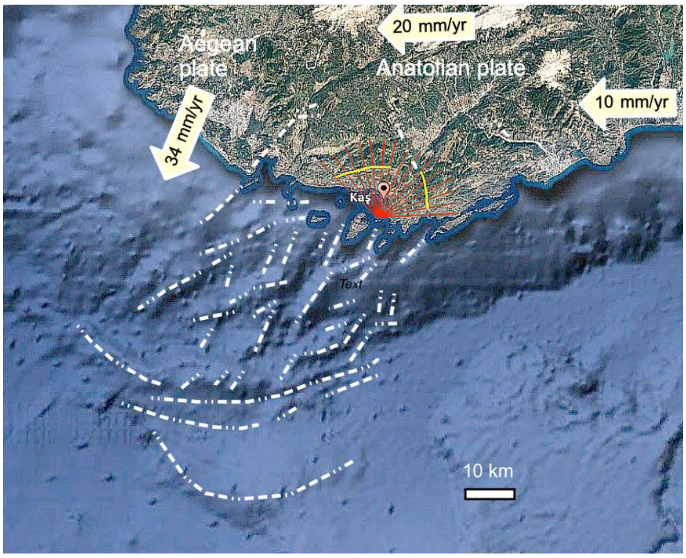

Figure 17: Plate movement skewing the crater shape.

On my return to the UK, it was now time to write the paper. Using the previous three papers as a starting point then adding in the findings from my latest field work I described 20 pieces of evidence from micro to macro proving Kaş Bay was indeed an impact structure. This I did on my own under Kord's supervision. The process combined with the peer review and the publishing was very stressful, maybe because it was a completely new situation for me. However, we got there and in April 2024 the paper was published on an online platform called **Open Science - Air Bursts and Cratering Impacts** (Ref. 4).

Is that the end of the story? No. Whilst on the Greek island in 2023, a colleague asked me to look at a rock which he and his friend had found up a mountain among the goats. He showed me a large dark coloured, almost black boulder, roughly the size of a backpack, which was clearly igneous and consequently in the wrong place in this all-carbonate landscape. I tried the acid test, it didn't fizz, confirming it was igneous, well certainly not limestone. I also put a little magnetic ball on it, and this showed some magnetic attraction. We weighed it on the airport weighing machine, as you do, and it was 19 kilogrammes, and we also put it through the X-ray machine (Fig. 18). We were able to do this because my colleague's friend, who found the boulder, oversees the airport on the Greek island.

Figure 18: ‘Edna’ where it was found, being weighed and X–rayed.

My colleague is a mathematician, and he worked out that at 19 kilos the furthest that the boulder could have travelled through the air was 10 kilometres. The nearest known volcanism is 100 kilometres to the east of the Greek island, and that's extinct; to the West there is active volcanism but 200 kilometres from the island. So where did this boulder come from? Could it be part of the meteorite? We ruled out ship’s ballast and religious artefact. I broke a couple of bits off, and it was very black but had white flecks, and looking on the Internet, it looked like it could be a carbonaceous chondrite which is a type of meteorite. I sent some samples to Monica Grady of the OU who analysed it and responded saying it wasn't a carbonaceous chondrite, but that it was basalt. I got some thin sections made from the crumbs that I had taken back to England and sent them to Kord. He agreed it was a basalt, but he said he'd never seen a basalt like it, and you did get basaltic meteorites. I parked this information and concentrated on the paper.

In October 2024 I went back to Kaş, to investigate the possibility of this rock which I had nicknamed Edna - long story - being part of a meteorite. Back in 2020, I had discussed what happens to a meteorite on impact, with someone from the Ballistics lab at Kent University in Canterbury. I assumed that the whole meteorite would vaporise on impact, but he said no. Quite often you will get crumbs left in the area after the impact has occurred. The dimensions of the meteorite that formed the Kaş Bay impact structure, would have been around 750 metres in diameter. The rock the size of a backpack, would be a crumb from something that size, and where it was found was roughly 4.5 to 5 kilometres from the central peak. Part of a meteorite this size could have travelled that far through the air after the impact. Looking around the Old Town on the Greek island, I noticed in some of the derelict houses, there were a few very dark rocks used in the walls and in the pavement (Fig. 19). People will always use whatever is to hand when they're building, so it appeared that more than one rock fell or at least turned up on the island. I had also asked my colleague to ask around if anybody else had found any large black rocks up on the mountains. One friend had and had brought them back and put them in his garden next to an olive tree. So, they got called Olive (Fig. 19). I took some samples of Edna and Olive back to England, along with several breccia dyke matrix samples that I'd collected from Five Islands, whilst out on the dive boat.

Figure 19: Olive and other assorted dark rocks in a wall and on the pavement.

I was still looking for the meteorite signature, which I had been told I needed, to prove this carbonate structure had in fact been formed by a meteorite impact. The fact that I had given 20 different types of evidence in my paper, from micro to mega size, wasn't good enough for the powers that be in the impact community! I had been looking for this signature over the years using the XRF, which tells you the amounts of the different elements that make up the sample you're analysing. Back at Durham in December 2024, I analysed samples from Edna and Olive to start with, and they came up with what you would expect the elements were for basalts. I then started analysing the breccia matrix recently collected from Five Islands. The reason the matrix is important is because it is a mixture of vaporised meteorite and pulverised country rock resulting from the impact, which got chucked up in the air then filled the cracks, dykes, when it came back to earth, and should therefore contain the meteorite signature. Whilst I was looking at the breccia matrix analysis coming through on the XRF I suddenly realised that there were slightly higher levels of things like silica, iron and aluminium which I didn't expect in a basically carbonaceous matrix. I then put a pebble of limestone into the XRF machine, I was using a pXRF which is a portable machine you can take out into the field, and the result that came back was totally different. When I got home, I looked at the spreadsheets, and as it is very difficult to work something out with just lists of numbers, I turned each set of data into pie charts (Figs. 20 & 21). The result was the country rock contained mainly calcium, as you would expect; both Edna and Olive looked very similar, but when I came down to the matrix it was a combination of the two. How did the extra elements get into the matrix if the meteorite wasn't basalt? This looked really interesting.

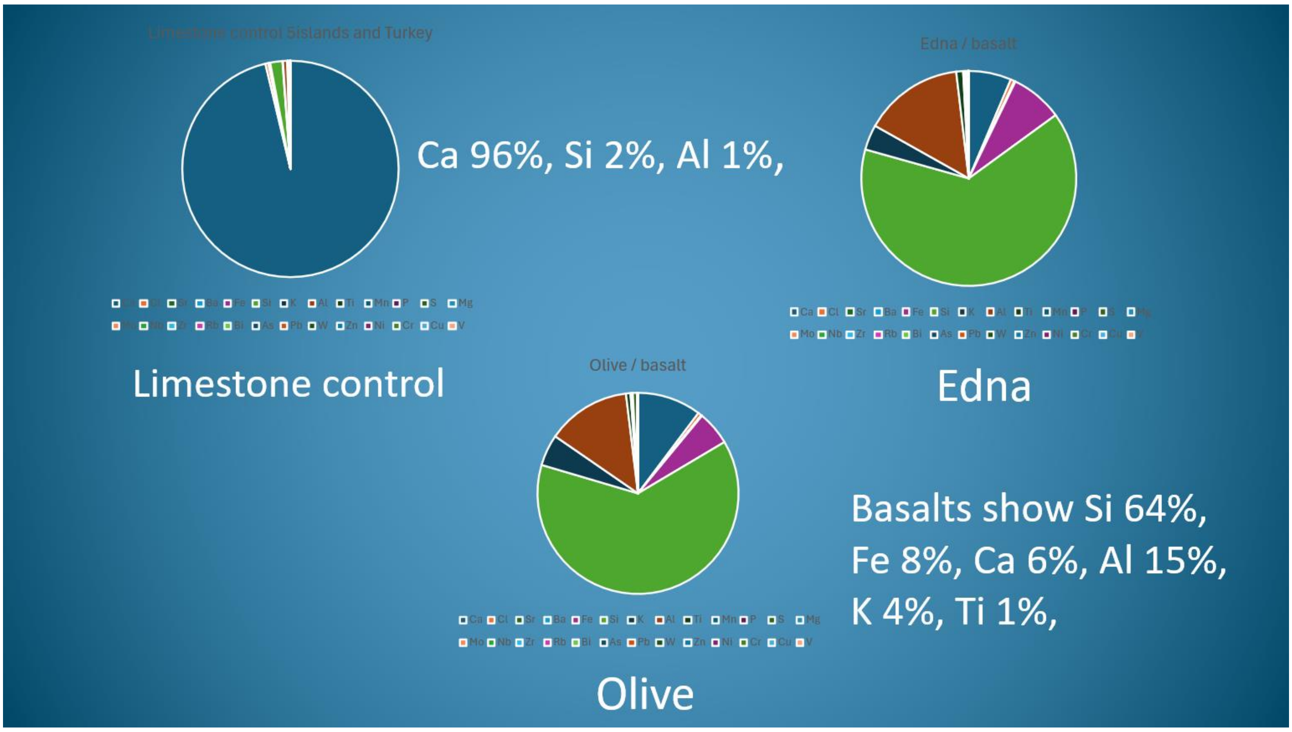

Figure 20: Pie chart from pXRF results of Limestone control, Edna and Olive.

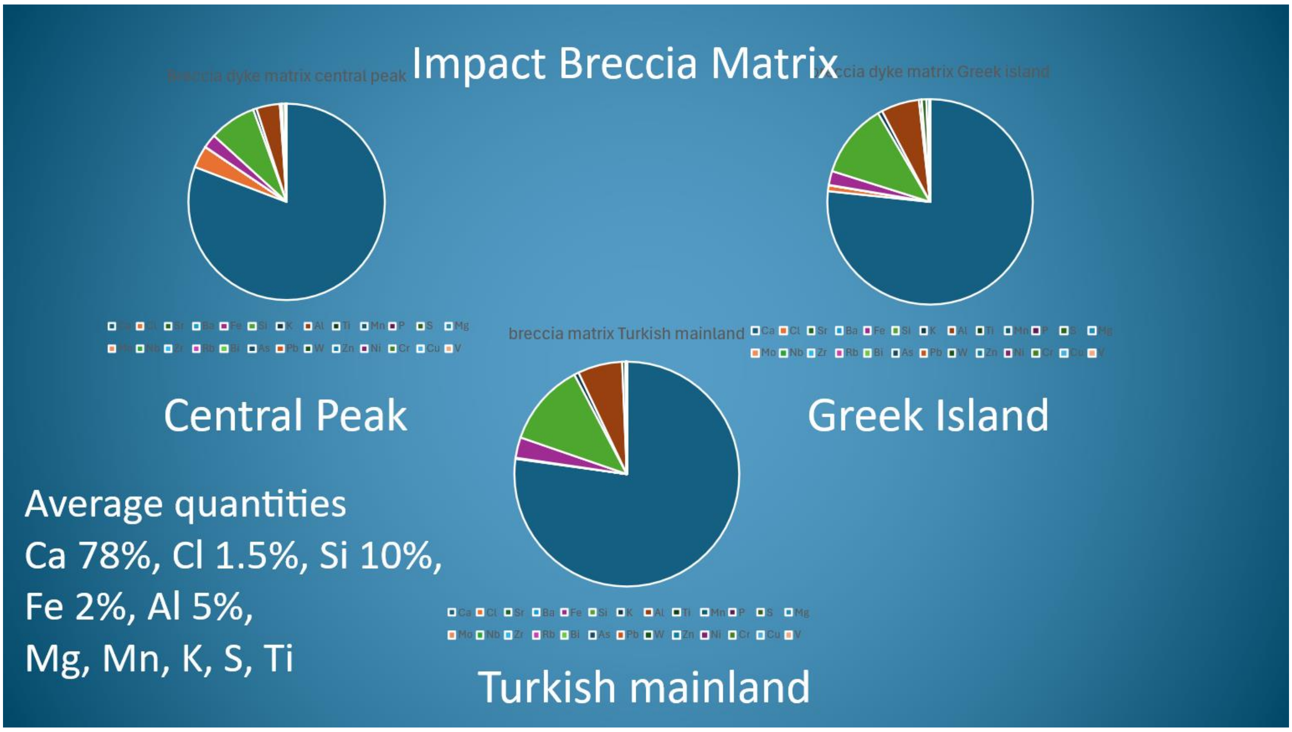

Figure 21: Pie charts showing pXRF of breccia matrix from 3 locations around the project area.

One thing that stood out in the pXRF results was that in the basalts there was a small amount of phosphorus, but in the matrix, there was none. My assumption is that if the basalt was a meteorite, because phosphorus is highly flammable, it would have burned off as it came through the atmosphere / or on impact. I then looked at trace elements as this is one way to figure out where a basalt originated. There were some interesting anomalies when I compared the average of Edna and Olive to the Earth's crust, which is mainly basaltic. I got some thin sections made by a friend of mine, who is into basalts and has 70 different samples from around the world. He said that Edna and Olive were completely different from any of these. They were very glassy and there appeared to be no olivine. Every time I looked at some more evidence it was pointing towards this basalt possibly being a meteorite: the big question is how do you tell terrestrial basalt from extraterrestrial basalt? What is the difference? I needed another expert. I contacted Simon Kelley, now retired, with this new information, he said basaltic meteorites made up around 5% of meteorites found on earth, so were very rare, and a common feature was they were glassy. He was unable to assist further, and I detected his scepticism.

In July 2025 I emailed a PhD student based at the Natural History Museum (NHM) who was looking into using oxygen isotopes to determine meteorite origins, I didn't hear back. In August I went to London, visited the NHM and I took in some samples and thin sections and a short synopsis of what I've discovered. I didn't hear anything. On September 17th I got an e-mail from Natasha Almeida who is the curator of meteorites at the NHM, responding to the e-mail I sent in July and asking one or two other questions, such as had I had EDS, Energy Dispersive Spectroscopy, analyses or EPMA, Electro Probe Microanalysis done. I said no I hadn't. She said the answer will be in the minerals, or more specifically in the ratio between certain minerals which is how they determine planetary basalt parentage. She couldn't give me a time scale but said next time she uses the electron microscope she will apply this analysis and let me know the result. If it turns out this is extraterrestrial basalt, they will then conduct an oxygen isotope analysis which will determine more specifically where the meteorite came from.

So, watch this space. If Edna and Olive are part of a basaltic meteorite, then the chemical signature I've been looking for has been hiding in plain sight and is not something exotic as I was expecting. It will also cross the T's and dot the I's in proving the Kaş Bay truly is an impact structure.

My final paper is open to view on-line by following the link below (Ref. 4) and gives a fuller amount of evidence than has been described here. The 3 conference papers (Refs. 1 to 3) are also possible to view on-line on the LPSC website. Select the correct year, then either search for my surname or the abstract number below. For any further information please feel free to contact me on alijoure@hotmail.com. Thank you for taking the time and a few cups of tea to read this!

Papers:

1) Ure, A. Westaway, R. Bridgland, D.R. Ernstson, K. (2017) *Evidence for a meteorite impact structure on the Turkey-Greece Frontier.* LPSC XLVIII, Abstract #1144. https://www.hou.usra.edu/meetings/lpsc2017/pdf/1144.pdf

2) Ure, A. Westaway, R. Bridgland, D.R. Demir, T. Ernstson, K. (2018) *Impact hypothesis for the Kaş Bay Structure (Turkey/Greece) strengthened*. LPSC XLIX, *Abstract #1455* https://www.hou.usra.edu/meetings/lpsc2018/pdf/1455.pdf

3) Ure, A. Westaway, R. Bridgland, D.R. Claudin, F. Ernstson, K. (2019) *Kaş (Turkey/Greece) and Rubielos de la Cérida (Spain) meteorite impact structures: comparative insights into prominent sedimentary carbonate targets.* LPSC, L, Abstract #1196 https://www.hou.usra.edu/meetings/lpsc2019/pdf/1196.pdf

4) Ure, A. Westaway, R. Bridgland, D.R. Tunstall, N. Çakmak, S. Demir, T. (2024) *Kaş Bay: Evidence of a 20 km-diameter complex impact structure on the Turkey-Greece frontier.* https://www.scienceopen.com/hosted-document?doi=10.14293/ACI.2024.0002

An excellent and fascinating talk by Alison Ure.

Alison describes herself as a Citizen Scientist who studied for an Earth and Environmental Science degree with the Open University in her 50's.

Alison has had many careers through her working life. She left school at 16 yrs and went to catering college with hospitality being her first career. She also trained as an Equestrian Instructor aged 17 yrs - and had her own riding school at the time – and this continued long after she had got tired of hospitality, morphing into becoming a Dressage Trainer on the back of competing at International level in the 80's. By the time she was 40 she wanted a change again, and trained as a massage therapist, the highlight of which was working at the 2012 Paralympics in the Athletes Village. By her mid 50's she reduced the amount of massage treatments she was giving and supplemented her income with care work. Now as a pensioner she still has a few clients to keep her hand in as a trainer, therapist and carer, but most of her time is taken up with an automotive passion in Lancia's. She has just been elected the first Lady Chairman of the Lancia Motor Club in its 78-year history.

Alison decided to do a degree when she was 50, to prove to herself that she wasn't stupid having left school with only 6 'O' levels. She chose a geology-based course as she had always been fascinated with volcanoes and the strange shapes and colours found in rocks generally and didn't know what else to study. She wanted to learn the language of the rocks and never thought for one moment it would lead to a geological discovery and published papers. It just shows you never know what's around the corner and what doors education can open for you at any age. She hopes you enjoyed the talk and that it inspires you to try something you thought was beyond you.

Down to Earth
'Earth science learning for all'

Lecture Summary

Friday, 14 November 2025

On Friday,14 November, 43+ attendees from the FGS, Reading and Mole Valley Geological Societies and from the u3a Geology 4 Non-Geologists group via Zoom welcomed Chris Darmon and Colin Schofield in presenting our talk.

New insights into the break-up of the North Atlantic Ocean

Chris Darmon with Colin Schofield, Down To Earth

The traditional picture

Most images of the North Atlantic make no differentiation between the North and South yet there are fundamental differences. Not least the ages of the ocean floor. Around the Canary Islands we have oceanic crust dating from the early Jurassic, around 190 Ma, whereas the oldest in the North Atlantic is around 65 Ma (Fig. 1).

It was initiated, not in the current centre, but in a place much closer to these shores - on the island of Skye. That massive outpouring of explosive ashes and basalt lava used to be called the Hebridean Igneous Province. We now refer to it as the North Atlantic Igneous Province (NAIP).

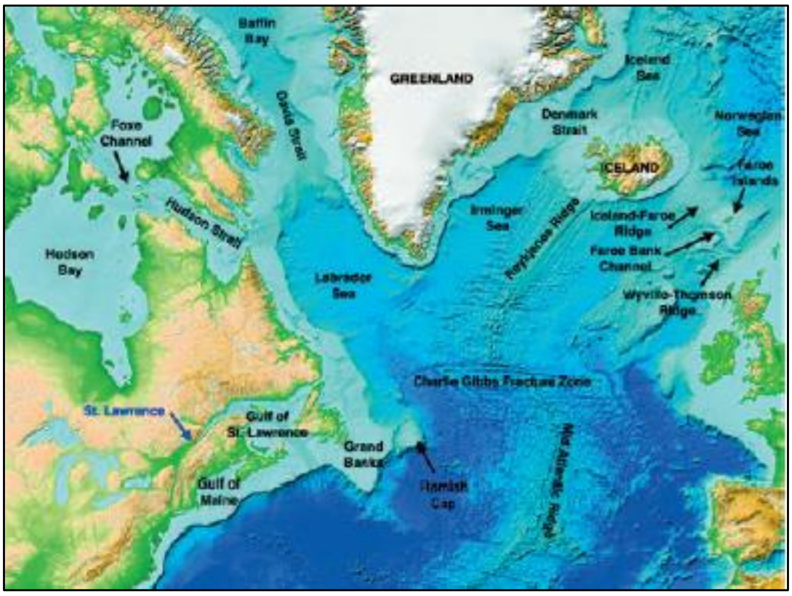

Figure 1: The North Atlantic. (Credit: Down To Earth)

The big picture...

Fig. 2 puts the North Atlantic into a tectonic context that takes in the Davis Strait between Greenland and Canada and also the wider European picture. Research in 2024 recognised continental crust filling the Davis Strait beneath a thick cover of basalt. The seafloor colours indicate relative ages in millions of years. Notice that south of the Mediterranean seafloor ages increase dramatically.

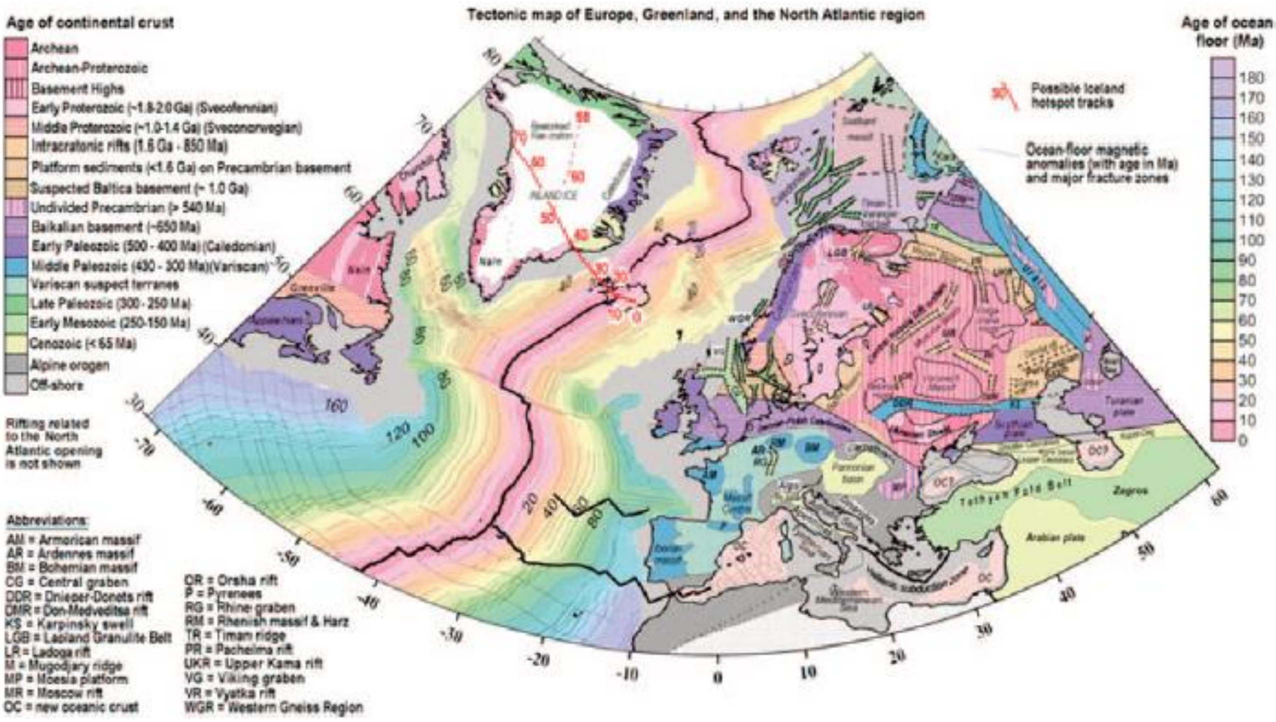

Figure 2: The tectonics of the North Atlantic. (Credit: Down To Earth)

The beginnings of the NAIP

Ask anyone for the most famous Palaeogene (Tertiary) basalt, they'll probably give you the Giant's Causeway that enigmatic hexagonal columned feature on the north coast of County Antrim in Northern Ireland. If you specify 'Scotland' then somebody might remember similar columns on the small west coast island of Staffa, just off the coast of the Island of Mull. Legend has it that these two place places are linked by the giant Finn McCool. But geologist don't need a mythical giant, they have radiometric dating and geochemistry to call upon.

Figure 3. The Isle of Staffa (left) and the Giant's Causeway (right) are both continental basalts. (Credit: Down To Earth)

These two places and their rocks are one in the same. They both date to around 63 Ma and have the same chemical composition. Crucially, they have the composition, not of oceanic mid-ocean ridge basalt (MORB) but continental basalt. Basalts with the same age and composition can be found off both the east and west coasts of Greenland.

The big NAIP event...

Our starting point for the NAIP is to look at the extent of it. Fig. 4 does just that.

Notice that there's no Iceland, that's because at this stage, it's yet to exist. Notice also that fact that an even earlier attempt to open the North Atlantic had taken place between Greenland and Canada, along the Davis Strait.

Notice also that there are several basins off the west coast of the UK, including the Rockall Basin. We know that these are underlain by continental crust because of the presence of hydrocarbons in Mesozoic sediments.

These basalts (dating from around 60 Ma) are of largely continental basalt, and not MORB that we'd expect, and as is erupting today.

As you might expect, the picture that is now emerging is the result of research

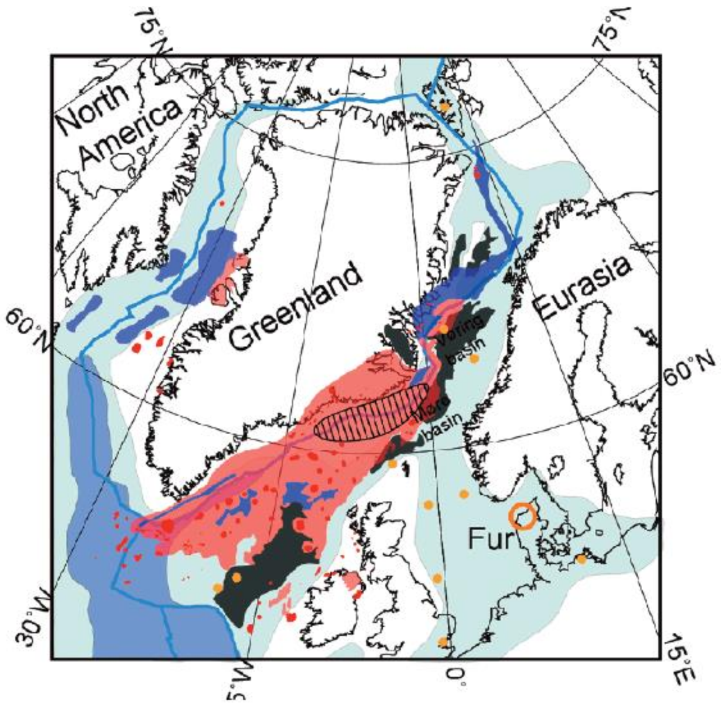

Figure 4: Map of the known extent of the North Atlantic Igneous Province (NAIP) in a regional palaeogeographic reconstruction from 56 Ma. The striped area indicates the most likely source area for the Danish ash layers. The yellow points show selected known localities of NAIP-derived ash, although NAIP-derived ash is also distributed far outside this map frame such as Goban Spur and in the Austrian Alps. Dark red: volcanic centres. Red areas: the known extent of subaerial and submarine extrusive NAIP volcanism. Purple areas: the known extent of only submarine volcanism. Dark grey areas: known extent of NAIP sill intrusions. Blue lines: plate boundaries. Black lines: present-day coastlines. Light blue: shelf areas. Dark blue: ocean basins. (From a 2020 paper by Ella Stokke, Emma Liu and Morgan Jones.)

by a number of people in a variety of different countries. The summary below is based on material in the 2020 paper *"Evidence of explosive hydromagmatic eruptions during the emplacement of the North Atlantic Igneous Province"* by Stokke, Liu and Jones.

The current hypothesis is that the NAIP began at around 63 Ma and that the bulk of the igneous material was emplaced around 60-58 Ma and was mainly basalt. As for the volume of that basalt, estimates vary widely but it seems to be in the range of 5-10 x 106 km^3 (5-10 million km^3) - no wonder it makes the NAIP one of the largest in Phanerozoic time! It largely ended with the eruption of a large volume of siliceous material between 56 and 54 Ma with eruptions associated with the so-called Skye super-volcano.

Some people think that this was coincident with the break-up of Greenland from Eurasia. Recent research suggests that this may have occurred quite a lot later and is associated with the current mid-ocean ridge passing through Iceland. They go on to argue that the real plate break-up may only be beginning to occur now, meaning both sides of the North Atlantic were on the same tectonic plate until quite recent times.

The later silica-rich volcanicity coincides with a major climatic event, the so-called Palaeocene-Eocene Thermal Maximum (PETM). This comes as little surprise given the fact that we know that much of the volcanism was explosive as evidenced by hundreds of tephra layers preserved in the North Sea and on land in Denmark. The discovery of such layers is a first in the study of any large igneous province (LIP). The assumption is that glaciation erased all evidence of such layers from mainland Britain.

UK evidence for the NAIP

There's plenty of evidence for the NAIP on land in the UK and also in our offshore zone out in the Western Approaches. These come in a variety of different forms, including central igneous complexes with both granites and gabbros, similar submarine centres, sills and dykes and lava and ash fields both onshore and offshore. Some of the offshore features present themselves as seamounts with nicely eroded top surfaces.

The most northerly complexes are exposed on Skye and St Kilda. The most southerly is Lundy Island in the Bristol Channel and comprises a small granite which sits atop a much larger gabbro. The notable granites are on Skye, Arran and in the Mourne Mountains.

The island of Rum in the Inner Hebrides is notable for hosting the only major ultrabasic rock which is presumed to be of mantle origin. It has been emplaced along a deep N-S fault line and is a pipe-like intrusion.

As can be seen from Fig. 5, Palaeogene dykes extend well into England and one, the Cleveland Dyke, got almost to the north sea coast in Yorkshire. These long-range features mostly emanate from the Mull Centre.

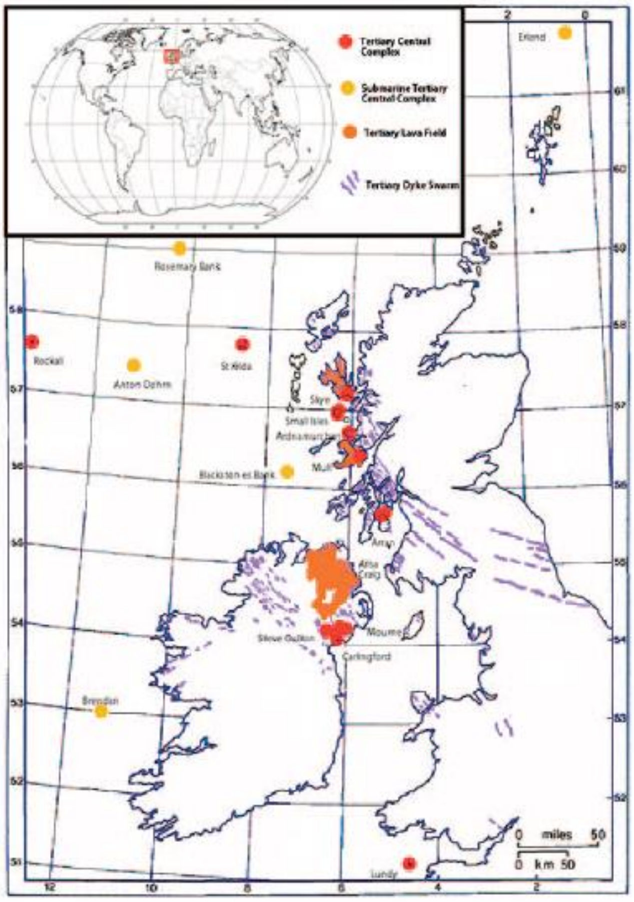

Figure 5: UK evidence for the NAIP. (Credit: Down To Earth)

The basalts and gabbros

Basalt poured forth from a number of volcanic centres on Skye, Ardnamurchan, Mull and in County Antrim. Some of this came about from fissure eruptions and in other cases it would have been low shield volcanoes. There's evidence in some places for the melting of overlying crust that gave rise to short lived early high silica explosive volcanicity such as can be seen on the Isle of Rum (Fig. 6).

Figure 6: Example of explosive volcanicity as seen on the Isle of Rum. (Credit: Down To Earth)

In both Mull and Ardnamurchan, the central vents moved over time. In both places we can recognise three igneous centres (Fig. 7).

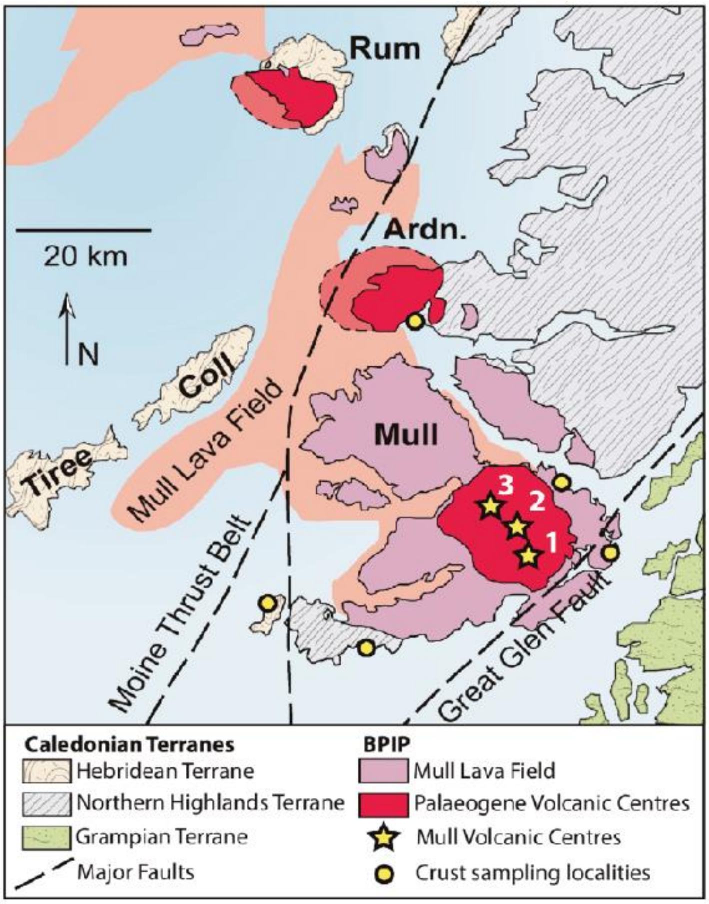

Figure 7: The Mull lava field. (Credit: Down To Earth)

The most prolific in terms of lava production were Skye and Mull. There was a short-lived igneous centre on the Isle of Arran.

Erosion over the past 50 or so million years has removed basalt and most other extrusive material from the area immediately surrounding the igneous centres, exposing large bodies of gabbro.

The Cuillin gabbros are cut by granites of the Western Red Hills. Other granites form the Eastern Red Hills. Some of these granites formed by a process of chemical evolution called 'fractionation'. As magma crystallizes, different components crystallize out at different times, leaving behind a melt that becomes progressively rich in silica, which forms quartz when it cools.

Other granites form the other way around - by partial melting of the deeper continental crust, heated up by the intrusion of very hot basic magma from the mantle. The granite in effect is like the more volatile component that gets driven off. Geochemical studies of the Skye granites indicate that both of these processes have occurred – illustrating the complexity of igneous processes that can happen as continents split apart. The finding of a Zircon crystal that dates to 1.2 Ga indicates that some of the melted material was the Precambrian Torridonian sandstone.

The Skye super-volcano...

It may not be as well-known as the super-volcano in Yellowstone, but the Skye example was certainly large. It's an integral part of the NAIP with components fitting directly into the main time frame. It started out life as a massive explosive stratacone volcano that was particularly prolific at producing huge volumes of high silica lava and ash. What have become recognised as the products of the super-volcano began with a couple of devitrified pitchstone flows, one of which forms the Sgurr of Eigg (Fig. 8).

Figure 8: Sgurr of Eigg lava flow. (Credit: Down To Earth)

These were considered to be almost the last events of the igneous activity, but we now know that they are an integral part of the Skye super-volcano that dates to the period 56-54.6 Ma.

As this map shows (Fig 9a), material was carried around 50 km from the site of the eruption at Marsco.

The work has been carried out by Swedish geologist Valentin Troll (Edinburgh Geol. Soc.):

"Valentin R. Troll *et al* compared mineralogy and isotope geochemistry of the pitchstone on Eigg and Òigh-sgeir (outside Rum see section above), and the results suggest that the two outcrops represent a single, pyroclastic deposit. Prior to this study, David Brown and Brian Bell (in a paper published in 2013) had suggested a connection between the outcrops and a volcanic eruption on Skye – the new paper confirms these results and proposes a connection with the PETM.

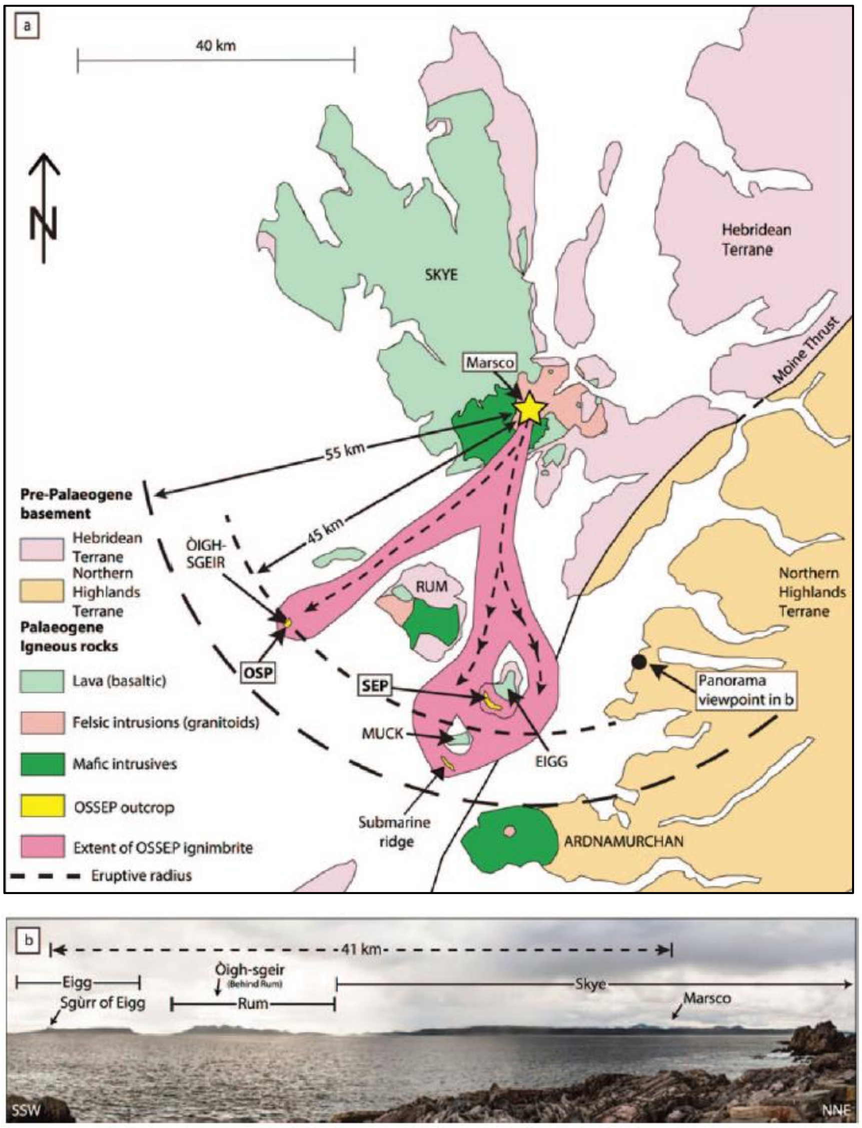

Figure 9: Source and run-out distances of the proposed Skye volcanic event. (Credit: Troll et al. 2019)

The magnitude of the Skye volcanic eruption was estimated to 3.9-15 km^3 DRE (dense-rock equivalent) and a 5-6 on the Volcanic Explosivity Index scale, which compares with historical examples such as the 1991 Pinatubo eruption (~ 5 km^3 DRE). The results imply that large-scale explosive silicic eruptions have likely been common during the opening of the North Atlantic. This paints a more violent picture of the rift to drift transition of the North-Atlantic region between 61 and 56 million years ago than previously assumed."

After about 54.6 Ma this early phase of the North Atlantic Igneous Province appears to have ended, at least for a period of time. The next time we see major action is in the western part of the North Atlantic about 30 Ma.

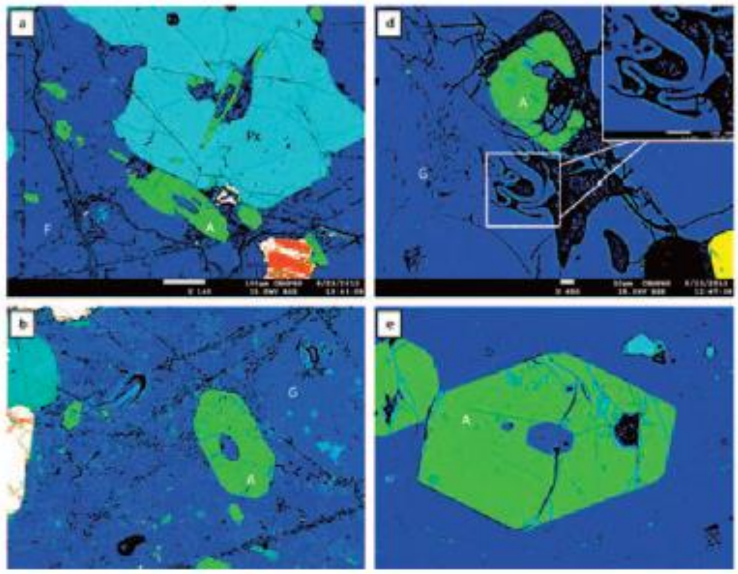

Figure 10: Examples of the pitchstone from Eigg & Òigh-sgeir (Credit: Down To Earth)

The enigma that is the Isle of Rum

Rum is known as one of the Small Isles of the Inner Hebrides, along with its neighbours, Eigg, Muck and Canna. But Rum's geology (Fig. 11) is nothing like what exists on those other isles, and neither is it like its other neighbour, Skye.

Rum is home to the largest peridotite anywhere in the UK. It's a cylindrical body of rock which shows excellent mineralogical layering, with alternating layers of dunite and harzburgite (olivine rich and pyroxene rich).

There are also explosive breccias from a brief period of silica rich volcanism and a significant granite in the west. All in all, a fair range of rocks for an island barely 8 km across! Added to this the Rum Cuillin is around 900 m in elevation.

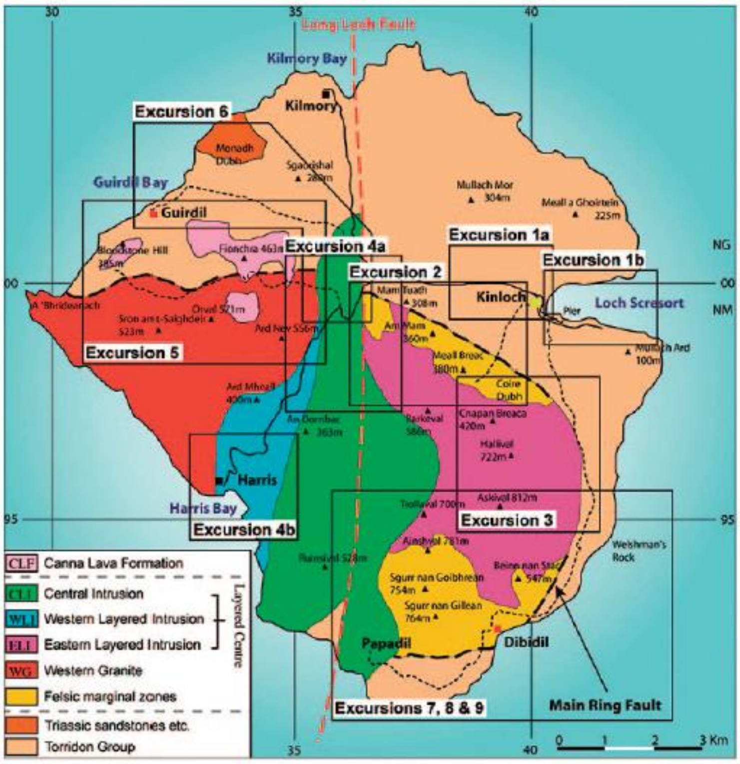

Figure 11: The Isle Of Rum (Credit: Down To Earth)

Meanwhile in the North Sea...

As if all this was not enough, it has recently been confirmed that there was an asteroid impact some 43 Ma in the southern North Sea (Fig. 12). The Silverpit crater has been the subject of a paper published this year in **Nature Communications** (Ref. 3). Scientists from Heriot Watt University have used seismic imaging date to examine it and confirm that is what it is. Does this have any bearing on the more general picture? At this stage it's fair to say that it's too early to give any definitive statement.

Fast forward to the present...

The NAIP has essentially continued to the present day, and this map (Fig. 13) shows the overall extent of the rocks that are attributed to it. The oldest rocks on mainland Iceland date to about 13 Ma and it's clear that there was an increase in basalt production about 5 Ma.

There is an ongoing hot debate about the role of a mantle plume which is currently suggested to lie beneath Iceland. The track of that plume has been mapped as it crossed Greenland and then the western Atlantic to its present position.

Simplistically, Iceland sits astride the mid-Atlantic Ridge, but even this is far from simple as over the last few million years the ridge has 'jumped' several times. At the present time, there are actually two lines of spreading that run semi-parallel to each other. In the past 50 years both 'branches' have seen volcanism. The most recent activity has been close to the capital Reykjavik.

Added to this, the dating of a Zircon at 242 Ma found in 13 Ma rhyolite in Eastern Iceland, cast further doubts on what lay beneath the surface basalts. We now think there's a thick slab of continental material - probably part of Jan Mayen island, beneath Iceland. This would also account for the apparent excess of rhyolite in Iceland.

Even Icelandic geologists are divided between those who believe the mantle plume/hot spot theory and those who reject it out of hand.

Maps, such as the one shown in Fig. 14, show the supposed trace of the hot-spot across Greenland over time, to its present position beneath eastern Iceland.

Finally, where does the North Atlantic go from here?

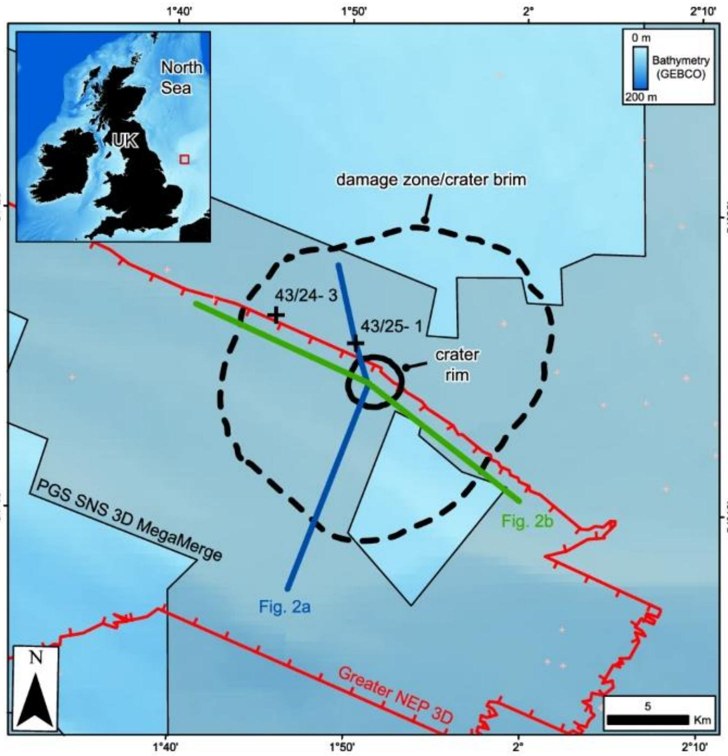

Figure 12: Location map showing the Silverpit Crater and its associated damage zone. (Credit: Ref. 3)

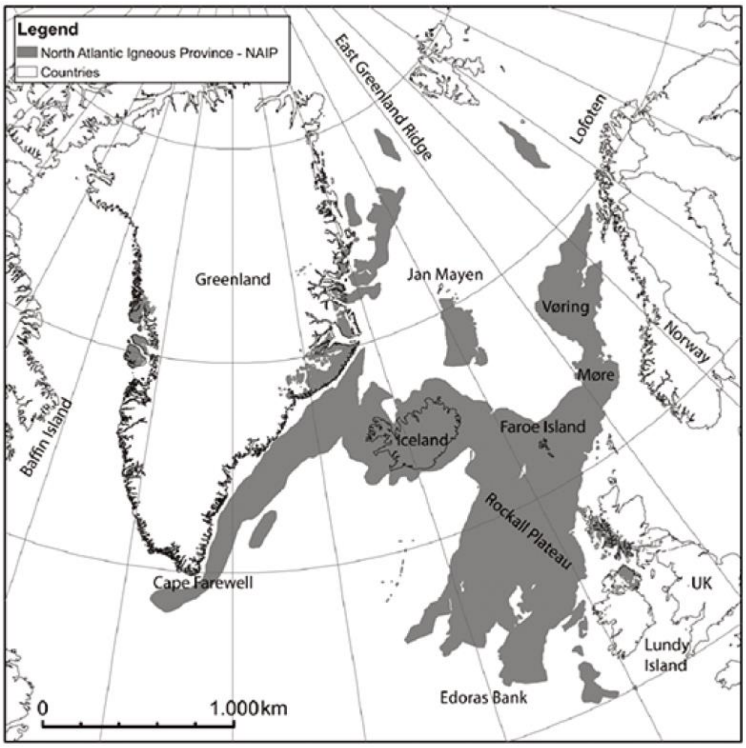

Figure 13: The extent of the NAIP. (Credit: Down To Earth)

With tentative evidence (by way of earthquakes) for the possible development of a new subduction zone off the coast of Portugal we might expect such developments to become more widespread. It's already clear that the Atlantic is home to an enormous amount of basalt, albeit a lot of it continental rather than oceanic.

This comes from BBC Science Focus and is dated August 30, 2025:

"A new tectonic fault could be emerging beneath the Atlantic Ocean, raising the risk of powerful earthquakes and tsunamis that could ripple across the basin. That's according to a new study published this week in **Nature Geoscience**. For centuries, scientists have puzzled over why Portugal has suffered huge earthquakes despite lying far from the world's major fault lines. On 1 November 1755, Lisbon was devastated by a magnitude 8.7 quake that killed tens of thousands and sent tsunami waves as far as the Caribbean. More recently, a magnitude 7.8 tremor struck off Portugal's coast in 1969, killing 25 people.

"One of the problems is that these earthquakes occurred on a completely flat plain, far from the faults," Prof. João Duarte, a geologist at the University of Lisbon and lead author of the study, told **BBC Science Focus.**

"After the 1969 earthquake, people started to realise that something strange was going on, because it had the signature of a subduction zone, yet there isn't one there."

Subduction zones – where one tectonic plate dives beneath another – are responsible for the planet's most devastating 'megathrust' quakes, such as the 2004 Indian Ocean and 2011 Tōhoku disasters. But the Atlantic has long been considered relatively calm as its plates slowly drift apart along a mid-ocean ridge. Duarte's team pieced together seismic records and computer models of the Horseshoe Abyssal Plain, a stretch of deep seafloor southwest of Portugal (Fig. 15). They found evidence that the mantle – the hot, dense layer beneath Earth's crust – is peeling away in a process called delamination.

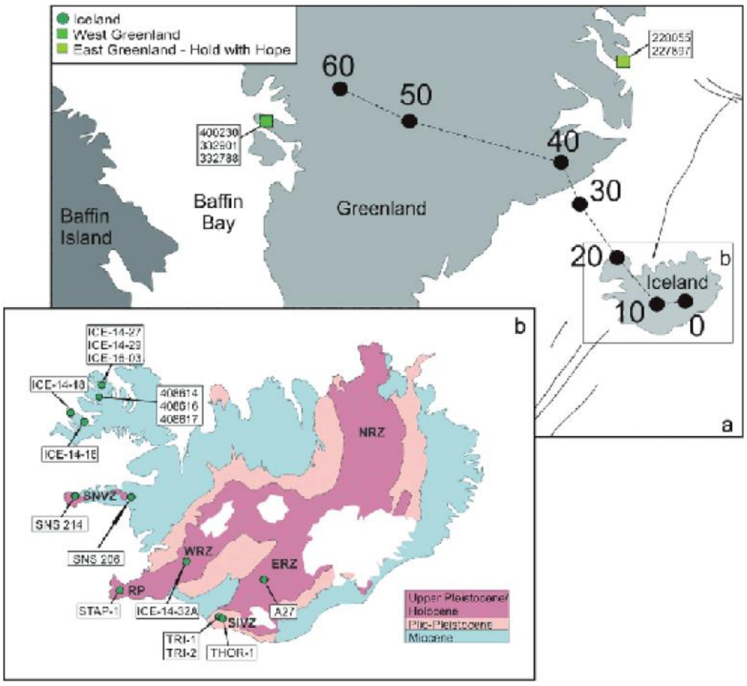

Figure 14: The supposed trace of the hot-spot across Greenland over time, to its present position beneath eastern Iceland. (Credit: Down To Earth)

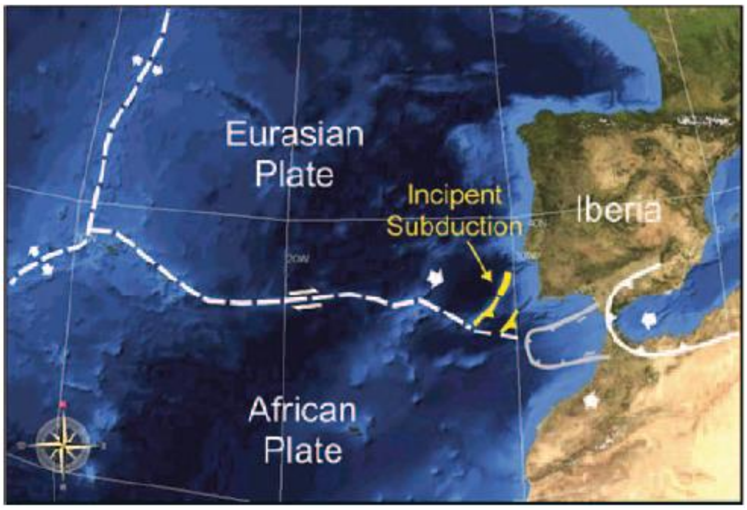

Figure 15: The Horseshoe Abyssal Plain, a stretch of deep seafloor southwest of Portugal. (Credit: Down To Earth)

"The base of the plate is separating like the sole of a shoe peeling off," Duarte said. "That was the first Eureka moment when I thought, 'aha, there's something there'. The second was when the computer models also showed delamination was happening." Such unpeeling is almost unheard of in the oceanic crust, which usually behaves like a "crème brûlée", as it has a rigid buoyant layer sitting atop a squishier one beneath.

But here, water appears to have seeped into the rock over millions of years, chemically weakening it and allowing chunks of mantle to sink into Earth's depths (Fig. 16). The findings suggest we may be witnessing the birth of a new subduction zone in the Atlantic – one that could eventually pull Africa, Europe and the Americas back together into a future supercontinent.

For now, the more immediate concern is seismic hazard. “Big earthquakes are going to happen again,” Duarte said, warning that the impacts of these could devastate unprepared coastal regions across the Atlantic. If you see on the forecast that it’s going to rain tomorrow, you take an umbrella,” he continued. “You don’t need to know exactly what minute it will start raining because you are prepared. With earthquakes, it's the same thing; we don’t know when a major one will hit, but we know that one will, so we need to be prepared for that.”

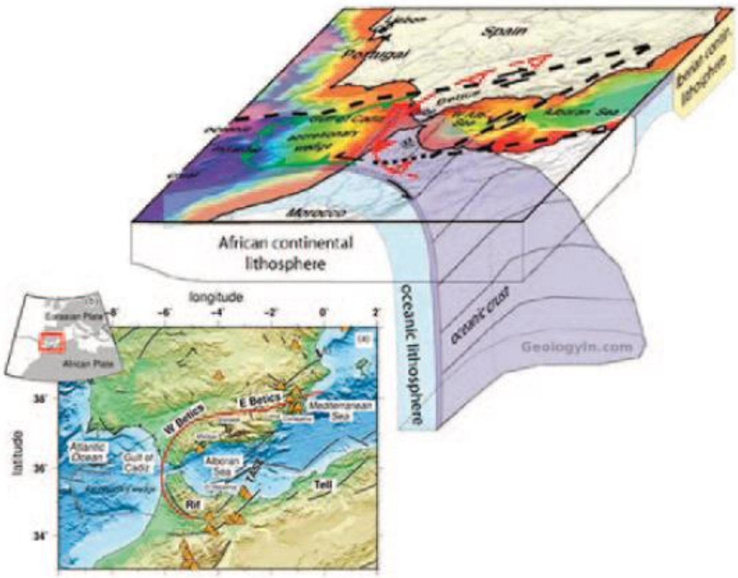

Figure 16: The birth of a new subduction zone in the Atlantic? (Credit: Down To Earth)

Despite this, the North Atlantic continues to dominate the Earth’s tectonic systems, with North and South America being pushed further west as spreading at the current mid-Ocean ridge continues. At some stage in the future the Pacific Ocean will be just a tiny relic as a new ocean begins to open somewhere else on the Earth’s surface in the continuum that is our tectonics.

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1. Evidence of a large explosive silicic eruption on Skye, Edinburgh Geol Soc, 7 Feb 2019. (https://edinburghgeolsoc.org/evidence-large-explosive-silicic-eruption-skye/)
2. Skye volcanic eruption 'changed climate', BBC Science News, 24 January 2019. (https://www.bbc.co.uk/news/uk-scotland-highlands-islands-46986509)
3. Multiple lines of evidence for a hypervelocity impact origin for the Silverpit Crater, **Nature Communications** volume 16, Article number: 8312 (2025). (https://www.nature.com/articles/s41467-025-63985-z?utm_medium=affiliate&utm_source=commission_junction&utm_campaign=CONR_PF018_ECOM_GL_PBOK_ALWYS_DEEPLINK&utm_content=textlink&utm_term=PID1612532&CJEVENT=6a5a5bf0eec811f0816201130a18ba72&countryCode=de)
4. https://www.geosupplies.co.uk/down-to-earth-magazine.php

A very interesting & thought-provoking talk from Chris Damon, assisted by Colin Schofield

Chris Darmon has had over 50 years in geological education beginning as a schoolteacher of O and A level geology. He went on to spend 25 years as an adult education tutor for the WEA and Sheffield University. Since 2010 he has run field trips for adults in a variety of different forms both in the UK and overseas. He now spends the ‘closed season’ teaching online courses and classes. Chris is also the **editor** of Geo-Supplies’ “Down To Earth” magazine.

Colin Schofield is a geology/geography graduate who has worked with Chris to deliver the fieldwork and online educational content over the past 15 years. Colin is the **assistant editor** of Geo-Supplies’ “Down To Earth” magazine.

Lecture Summary

Friday, 12 December 2025

On Friday,12 December, 52+ attendees from the FGS, Reading and Mole Valley Geological Societies and from the u3a Geology 4 Non-Geologists group via Zoom welcomed Ros Mercer in presenting our talk.

Flint, an amazing material!

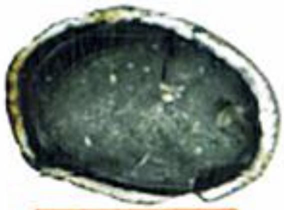
Ros Mercer, Retired Geologist

Many pebbles in England are made of the natural material we call 'flint'. Especially if you live in southern or eastern England, the pebbles you find in your garden or on the beach are mainly made of flint. But what is flint? What does it look like and how is it formed? Here and on the following pages, ROS MERCER tells us more.

Chalk and flint

Flint occurs in nodules and layers in the Chalk. Chalk is that soft white rock seen in the white cliffs of Dover and the cliffs of Sussex, Beachy Head for example, and The Needles on the Isle of Wight.

Line of flints in chalk.



Flint traps light!

Fresh out of the chalk, flint appears black when broken open. Actually, flint is pale brown and transparent, but it looks black because while it lets the light in, it cannot get back out again! This is caused by the minutely random structure of the silica crystals inside the flint. Fresh flint often has a white rind or 'cortex' from its interaction with the chalk. This rind gets worn away as the flint nodules are rolled around in rivers and on beaches.

Chatterboxes...

If you look very carefully at the flint pebble right, you can see curved markings on the surface, known as 'chatter-marks'. These are formed when the pebbles bash into each other as they are jostled in rivers and particularly on beaches when the tide swashes them backwards and forwards twice a day. Chatter marks are one way to identify flint pebbles.

Another way to spot that it's flint

Another way to identify flint is to look for a conchoidal fracture. This is a series of concentric circular ridges that resemble a shell. They may be very tiny along the chipped edge of a piece of flint or spread across a broken surface. Flint breaks like this because the crystals of which it is made are so minute that it acts like glass.

A many-coloured material

Images Ros Mercer unless credited otherwise

Flint found in soil or gravels has many different colours – orange, brown, red or white. Rusty looking orange and brown flints have been stained by iron solutions that can get into flint because it is microporous. When a rusty iron flint pebble is heated, water is driven off and the iron becomes red hematite, making the flint red coloured. It may have been heated in a naturally occurring forest fire or a beach barbecue. Flint pebbles were used as pot-boilers before metal saucepans or kettles were available. Pebbles were heated in a fire and then dropped into a container of water to heat it up. The resulting flints look red, white and hackly.

Marble-ous

Many flints look marbled with some areas black or grey and others white. This is because the pebble has been made from an irregularly shaped flint nodule and some parts of the pebble are made from the cortex on the outside of the nodule, and other parts are from nearer the centre.

Fooling you into thinking fossils...

Some flints have curious ridges and banding that make them look like fossils! The banding is caused by solutions going through the flint during its formation when it is still in a gel state. The bands are called 'Liesegang rings' after the German chemist who first observed their formation, but the process is still not well understood. Weathering picks out the different hardness of the layers leading to the fossil-like appearance.

Charming hagstones

Flint pebbles may have holes in them. These are called 'hagstones' and may be worn as a charm (if they are not too big!) as they are thought by some to have mystical properties. Holes could indicate their origin around a sponge in or on the Chalk seabed. Slicing a pebble in two often proves this.

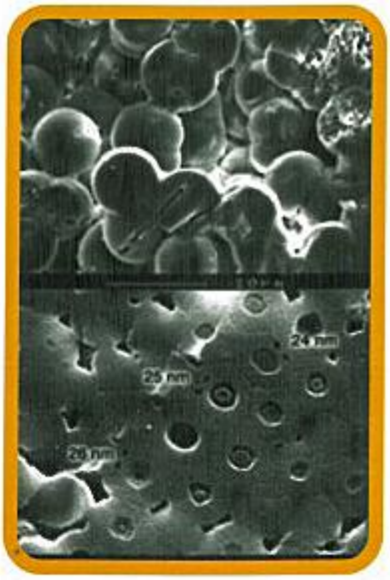
Sometimes the holes in flint are lined with tiny quartz crystals that sparkle or blobby layers of chalcedony that sometimes looks blue or may be iron-stained red.

Stone age

Of course, our stone age ancestors had expert knowledge of the properties of flint. They made all their edge tools from it!

Image by Roy Miller CC-BY-SA-2.0

How was Flint formed?



Microscopic secrets

The origin of flint has only been understood since we have been able to use extremely powerful microscopes to see what it is made from. This is the same for the Chalk in which flint is found. Both are made of very tiny crystals.

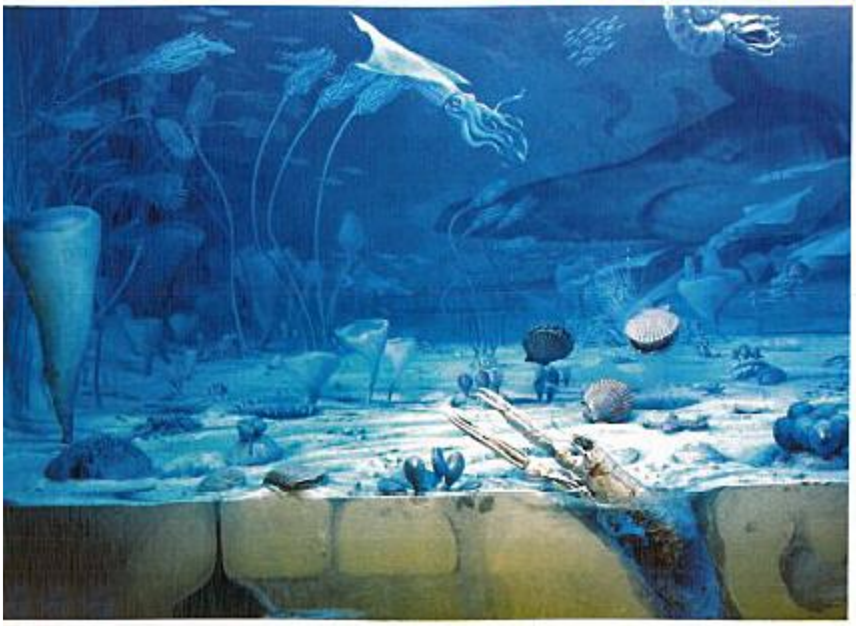
Flint is made of silica, the same substance as quartz and sand. Scanning electron microscope (SEM) images reveal tiny balls of opaline silica that formed as a gel, held together in a matrix of chalcedony – a micro-crystalline type of quartz.

Chalk sea sponges rule

This type of silica came mainly from animals that extract this mineral from sea water to make their frameworks or shells. Planktonic creatures such as diatoms and radiolaria make their tiny, very intricate shells of silica. These inhabit the oceans, but in the shallower Chalk sea, the role of sponges is dominant. Glass sponges make their framework from needle-like spicules of silica, extracted from sea water. Occasionally these can be seen in flint by using a hand lens or a microscope.

Images Ros Mercer unless credited otherwise

Life and death on the sea floor

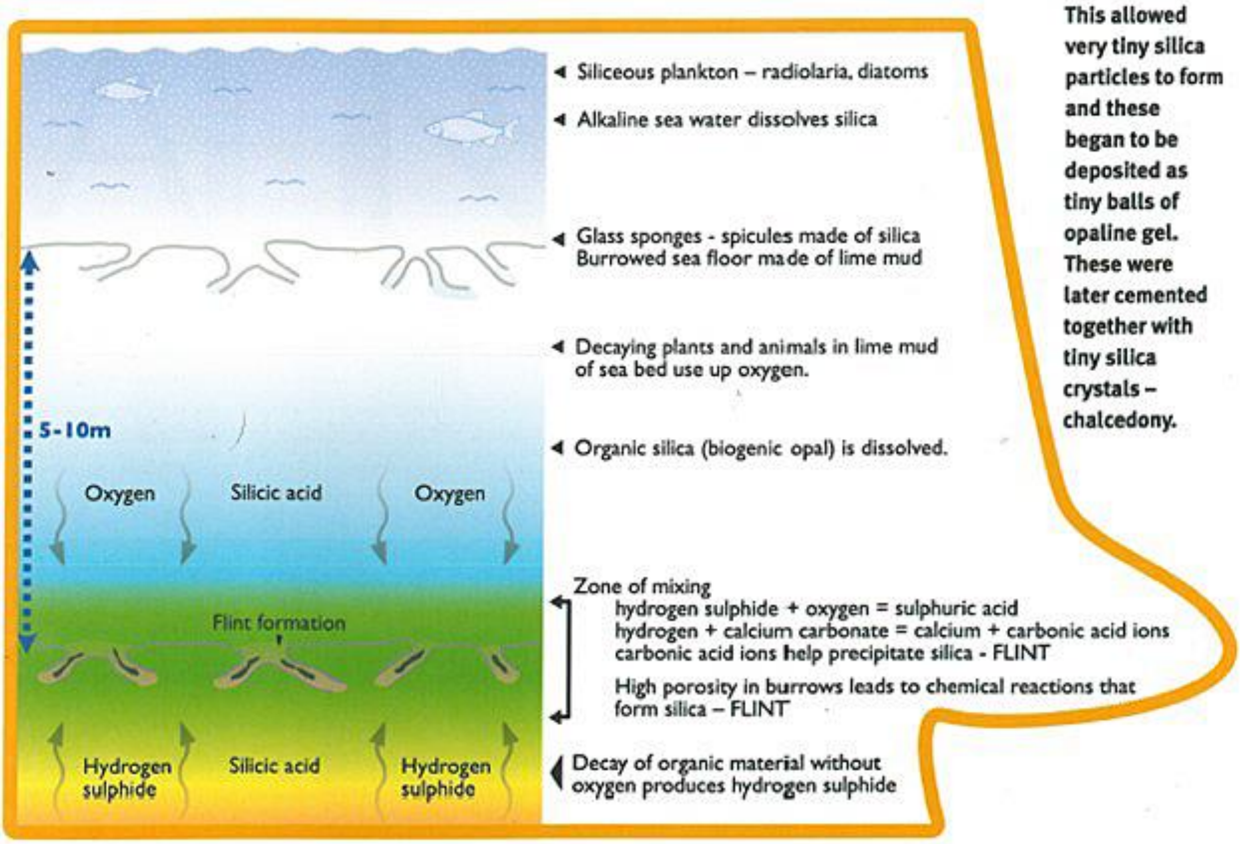


Usually, upon the death of a sponge, the spicules were dissolved in the slightly alkaline waters at the bottom of the Chalk Sea. These silica-rich solutions went into the chalky mud of the sea bed. They were collected inside the burrows made by creatures such as sea urchins and lobsters, as well as soft bodied worms, which made their homes within the sea bed sediments – much like ragworms whose casts we see on beaches today when the tide goes out. When the creatures living on or in the seabed died, they were buried and they began to decay. If they decayed deeper in the sea bed where no oxygen was available, their decay made the waters more acid.

When acid meets alkaline...

Where the silica-rich alkaline waters from the sea floor mixed with the acid solutions rising from deeper in the sea bed, they were neutralized.

This allowed very tiny silica particles to form and these began to be deposited as tiny balls of opaline gel. These were later cemented together with tiny silica crystals – chalcedony.



A slow build-up of chalk

The mixing layer remained at the same depth for some considerable time. This is because the chalk was deposited very slowly, giving rise to the separate layers of flint in the chalk. More and more flint layers formed in later deposits of chalk and this is well seen in the cliffs of Sussex. The Chalk in Lincolnshire and Yorkshire was deposited even more slowly in a backwater of the main sea, so that continuous layers of flint formed, called tabular flint.

Burrowing for more knowledge

The shapes of the flint nodules pick out the burrows of the various creatures. There are large burrows as thick as your arm. Sometimes these include sea urchins "caught in the act" of burrowing! Others are thin, intricate networks in burrows formed by much smaller creatures.

Worn nodules often have strange shapes, looking like antlers or twigs and sometimes with a hole to form a lucky 'hagstone'. Sometimes you can see the claw marks of the prawns or lobsters that made the original burrow.

So what sort of rock is flint – sedimentary, metamorphic or igneous? Or is it a mineral perhaps? As yet, it's uncertain how to describe it.

Reference:

Rockwatch Magazine, Issue 91, August 2022

Field Trip to Anglesey 16 - 19 October 2025

By Mike Millar, with grateful thanks to Rob Crossley for proof reading & correcting the errors.

The geology of Anglesey is characterized by the Mona Complex, a collection of metamorphosed late Precambrian to Cambrian rocks like gneisses, schists, and volcanic lavas. These older rocks were intensely deformed during mountain-building events which provided sediment sources for Ordovician and Silurian marine deposits and interbedded volcanic rocks, which in turn were more gently folded. More recently, glacial activity has smoothed the landscape and left extensive deposits, with the overall rugged features reflecting the underlying bedrock structure and glacial ice flow direction. Anglesey is designated as a Global Geopark validated by UNESCO.

Our field trip leader was Dr. Robert Crossley. Rob is a senior geologist with consulting firm Viridien and is also the joint managing director and events coordinator for GeoMôn Global Geopark. Under the guidance of Rob, the group was able to see some spectacular examples of Island's geological features and discuss their origins and subsequent evolution and development.

Our group consisted of members of the FGS and the Open University Geological Society, and we were based at the Trecastell Hotel in Bull Bay, just north of Amlwch. The field trip was organised by Tessa Seward.

Figure 1: Group photo at the Marquis of Anglesey monument

Day One

On the first evening, Rob gave us an introduction to the geology of Anglesey and the history of the geological exploration of the island.

Much of Anglesey's early sedimentation, deformation and metamorphism took place in an orogenic belt setting close to the South Pole. Between 650 Ma and 514 Ma (million years ago), the geological setting of Anglesey changed from widespread glaciation near the South Pole to lying in an active tectonic mountain belt a little further north. Rob was at pains to point out that dating is only approximate as very little radiometric dating has been done on the Island.

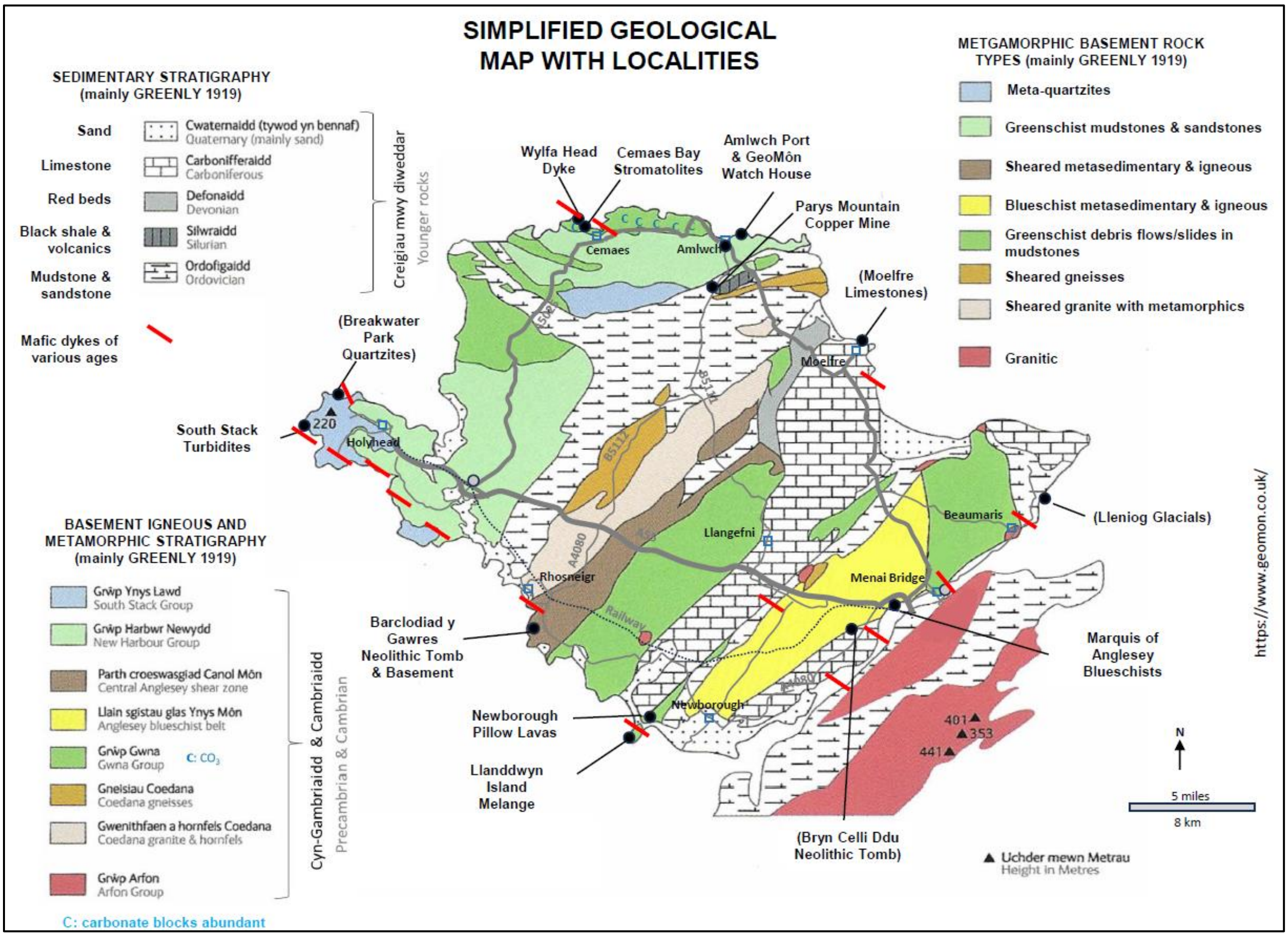


Figure 2: Simplified geological map of Anglesey. (Credit: GeoMôn)

By the Carboniferous, plate tectonics had carried Anglesey into the Tropics. By the Palaeogene (c.50 Ma) Anglesey experienced a series of mafic igneous dyke swarms concurrent with break-up of America from Europe and the opening of the Atlantic Ocean.

With regards to the history of the geological exploration of the island, John Henslow published the first substantial geological map of Anglesey in 1822. Edward and Annie Greenley published a much more detailed map in 1919, and the current British Geological Survey map of Anglesey is still largely their work.

Figure 3: Gwna Group sediments at Newborough Warren. (Credit: M Millar)

Day Two

Our first stop was at Newborough Warren and Llanddwyn Island, where we saw pillow lavas, melange and associated meta-sediments of the Gwna Group. All the exposures at this site showed signs of considerable syn- and post-depositional tectonic activity.

At Newborough Warren, we saw deep water fine grain sediments and metasediments all showing signs of syndepositional folding, slumping and faulting (Fig. 3). Colours vary with iron and quartz content. There is a probability that some of the quartz is biogenic, derived from siliceous plankton, and a research project is planned to investigate whether it is possible to extract microfossils from these mudstones and date them.

Jasper is present in varying amounts, possibly related to hydrothermal activity (Fig. 4). Despite its intense red colour iron content can be quite low at less than 5%.

Figure 4: Jasper. (Credit: M Millar)

The pillow lavas at Newborough Warren and on Llanddwyn island probably just predate the sediments (Fig. 5). They too show significant movement, some currently tilted up to 90°. These pillow lavas were formed when basalt magma erupted onto the sea floor. The 'pillow' structures are seen as large ovoid shapes with a concave base, and as one blob of magma cools in contact with seawater, it forms a glassy skin and then sags down over the preceding pillows.

Figure 5: Pillow Lavas at Newborough Warren. (Credit: S Pritchard)

On the beach at Newborough Warren we saw a Pleistocene glacial till deposited between two outcrops of pillow lavas (Fig. 6). This till is truly a boulder clay, with cobble sized angular clasts in a heavily compacted clay matrix.

On the tip of Llanddwyn Island we saw the internationally significant Gwna Mélange first described by Edward Greenly and included in International Commission on Geoheritage (IUGS) "First 100 IUGS-Geological Heritage Sites" (Fig. 7).

A melange is a breccia that lacks clear internal bedding and consists of a chaotic mixture of clasts of varying compositions and sizes in a fine-grained matrix. It can form when sediments accumulate in the trench of a subduction zone due to gravitational sliding and/or being scraped off the descending plate. They are then incorporated into the base of the accretionary wedge (a wedge-shaped accumulation of sediments that develops on the overriding plate along the trench) where they are deformed and metamorphosed (Leeds Uni). On Llanddwyn Island, the melange has a mix of conglomerates, sandstones, mudstones, limestones, and schists, and is cut across by dykes. The more brittle sediments have quartz veins.

From Newborough Warren, we moved north to South Stack on the western edge of Holyhead Island.

The South Stack Formation is composed of grey to white turbiditic metasandstone and interbedded blue-grey silty metamudstone of Cambrian or early Ordovician age (BGS) and are most likely to be turbidites (Fig 8). These metasediments show spectacular post depositional thrusting and folding.

Cambrian-age worm burrows are reported to occur in the rocks of the South Stack group, but we didn't find any.

Day Three

Our first stop on day three took us to Wylfa Head on the north coast of Anglesey. The Wylfa A nuclear power station dominates the headland, this is no longer operative and is being decommissioned. Much of the rest of the headland is a local nature reserve. We were there to see an exposure originally described by Henslow over 200 years ago, but still recognisable (Fig. 9). We saw Gwna Group metasediments and quartzites cut through by a Palaeogene dyke.

Further round to the east along the coast we saw more Gwna Group melange (Fig. 10). This was somewhat different to the melange on Llanddwyn Island, as it was much coarser grained with large boulder size clasts. It is possibly that some of these are glacial in origin from Cryogenian "Snowball Earth", predating the Ediacaran Period age suggested on the BGS map viewer/lexicon. There were dolomite boulders included here, which gave a minor fizz with HCl.

Like most of these old rocks we saw on Anglesey, this melange has suffered considerable tectonic activity, with quartz veins emplaced and slickensides and possibly slickecrysts in evidence. *(Please see references below for more on slickencrysts).*

Stop two on Day Three was on the coast just north of Cemaes. The GeoMôn Geopark has a nice selection of illustrated Anglesey rock types on display on the headland, as well as information boards.

Figure 6: Boulder clay at Newborough Warren. (Credit: M Millar)

Figure 7: Gwna Melange at Llanddwyn Island. (Credit: T Seward)

Figure 8: South Stack turbidites showing folding and thrusting. (Credit: S Pritchard)

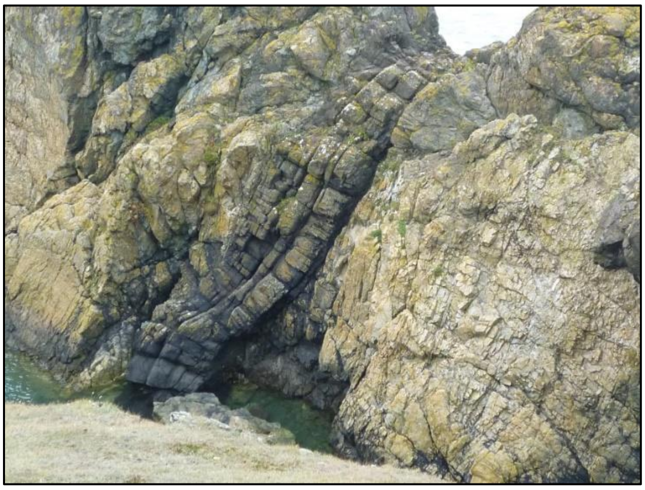


Figure 9: The "Henslow exposure", Gwna group rocks cut through by Palaeogene dyke.

Figure 10: Gwna Melange from Wylfa Head.

(Credit: M Millar)

We are still within the Gwna Group deposits, but here they have a number of dykes cutting through which have been eroded more than the country rock (Fig. 11). But the 'star' exposures at this location were ancient stromatolites. These are believed to be c.860 Ma (Fig. 12).

Figure 11: Gwna Group rocks with eroded dykes cutting through at Cemaes.

Figure 12: Precambrian stromatolite from Cemaes Limestone.

(Credit: M Millar)

Our third stop on Day Three was at Parys Mountain to view the old copper workings (Fig. 13). Parys Mountain is to south of Amlwch. Although it is called a mountain, it is only about 150m high.

The rocks at Parys Mountain form part of a late Ordovician/early Silurian volcanogenic massive sulphide deposit. As deep-water mudstones were deposited, submarine volcanic and hydrothermal activity resulted in extensive mineralisation and the formation of iron, copper, lead and zinc sulphide ore deposits (Fig. 14). The ores occur in disseminated layers, veins and lenses and are found in the mudstones, cherts and with the rhyolitic lavas. In places, syn-volcanic slumping has disrupted the layers. During Caledonian/Acadian deformation, these were folded into a tight, overturned syncline with cleavage development in the finer grained rocks and extensive silicification.

The wide variety of colours seen in outcrop are due to variations in the oxidation state of the weathered iron-rich sulphides. The orange colour of many of the ponds is due to mine drainage with high concentrations of sulphuric acid. Mining activity dates back to the Bronze age and Roman times. The main period of copper extraction was from the late 18th and 19th century, by the early 20th century mining had more or less ceased (Leeds Uni).

The ores were extracted from two main open cast pits and a series of underground mines. Today exploitation rights are owned by Anglesey Mining PLC, who are exploring the possibility of further copper extraction should technical and economic conditions permit.

Most of the variable colours on the exposures are due to weathering of iron pyrite in the rocks. At one time, miners supplemented their income by extracting these pigments and selling them to a paint factory in Amlwych as dyes (Fig. 15).

The final location on day three was Port Amlwch. Here we spent time in the excellent GeoMôn Geopark visitors centre. We also discussed the various phases of the development of the port, much of which was related to the changing fortunes of the Parys Mountain copper mine.

Day Four

The first stop on day four was back to Holyhead Island, where we looked at the Holyhead Formation quartzite. This metamorphic bedrock formed between 635 and 541 Ma during the Ediacaran period (BGS). The quartzites showed extensive quartz veins. These have been heavily quarried and were used to build the breakwaters for the port of Holyhead in the 19th century (Fig. 16).

We also saw a small outcrop of New Harbour Group, Mica schist and psammite, and saw their use in local Victorian buildings (Fig. 17).

Our second stop on day four was at the Marquis of Anglesey monument to view the blue schist. This is the best exposure of the Anglesey Blueschist Belt, a complex zone of rocks comprising mainly blueschist, greenschist and metabasite. It stetches from Llanddwyn Island across to Pentraeth and as far south as the Menai Strait. These rocks were formed at a destructive plate margin. Although some seafloor rocks were scraped

Figure 13: Parys Mountain, the Great Open Cast Pit. (Credit: M Millar)

Figure 14: Parys Mountain, Silurian Black Shale. (Credit: S Pritchard)

Figure 15: Parys Mountain, different coloured spoil heaps, reflecting varying iron content. (Credit: M Millar)

off the descending plate to form the melange, much continued down the subduction zone (Ref: GeoMôn).

Figure 16: Holyhead Quartzite from Breakwater Park. (Credit: M Millar)

Figure 17: New Harbour green schist from Breakwater Park. (Credit: S Pritchard)

The rocks are metamorphosed equivalents of the pillow lavas and seafloor sediments we saw at Llanddwyn Island with the degree of metamorphism reflecting their relative depths of burial. It is estimated that the basaltic pillow lava was converted to blueschist at a depth of around 35 km (Ref: GeoMôn).

Figure 18: Anglesey Blueschist at the Marquis of Anglesey monument, with the more resistant boudinage and the green schist for comparison. (Credit: T Seward)

The blueschist gets its name from the diagnostic mineral, glaucophane, which is formed under high pressure but relatively low temperature of <500^{O}C, which is low for rocks at 35 km depth (Ref: GeoMôn).

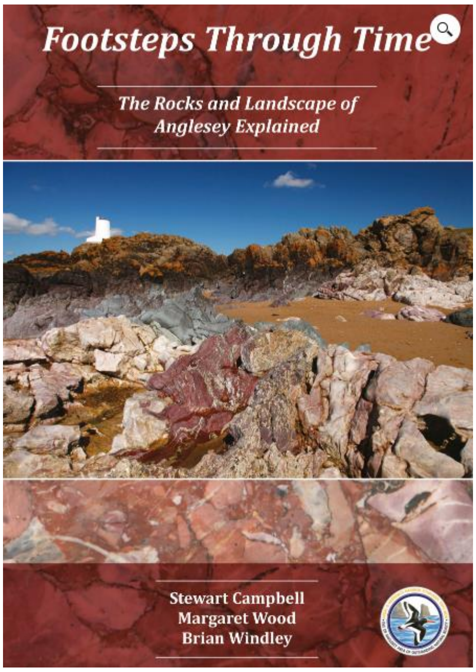
The blue colour is the mineral glaucophane, rather than the rock and is only seen in thin section under the microscope. In contrast the greenschist formed from seafloor sediments that had travelled about 15km down and a temperature of only ~300^{O}C. The greenschist gets its name and colour from chlorite, a mica-related mineral (Ref: GeoMôn).

Acknowledgements.

- With thanks to Rob Crossley for his incredible knowledge and insight, and his patience and understanding.
- With grateful thanks to Tessa Seward for organising this trip.
- Many thanks to Sally Pritchard for the photos.

For more information please see:

- GEOMÔN GLOBAL GEOPARK - https://www.geomon.org.uk/
- BGS map viewer and lexicon - https://www.bgs.ac.uk/
- University of Leeds - https://accessanglesey.leeds.ac.uk/home/the-geology/
- Wikipedia - https://en.wikipedia.org/wiki/Geology_of_Anglesey
- Anglesey Mining - https://www.angleseymining.co.uk/geology/
- Footsteps Through Time, 2014 – Stewart Campbell, Margaret Wood and Brian Windley



Slickencrysts - examples of use in publications:

Ponterwyd Quarry | GeoGuide W.R. Fitches

A feeble crenulation cleavage is axial planar to the steeper folds. Bedding surfaces in this fold complex are commonly slickensided (striations and quartz slickencrysts) as a result of flexural slip during folding.

https://geoguide.scottishgeologytrust.org/p/gcr03/gcr03_ponterwydquarry

The spatial distribution and geochemical variation of fault ...

ScienceDirect.com

https://www.sciencedirect.com › article › abs › pii

by N Debenham · 2020 · Cited by 3 — A series of integrated geochemical analyses have been undertaken on calcite and gypsum veins and slickencrysts (i.e. elongate mineral precipitates formed).

Wiley

https://novel-coronavirus.onlinelibrary.wiley.com ›abs

The mineralization within shear fractures and faults commonly also shows an asymmetrically stepped habit with lineations called “slickencrysts”. Where only ... Bramcrag Quarry.

News

Vital carbon storage industry gains momentum with landmark appraisal well

NSTA ***14 October 2025***

- ***First appraisal well drilled on first-round carbon storage licence for the Bacton CCS project***
- ***Significant milestone reached in UK's energy transition***
- ***Project builds on recent successes of permit awards for Liverpool Bay CCS and Northern Endurance***

The UK's carbon storage industry has reached an important milestone with the drilling of an appraisal well on the Hewett field, in the Southern North Sea, for the **Bacton CCS project**.

It is the first carbon storage appraisal well to be drilled on acreage licensed by the North Sea Transition Authority (NSTA) as part of the world's first large-scale carbon storage licensing round in 2023.

The appraisal well, operated by **global energy company Eni**, is an important step towards assessing the carbon storage potential of the UK continental shelf (UKCS). The basin has up to 78 gigatonnes of potential storage capacity in depleted reservoirs and saline aquifers, enough to sequester all the CO2 emitted in the UK since the industrial revolution.

The NSTA estimates that up to 100 stores may need to be appraised to identify the best candidates for storage and help the UK reach its net zero target by 2050.

Hewett, 18 miles off the Norfolk coast, was one of the UKCS's longest serving gas fields. Its original operator, Phillips, started production from the field in 1969, making Hewett only the third North Sea field to reach this stage, after West Sole and Leman. The field had produced 3.5 trillion cubic feet of gas by the time it permanently shut down in 2023.

Now Eni wants to give Hewett a new lease of life as a carbon store, underpinning its Bacton CCS project. It is thought to be capable of storing up to 10 million tonnes of CO2 per year emitted from the Bacton and wider Thames Estuary area, as well as potentially offering decarbonisation solutions for emitters across the European Union.


The Valaris 72 rig

Eni contracted the Valaris 72 rig to drill the well – and work got under way in May 2025. Extensive data sampling was conducted, including cutting 270 ft of core and performing a nitrogen injection test, before plugging and abandoning it.

The data collected will inform the development plans for the Bacton CCS project by enabling the operator to build a fuller picture of the reservoir's post-production characteristics and conditions, including reservoir pressures, possible injection rates, wellbore integrity and leakage risk.

In time, the data will be made available on the NSTA's National Data Repository, helping to provide a richer data set to all operators looking to evaluate and derisk similar stores.

This is just the latest example of the UK's exciting progress on the path to becoming a global leader in carbon capture and storage, an industry estimated to support 50,000 skilled jobs in the long-term.

The NSTA awarded permits for the UK's first two carbon storage projects to the Northern Endurance Partnership in December 2024 and Liverpool Bay CCS, also operated by Eni, in April 2025. Together, they could store more than 200 million tonnes of CO_2, equivalent to taking 110 million cars off the road for a year. The permits also unlocked £6 billion worth of supply chain contracts and 4,000 construction jobs.

In May, the NSTA put out a call for nominations for potential carbon storage locations to encourage companies to focus on areas where they have already done some technical work, leading to higher quality applications and likely cutting time to project delivery.

The NSTA offered 21 licences in the UK's inaugural carbon storage licensing round, which concluded in September 2023. Licence CS008, which covers Hewett, is held by Bacton CCS Limited, a subsidiary of Eni CCUS Holding.

The well on Hewett is also the first to be consented as a dedicated carbon storage appraisal well via our Well Operations Notifications System.

Andy Brooks, NSTA Director of New Ventures, said: "The carbon storage industry has entered an exciting period of delivery, with two multibillion-pound projects getting the go-ahead in the past year, unlocking thousands of supply chain jobs. Long-held ambitions for this industry, which is essential to the UK's energy transition, are rapidly becoming reality.

"The appraisal well on Hewett – the first to be drilled on acreage awarded by the NSTA as part of the world's first large-scale carbon storage licensing round – is yet another important milestone for the sector as it looks to assess further stores which should progress towards development. The NSTA continues to work with licensees to ensure that their plans are the right ones."

Note:

- In September 2023, the NSTA awarded 21 licences as part of the UK's first carbon-storage licensing round. Those licences were in addition to six which had been awarded previously.
- A carbon storage appraisal well was drilled on the Endurance structure in 2013.

Reference:

https://www.nstauthority.co.uk/news-publications/vital-carbon-storage-industry-gains-momentum-with-landmark-appraisal-well/

Scientists discover new way to predict next Mount Etna eruption

Sascha Pare, LiveScience ***19 October 2025***

Researchers analysed changes over time in the ratio of small earthquakes to bigger ones beneath Mount Etna and found a strong correlation with the volcano's activity over the past 20 years.

A newly discovered way to monitor magma movements beneath Mount Etna could help scientists forecast when it might erupt.

Mount Etna, located on the Italian island of Sicily, is Europe's largest active volcano. Humans have documented its activity for the past 2,700 years, but the volcano's eruptive history stretches as far back as 500,000 years.

Etna's most recent eruption, in June 2025, ejected a giant, 4-mile-high (6.5 kilometres) cloud of ash and triggered an avalanche of hot lava blocks and other debris. The eruption was expected, so officials were able to issue warnings on the morning of the event, but predictions don't always hit the nail on the head.

A powerful eruption rocked Mount Etna on June 2, 2025. (Image credit: Salvatore Allegra/Anadolu via Getty Images)

The novel method could make it easier to predict Mount Etna's eruptions. In a new study, researchers at **Italy's National Institute of Geophysics and Volcanology** (INGV) analysed a parameter called the **b value**, which describes the ratio of low-magnitude to high-magnitude earthquakes in a region of Earth's crust. This ratio can change as magma rises through the crust to the summit of a volcano, the researchers reported in a study published Oct. 8 in the journal ***Science Advances.***

"Changes in the b value over time reflect how the stress inside the volcano is evolving," study lead author Marco Firetto Carlino, a geophysicist at INGV's Etna Observatory, told **Live Science** in an email. "Since magma ascent induces stress changes within the crust, tracking the b value can help reveal different stages of magma transfer from depth to the surface."

The b value is an established parameter in volcanology, but the researchers examined it in a novel way, with an updated statistical model. By compiling 20 years' worth of earthquake data from Mount Etna, they found a **"very strong" correlation between the b value and Etna's volcanic activity**, Firetto Carlino said.

Mount Etna sits in the collision zone between the African and European tectonic plates. As a result, a vertical fracture in Earth's crust known as a strike-slip fault underlies the volcano, thus facilitating the rise of magma to the surface, according to the study.

The crust beneath Mount Etna is up to 19 miles (30 km) thick. Magma rises through this volume before an eruption, but instead of replenishing a single magma chamber, the molten rock feeds a series of interconnected storage zones that are embedded in the crust at different depths.

The deepest magma storage zone is 7 miles (11 km) below sea level, Firetto Carlino explained, and it feeds an intermediate storage system with different zones likely extending 2 to 4 miles (3 to 7 km) deep. As magma rises, it travels through an intricate network of fractures and eventually reaches the last storage zone, which is located above sea level inside the volcano edifice.

The researchers had a wealth of data to work with and extract b values from, due to Etna's frequent activity. They analysed seismic patterns in the 19 miles of crust beneath the volcano from 2005 to 2024, paying particular attention to how these patterns varied between crustal regions.

Generally, regions of Earth's crust with active magma storage zones show higher b values than more stable regions do, because the active zones experience more small earthquakes than bigger ones.

"This happens because rocks affected by moving magma become weak and highly fractured," Firetto Carlino said. "For example, when magma inside a storage releases volatiles, they permeate the surrounding rocks, making it easier for small fractures to slip."

Conversely, regions of Earth's crust that are more stable typically experience more big earthquakes than smaller ones, because it takes more force to break the rock. "Rocks with good mechanical properties can store stress for longer periods," Firetto Carlino said. "When they finally break, they produce larger earthquakes, corresponding to lower b values."

So, by tracking the b value over time, it may be possible for researchers to follow the movement of magma through the deep crust to the first storage zone, up from there to the intermediate storage system, and up again to the shallow storage zone. **This method could help experts estimate the timings of eruptions at Mount Etna.**

"Monitoring the b value offers a powerful way to track magma movement within the crust and assess the volcano's evolving state before eruptions," Firetto Carlino said.

Mount Etna was a good test for the study due to its layered magma storage zones and enormous seismic catalogue, but the results might also apply elsewhere.

"In principle, the b value could also be used to track magma movements in other volcanic areas, provided that a sufficient number of earthquakes is available and that their locations are distributed across different crustal sectors, well constrained by previous geological studies," Firetto Carlino said.

Reference:

https://www.livescience.com/planet-earth/volcanos/scientists-discover-new-way-to-predict-next-mount-etna-eruption?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=8268DA87-C024-405E-A798-E6D26B489946&utm_source=SmartBrief

Rare half-pink rough diamond with 'astounding' weight of 37.4 carats discovered in Botswana

Sascha Pare, LiveScience ***23 October 2025***

Experts at a laboratory in Botswana managed by the Gemological Institute of America recently examined an extraordinary natural diamond with two distinct colour zones.

Miners have unearthed a rare, **two-coloured natural diamond in Botswana** — and experts say it likely formed in two stages.

The diamond is half pink, half colourless. It measures about 1 by 0.63 by 0.57 inches (24.3 by 16 by 14.5 millimetres) and weighs an "astounding" 37.41 carats (0.25 ounces, or 7.5 grams), according to the Gemological Institute of America (GIA), a nonprofit research centre based in Carlsbad, California.

The pink half probably formed first, but from what scientists know about colourful diamonds, there's a good chance that it wasn't always this rosy, Sally Eaton-Magaña, senior manager of diamond identification at GIA, said in a statement emailed to **Live Science**. "The pink section likely was initially colourless and then plastically deformed, perhaps by a mountain-forming event millions of years ago, resulting in its pink colour, with the colourless section forming at a later time," she said.

The boundary between the pink and colourless halves of the diamond is "sharp," experts said. (Image credit: Photomicrograph by Wanling Tan/GIA)

Pink diamonds are incredibly rare, and it's still unclear exactly how they form. Diamonds originate more than 100 miles (160 kilometres) beneath Earth's surface, inside a planetary layer called the mantle. Extremely high temperatures and pressure bind carbon atoms together into a tight lattice, and this structure can rise quickly to the surface through volcanism, giving us rough diamonds.

Diamonds can acquire colour through impurities that get locked inside the lattice, but this is very rare because few elements are small enough to penetrate the mineral structure. Another way diamonds can become tinted — usually green — is through radiation, if nearby rocks contain elements such as uranium that can "steal" carbon atoms and create vacancies in the mineral structure.

The diamond formed in two stages, with the pink half arising first. (Image credit: Tebogo Hambira/GIA)

But pink diamonds are the product of structural deformity, meaning their lattice structure has been bent or compressed through geological processes. Temperature and pressure conditions have to be just right for diamonds to turn pink, because too much deformation turns the gems brown.

"It's kind of like Goldilocks," Luc Doucet, a senior research geologist at Curtin University in Australia, previously told **Live Science**. "There are a lot of brown diamonds, and very, very few pink diamonds."

For a diamond to have two distinct colour zones, it must have formed in two phases, according to GIA. First, the pink half assembled and deformed; then, the colourless half sprouted, and its lattice remained unaffected by temperature and pressure.

The new diamond is not the first pink-and-colourless natural diamond ever discovered. However, GIA experts said similar diamonds they have examined were much smaller, weighing no more than 2 carats (0.014 ounces, or 0.4 g).

The new find is from **Botswana's Karowe mine**, which has previously yielded other spectacular diamonds. For example, it's where the second-largest rough diamond ever recovered — a giant, 2,488-carat (1.1 pounds, or 0.5 kilograms) gem dubbed the "Motswedi" diamond — and the 62-carat (0.44 ounces, or 12.4 g) "Boitumelo" pink diamond were discovered, GIA said.

Reference:

https://www.livescience.com/planet-earth/geology/rare-half-pink-rough-diamond-with-astounding-weight-of-37-4-carats-discovered-in-botswana?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-

62503D85375D&utm_medium=email&utm_content=84B3FE21-FDBA-469E-BA5E-997342F8CAC3&utm_source=SmartBrief

First-ever 'mummified' and hoofed dinosaur discovered in Wyoming badlands

Patrick Pester, LiveScience **29 October 2025**

Researchers have unearthed two dinosaur "mummies" in the badlands of Wyoming, confirming duck-billed dinosaurs had hooves, alongside a string of other discoveries.

Two extremely rare dinosaur "mummies" found in the badlands of Wyoming are the first examples of hoofed reptiles, according to a new study.

Researchers discovered the pair of 66 million-year-old duck-billed dinosaur *(Edmontosaurus annectens)* skeletons complete with skin, spikes and hooves, as if the creatures had been naturally mummified.

The fossils aren't true mummies, as their original tissues have been replaced with rock, but they give scientists an unprecedented look at duck-billed dinosaur biology, confirming they had hooves. The researchers reported their findings Oct. 23 in the journal **Science.**

This mummified duck-billed dinosaur fossil is a juvenile Edmontosaurus annectens, nicknamed "Ed Jr." (Image credit: Photograph courtesy of Tyler Keillor/Fossil Lab))

"It's the first time we've had a complete, fleshed-out view of a large dinosaur that we can really feel confident about," study senior author Paul Sereno, a professor of organismal biology and anatomy at the University of Chicago, said in a statement.

Duck-billed dinosaurs used their hooves to stomp through mud at the end of the Cretaceous period (145 million to 66 million years ago). They lived alongside other large dinosaurs, such as *Tyrannosaurus rex* and *Triceratops*, just before the age of dinosaurs came to a crashing end when a massive asteroid hit Earth and wiped them all out (except for birds).

Dinosaur mummies are exceptionally preserved fossils that contain a clay copy of dinosaur skin and other organic tissues. Several of these fossils were discovered in Wyoming in the early 1900s, which inspired the new research. Sereno and his colleagues found the two new specimens by tracking down the locations of the historical discoveries, using old photographs and letters, and mapping out what they described as a "mummy zone."

One of the newly discovered *Edmontosaurus* specimens, nicknamed "Ed Jr.," was a late juvenile and estimated to be about 2 years old at the time of its death. The other specimen, nicknamed "Ed Sr.," was an early adult about 5 to 8 years old when it perished.

The researchers reconstructed the dinosaurs' biology, movement and preservation using a variety of imaging techniques, including X-rays and micro-CT scans, as well as by analysing clay, examining the site where they were discovered, and studying fossilized duck-billed dinosaur footprints.

The dinosaurs had a fleshy crest running along their neck and trunk that transitioned into a row of spikes at the tail. Small, pebble-like scales also peppered the animal's lower body and tail, the largest of which were only 0.2 inches (4 millimetres) across — tiny considering the dinosaur could grow to more than 40 feet (12 meters) long, according to the statement.

Edmontosaurus annectens as it appeared in life. (Image credit: Artwork by Dani Navarro)

The team determined that the mummification-like preservation occurred because the dinosaurs' bodies were dried out in the sun — they may well have perished in a drought — before being quickly covered in a flash flood. Static electricity, reacting with microorganisms on the surface of the carcasses, then sucked clay from the wet sediment to form a thin template later around the remains. The organic material then slowly decayed and was replaced with rock.

"There are so many amazing 'firsts' preserved in these duck-billed mummies — the earliest hooves documented in a land vertebrate, the first confirmed hooved reptile, and the first hooved four-legged animal with different forelimb and hindlimb posture," Sereno said.

Reference:

https://www.livescience.com/animals/dinosaurs/first-ever-mummified-and-hoofed-dinosaur-discovered-in-wyoming-badlands?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=E7CE22C8-D34B-4F60-B084-1EAC80C82A8B&utm_source=SmartBrief

Researchers discover new tyrannosaur species in 'duelling dinosaurs' fossil

Analysis of Montana fossils shows the battling predator was a fully grown Nanotyrannus, not a young T rex

Nicola Davis, Guardian Science correspondent ***30 October 2025***

The fossilised remains of two dinosaurs locked in combat have unleashed a fresh drama, suggesting diminutive specimens thought to be *Tyrannosaurus rex* teenagers could instead be a ***separate, smaller species***.

The "duelling dinosaurs" fossil, which reveals a triceratops in battle with a medium-sized tyrannosaur, was unearthed in Montana by commercial fossil hunters in 2006 and dates to shortly before the asteroid strike that ended the reign of the dinosaurs 66m years ago.

It only became available for scientific research after it was acquired by the North Carolina Museum of Natural Sciences (NCMNS) in recent years.

Dr Lindsay Zanno said: 'The anatomy of Nanotyrannus … is incompatible with the hypothesis that this skeleton is a teenage T rex.' (Photograph Credit: Marc Hall/AP)

Now researchers say a detailed analysis of the fighting tyrannosaur reveals it is not a juvenile *T rex* as many had thought but an adult of a different species, *Nanotyrannus lancensis*.

"Our specimen is a fully grown *Nanotyrannus* weighing only 1,500 pounds after two decades of growth," said Dr Lindsay Zanno, a co-author of the study from North Carolina State University and the head of palaeontology at NCMNS.

"The anatomy of *Nanotyrannus*, from its higher tooth count, enlarged hands, shorter tail, unique pattern of cranial nerves and sinuses and smaller adult body size, is incompatible with the hypothesis that this skeleton is a teenage *T rex*," Zanno said.

The name *Nanotyrannus lancensis* was previously given to a small skull that was reported in the Hell Creek Formation of Montana in 1946. However, experts later argued that specimen, known as the Cleveland skull, was actually a juvenile T rex.

Now the study by Zanno and colleagues, published in the journal ***Nature***, reveals *Nanotyrannus lancensis* was indeed a species in its own right that lived at the same time and inhabited the same ecosystems as T rex.

What's more, the team say the skeleton of a juvenile dinosaur named Jane found in the Hell Creek Formation in 2001 is not a young T rex either but a new species of *Nanotyrannus*. "Our study suggests some specimens previously argued to represent juveniles of T rex are instead *Nanotyrannus*," Zanno said.

She said the results had important implications. "For decades, palaeontologists have unknowingly used *Nanotyrannus* specimens as a model for teenage T rex to understand the biology of Earth's most famous dinosaur – studies of its locomotion, growth, diet and life history. Those studies need a second look," she said.

Prof Steve Brusatte, of the University of Edinburgh, who was not involved in the work, said that for many years in his research on tyrannosaurs he had considered a set of smaller skeletons found in the same rocks as T rex fossils to be T rex juveniles.

"I think new evidence from this exquisite new specimen in the North Carolina Museum of Natural Sciences shows that I was wrong – at least in part," he said, adding that the analysis of the duelling tyrannosaur offered "solid evidence" *Nanotyrannus* was real.

But Brusatte said he was not convinced there were multiple species of *Nanotyrannus*, while he also pointed out that the multitude of fossilised T rex adults that had been unearthed suggested there should be fossilised juveniles too.

"So, I'm not yet ready to proclaim every smaller tyrannosaur skeleton to be *Nanotyrannus*," he said. "Some of these must be juvenile T Rexes, and I think it is ultimately going to be very hard to tell apart adult or near-adult *Nanotyrannus* from teenage T rex."

References:

https://www.theguardian.com/science/2025/oct/30/researchers-discover-nanotyrannus-tyrannosaur-species-in-duelling-dinosaurs-fossil

https://www.livescience.com/animals/dinosaurs/i-was-wrong-dinosaur-scientists-agree-that-small-tyrannosaur-nanotyrannus-was-real-pivotal-new-study-finds?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=12D81848-348F-46CF-BA9B-1C1CCAEC42F6&utm_source=SmartBrief

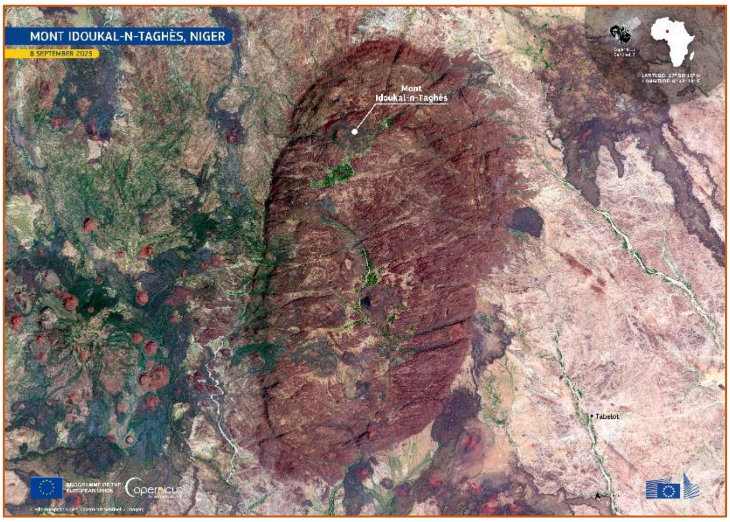
Image of the Day 1

Mont Idoukal-n-Taghès, Niger

Date: 28/10/2025

Location: Niger

Credit: European Union, Copernicus Sentinel-2 imagery



Rising to 2,022 metres, Mont Idoukal-n-Taghès is the highest peak in Niger and a prominent feature of the Aïr Massif in the north of the country. This mountainous region of volcanic origin stands out as a biodiversity hotspot within the arid expanse of the southern Sahara.

This natural-colour image, acquired on 8 September 2025 by one of the Copernicus Sentinel-2 satellites, shows Mont Idoukal-n-Taghès and its surroundings in northern Niger. The area, designated as a UNESCO Biosphere Reserve, plays a key role in preserving biodiversity and supporting traditional livelihoods in one of the driest regions on Earth.

The Copernicus Sentinel satellites provide essential data for monitoring remote regions worldwide, including desert areas. These observations are essential for tracking environmental changes and informing efforts to preserve and protect vulnerable ecosystems.

Reference:

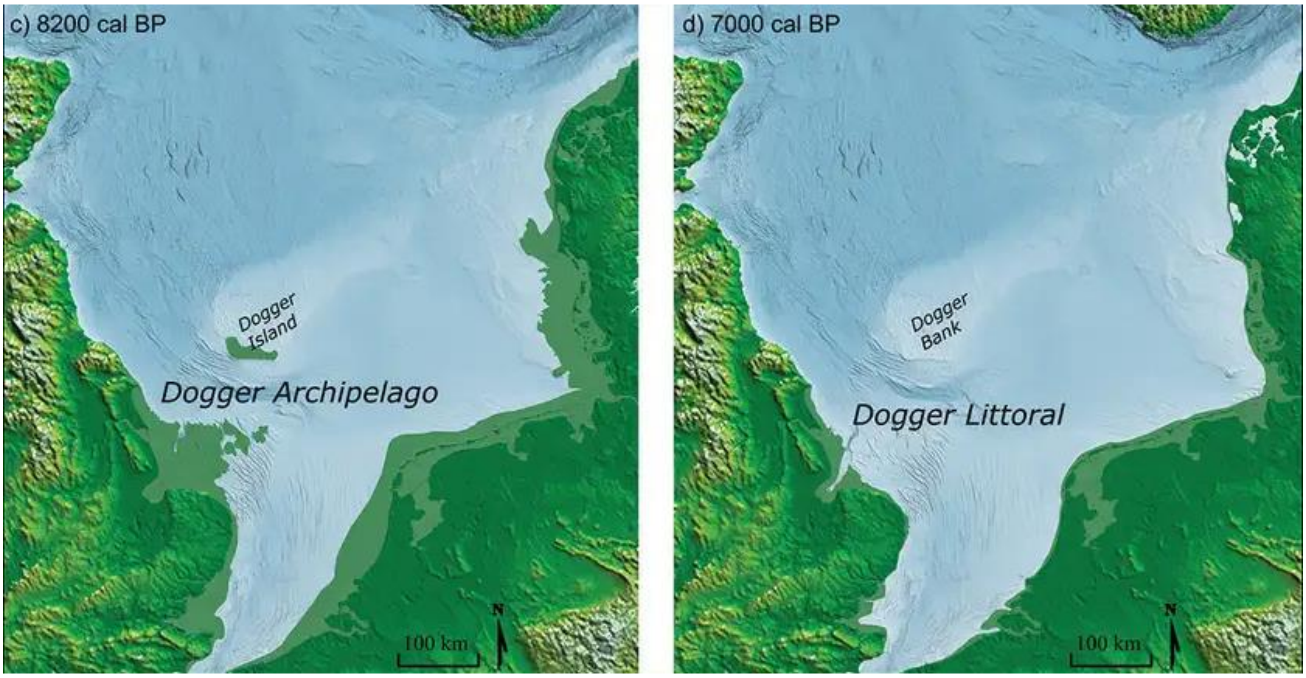
https://www.copernicus.eu/en/media/image-day-gallery/mont-idoukal-n-taghes-niger

ka (kilo-annum)	**=**	**thousand years** (10^3)	**One thousand seconds**	**=**	**16.67 minutes**
Ma (mega-annum)	**=**	**million years** (10^6)	**One million seconds**	**=**	**11.57 days**
Ga (giga-annum)	**=**	**billion years** (10^9)	**One billion seconds**	**=**	**31.71 years**
Ta (tera-annum)	**=**	**trillion years** (10^{12})	**One trillion seconds**	**=**	**31,709.79 years**

Into The Archives

Tiny island survived tsunami that helped separate Britain and Europe

Michael Marshall, New Scientist **1 December 2020**



By 8200 years ago (8200 calibrated years before the present), Doggerland existed as a small archipelago, which had drowned by 7000 years ago. (Credit: M. Muru)

The Atlantis of northern Europe sank under the seas slowly, rather than being obliterated by a tsunami. A little over 8000 years ago, a devastating tsunami swept across the North Sea, striking a small island that existed there at the time. But new evidence suggests the wave didn't permanently swamp **Dogger Island** and its surrounding archipelago. People may have lived on the remaining land for centuries afterwards.

Between 110,000 and 12,000 years ago, Earth was in the grip of a glacial period – sometimes rather misleadingly called the last ice age. Because so much water was locked up in ice at the poles, sea levels were many metres lower. This means land that is now underwater was exposed.

This includes much of what is now the southern North Sea, between Britain and mainland Europe. As a result, Britain was connected to Europe by a fertile plain called **Doggerland**.

What happened to it? We know much of the polar ice melted, causing sea levels to rise around the world. By about 8200 years ago, Doggerland had gradually shrunk in size, leaving Dogger Island surrounded by a small archipelago *(see image above).* There is some evidence that this final piece of Doggerland had a dramatic end.

About 8150 years ago, a submarine landslide occurred off the coast of Norway, dubbed the **Storegga Slide**. This created a tsunami in the North Sea that hit the surrounding coastlines – in many areas, the wave was many metres deep. Many researchers have argued that the Storegga tsunami helped cut Britain off from Europe.

The issue is that so far, we have had no archaeological records of the tsunami's impact on Doggerland. "We know essentially nothing about the actual impact on the areas which were patently most susceptible to be hit," says Vince Gaffney at the University of Bradford in the UK.

As part of a long-term project to map Doggerland, Gaffney's team took sediment cores from the seabed off the coast of East Anglia, in the east of England. The cores contain traces of the Storegga tsunami, such as broken shells. It seems the tsunami slammed up a river valley, ripping trees from the sides – and leaving their DNA in the sediments for the team to find. But the water soon retreated and later sediments suggest the area was above water again.

Gaffney's team compiled existing data from around the North Sea. The researchers argue this suggests the Dogger archipelago survived for several more centuries. By 7000 years ago, it was underwater and had become what is now **Dogger Bank**: a submarine sand bank.

Simply obtaining the sediment cores was "a major undertaking", says Karen Wicks at the University of Reading in the UK.

"It kind of confirms things we'd been thinking anyway," says Sue Dawson at the University of Dundee in the UK.

Simulations of the tsunami had suggested it couldn't have swamped Doggerland, and in some places, such as northern Norway, the wave may have been fairly small. The crucial factor is the exact shape of the coastline and nearby seabed, which affects how high the water rises, says Dawson.

Wicks has previously found evidence that the hunter-gatherer population in north-east Britain fell around the time of the tsunami. She argues that the tsunami was part of a "perfect storm" of environmental crises in the region, as it combined with a period of climate cooling 8200 years ago.

However, almost nothing is known about the people living on Doggerland. Last year, Gaffney's team recovered the first known artefacts: two small pieces of flint. As a result, it is unclear how long people continued living there as the area slipped beneath the sea.

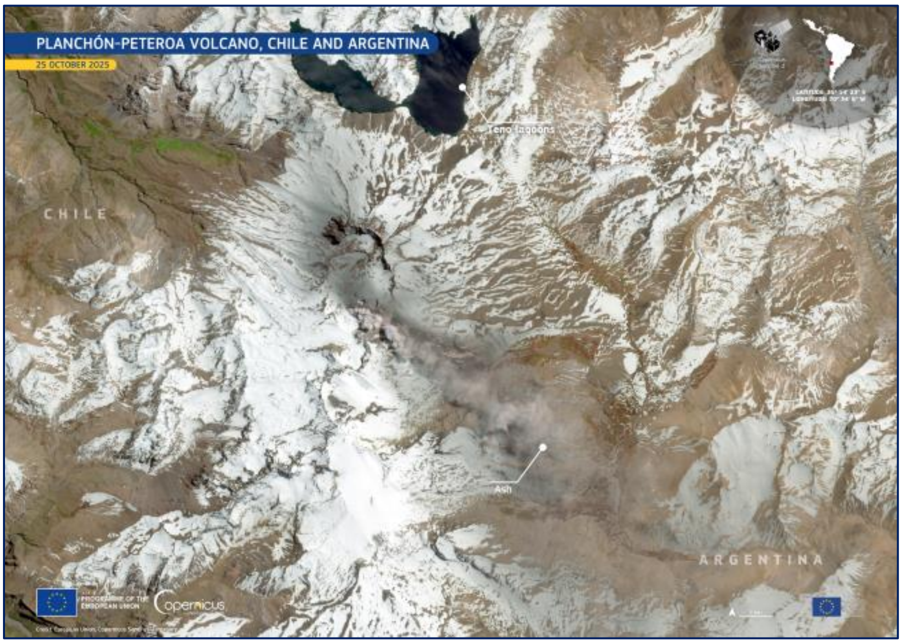
References:

https://www.newscientist.com/article/2261173-tiny-island-survived-tsunami-that-helped-separate-britain-and-europe/#ixzz6fOXjn3ED

https://www.cambridge.org/core/journals/antiquity/article/great-wave-the-storegga-tsunami-and-the-end-of-doggerland/CB2E132445086D868BF508041CC1B827

Image of the Day 2

Ash emissions from the Planchón-Peteroa volcano



Date: 03/11/2025

Location: Chile and Argentina

Credit: European Union, Copernicus Sentinel-2 imagery

Satellite image of the Planchón-Peteroa volcano, located on the border between Chile and Argentina, captured on 25 October 2025. The snow-covered Andes Mountains dominate the scene, with the volcano near the center emitting a plume of ash drifting eastward into Argentina. The Teno lagoons are visible to the north of the volcano. Labels mark Chile and Argentina, as well as the ash plume and Teno lagoons. The image includes a small inset map showing the volcano's location in South America and logos from the E

This image, acquired by one of the Copernicus Sentinel-2 satellites on 25 October 2025, shows the volcanic complex with a distinct ash plume extending eastwards from the summit area. Ash is clearly visible spreading across the snow-covered slopes and into Argentina.

The Copernicus Sentinel satellites provide crucial data on volcanic activity worldwide, supporting authorities and researchers with information on eruptions and their impacts on human activities.

Reference:

https://www.copernicus.eu/en/media/image-day-gallery/ash-emissions-planchon-peteroa-volcano

News

Family find 'exceedingly rare' Stone Age hand axe

Katie Waple, BBC South of England ***4 November 2025***

As suggested by Keith Clark.

An "incredible discovery" and a "chance finding" is how a family have described uncovering a prehistoric hand axe.

Mel Harrison picked up the hand-sized flintstone which tour guide Martin Simpson immediately recognised as a Stone Age implement last Wednesday at Brook Bay, Newport on the Isle of Wight.

The hand axe with a 50p for size comparison. (Image source: Island Gems Fossil Trips)

Ms Harrison was joined on the walk by her husband Tony, her friend Laura and "keen fossil hunters" Jack and Charlie both aged nine. She said: "It's incredible to think that this stone tool was made between 250,000-600,000 years ago and has lain undiscovered all this time."

The flintstone was authenticated by Dr Ferrero, the Isle of Wight Finds Liaisons Officer, who confirmed the stone tool was "a Palaeolithic or pre-Palaeolithic hand axe perfectly intact and could possibly be the oldest to be found on the island".

Mr Simpson, from **Island Gems Fossil Trip**, has been working on the island for 40 years and said, "it had the right look and feel about it". He explained "these finds are exceedingly rare and emanate from a time when the island was joined to the mainland". "The coastal erosion in this case is actually doing some good by uncovering rare treasures," he added.

Ms Harrison said the find was the "highlight" of the trip.

Reference:

https://www.bbc.co.uk/news/articles/crmxd1v9910o

No new North Sea oil wells for first time since 1960s

Labour's crackdown on oil and gas industry blamed for collapse of exploration in UK waters

Jonathan Leake, The Telegraph, Energy Editor ***02 November 2025***

No new oil wells are to be drilled in the British North Sea this year for the first time since 1964 as Labour's crackdown on profits and exploration hammers the sector.

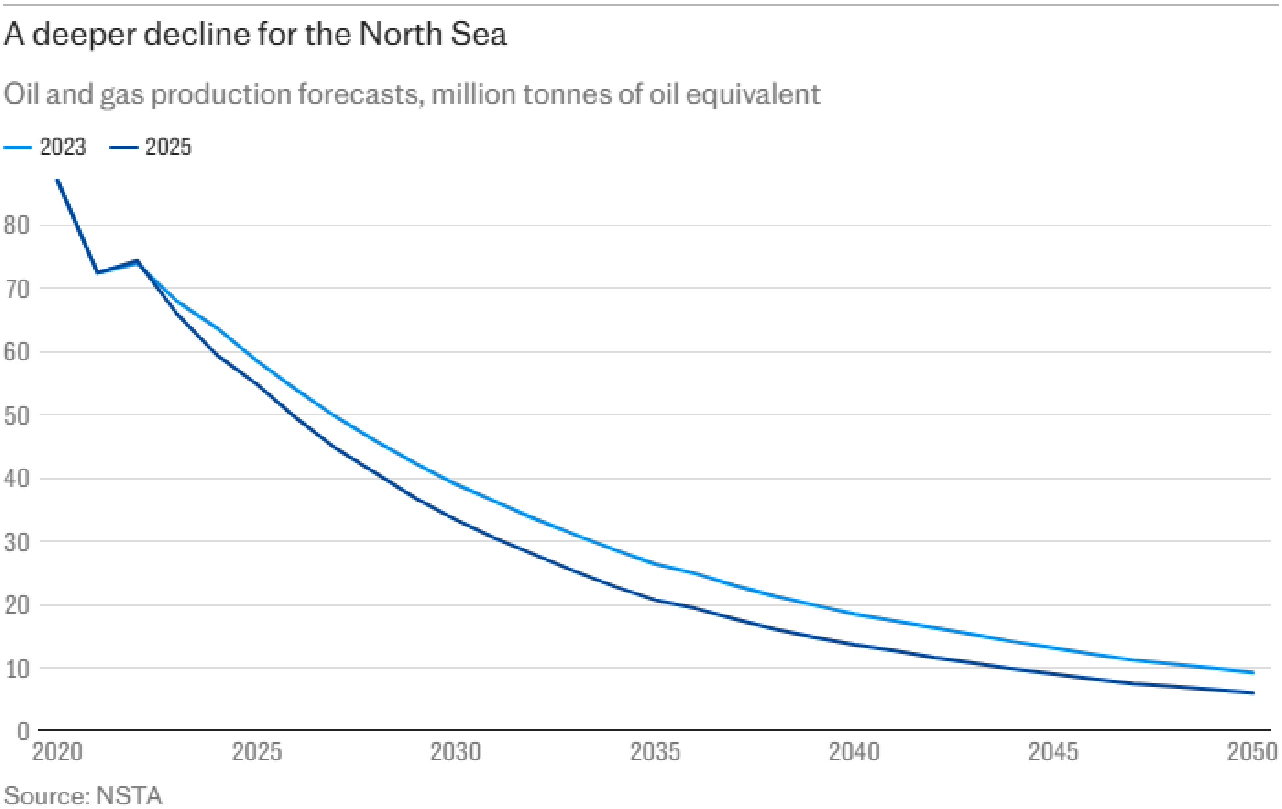
A survey of offshore operators has found that zero exploratory wells – the vital first stage of discovering new resources – have been drilled so far in 2025, with no plans for the final two months of the year.

By contrast Norway, whose geology is similar and whose government takes a very positive approach to oil and gas, has seen 30 new exploration wells drilled so far in 2025, with up to nine more expected before year end.

The collapse of exploration in British waters comes in response to a windfall tax on oil and gas profits, which Labour raised to 78pc, and a ban by Ed Miliband on licences for exploratory drilling in new areas.

Exploratory drilling is still allowed in areas licensed before the ban, but industry say the threat of a future raid by government means few are willing to risk investing in new developments.

This year is now on track to be the first in the industry's history when no new wells are drilled.



The first offshore wells were drilled after the UK Continental Shelf Act in 1964, with the first commercial gas field discovered the following year by BP. The first commercial oil field was discovered in 1969 by Amoco.

The research, carried out by analysts at **Westwood Global Energy**, comes amid rising political tension over the future of North Sea oil and gas.

Mr Miliband, the Energy Secretary, is due to publish a revised North Sea strategy before the Budget, aimed at restarting some drilling. Rachel Reeves separately is considering ending the windfall levy early.

Westwood's findings suggest any changes may come too late, with the UK oil and gas industry in rapid decline.

Alyson Harding, at Westwood Global Energy, said: "Our dataset shows that in 2025 to date, oil and gas companies in the UK have not initiated the drilling of any offshore exploration wells. This is the first such year since 1964 when the first offshore exploration well was spudded. Investor sentiment ... is at an all-time low, due to the current tax regime and uncertainties around government policies and regulation."

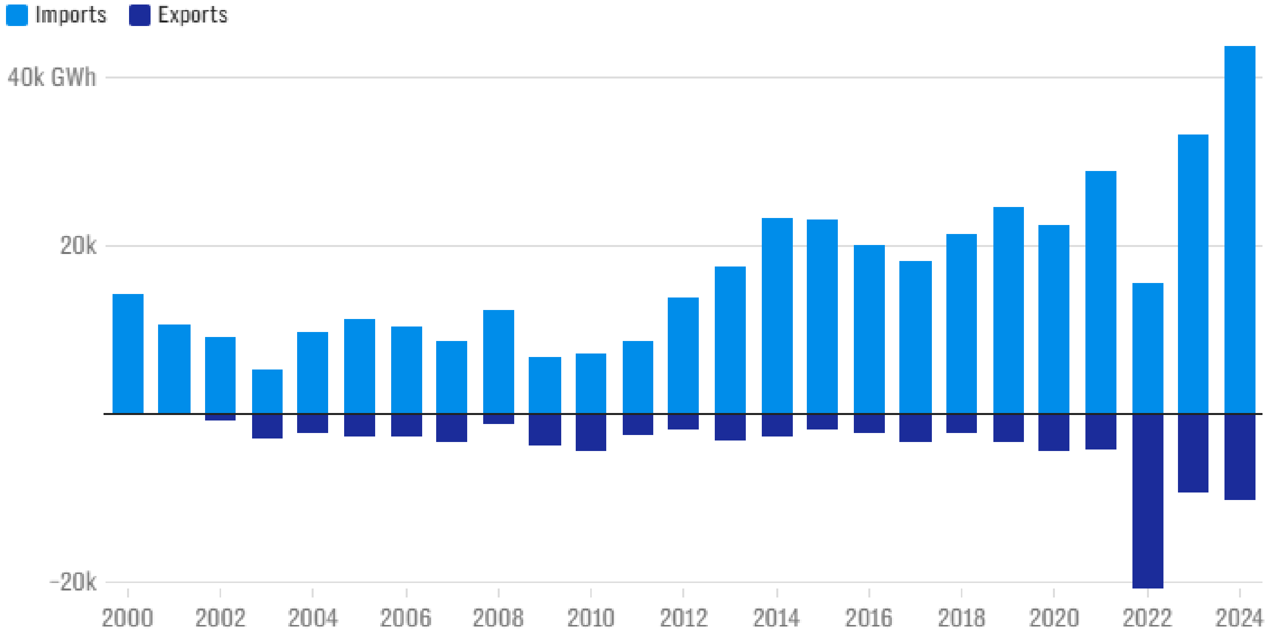
Most UK reservoirs only last for a relatively short time before becoming depleted, so constantly finding and drilling new fields is essential to maintain production.

The slowdown in drilling is one reason that last year the UK had to import 43 million tonnes of crude oil plus another 31 million tonnes of refined oils such as petrol, diesel and jet fuel.

The UK also consumed about 72 billion cubic metres (bcm) of gas but was only able to produce about 29bcm in its own waters, with the rest coming largely from Norway and the US.

Britain's energy imports are at an all-time high

UK trade in electricity, in gigawatt-hours



Source: IEA

"The Government has taken an exceptionally hostile approach to our sector, at the expense of UK workers, communities, tax take and energy security," said Robin Allan, chairman of the Association of British Independent Exploration Companies (Brindex).

"With the total collapse of exploration drilling, British homes, factories and power stations are being fuelled with imported oil and gas instead of the abundant resources under our shores, an example of what not to do to demonstrate 'global leadership'."

The British North Sea is still estimated to contain reserves of up to 24 billion barrels of oil and gas. There are about 283 active oil and gas fields in the North Sea, but about 180 will have ceased production by 2030.

Claire Coutinho, the shadow energy secretary, said: “The blame for this collapse lays squarely at Ed Miliband’s door. He has chosen to shut down the North Sea while over the border in Norway they are making new finds in the exact same basin – creating jobs, investment, and tax revenue that we’re missing out on in Britain. Making ourselves more dependent on foreign imports while refusing to drill our own resources will be remembered as the biggest act of economic self-harm in a generation.”

David Whitehouse, chief executive of Offshore Energies UK, the industry trade body, said: “It is government policy, not North Sea geology, that is prematurely driving the decline of UK oil and gas production. It doesn’t have to be this way. We’re asking the Chancellor to use the upcoming Budget to reform the Energy Profits Levy in 2026, a decision that will determine whether we keep investment and jobs here or lose them overseas.”

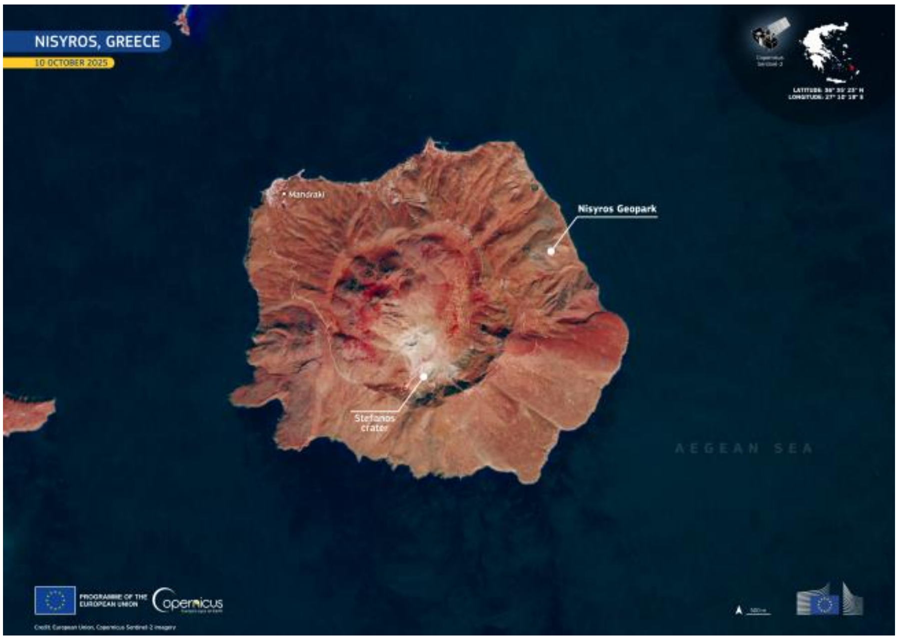
A spokesman for the Department for Energy Security and Net Zero said: “Oil and gas production will be with us for decades to come, and we are working with industry to manage our existing fields for the entirety of their lifespan.”

Reference:

https://www.telegraph.co.uk/gift/7d00ae6a2f8f842c

Image of the Day 3

The volcanic Nisyros Island, Greece, designated a UNESCO Global Geopark



Date: 13/11/2025

Location: Greece

Credit: European Union, Copernicus Sentinel-2 imagery

In October 2025, the volcanic island of Nisyros, in the south-eastern Aegean Sea, was recognised as the tenth Greek site to join the UNESCO Global Geoparks Network, reflecting its geological and environmental value. Nisyros is a dormant volcano within one of the most tectonically active zones of the eastern Mediterranean, shaped by past eruptions, caldera formation, and ongoing hydrothermal activity.

This false-colour Copernicus Sentinel-2 image, acquired on 10 October 2025, reveals the island’s volcanic terrain. Vegetation appears in red tones, while bare surfaces and lava fields are shown in grey and brown. The Stefanos Crater, measuring 330 m wide and 27 m deep, is visible in the centre. The Nisyros Geopark encompasses the entire island and nearby islets, formed by volcanic and submarine processes over thousands of years.

In addition to helping monitor global volcanic activity, Copernicus data is key to informing strategies to protect important heritage sites.

Reference:

https://www.copernicus.eu/en/media/image-day-gallery/volcanic-nisyros-island-greece-designated-unesco-global-geopark

News

Extreme 'paradise' volcano in Costa Rica is like a piece of ancient Mars on our doorstep — Earth from space

Harry Baker, LiveScience ***11 November 2025***

A 2025 satellite photo captures the stark contrast between the barren Poás volcano and the surrounding Costa Rican jungle. The volcano's super-acidic lake provides the perfect analogue for studying how hardy microbes may have emerged on Mars billions of years ago.

Costa Rica's Mars-like Poás volcano clearly stands out from the surrounding rainforest when viewed from space. (Image credit: NASA/Landsat 8)

This striking satellite photo shows a barren Mars-like volcano lurking in the heart of the Costa Rican rainforest. The alien landscape contains a super-acidic lake that is a "paradise" for extreme microbes and provides researchers with an excellent analogue for studying potential lifeforms on the Red Planet.

The unique volcano, named Poás, is the focal point of the Poás Volcano National Park in Costa Rica's Alajuela province. It is a stratovolcano that formed between 1.5 million and 700,000 years ago, with a summit that reaches 8,848 feet (2,697 meters) above sea level.

Satellite images make it look like Poás is situated in the middle of nowhere. However, around 10 miles (16 kilometres) southeast of the volcano (just out of shot in this photo), lie the suburbs of Costa Rica's capital San José, which is home to around 1.5 million people. As a result, the volcano is a popular tourist destination, despite being one of the most active volcanoes in Central America.

Poás has had dozens of major eruptions in the last 200 years, but also experiences many more smaller outbursts, where it puffs out a mix of steam, smoke and toxic gases, as well as the occasional ash cloud. Since 2005, the volcano has had 13 of these minor eruptive phases, according to the Smithsonian Institution's Global Volcanism Program.

Its most recent eruption began on Jan. 5 and persisted for the majority of 2025, although it has likely now come to an end. This phase's activity peaked in early May, when sulfur dioxide levels briefly impacted air quality in San José and ashfall damaged some nearby crops, according to NASA's Earth Observatory.

QUICK FACTS

Where is it? Poás Volcano National Park, Costa Rica [10.19781287, -84.238304442]

What's in the photo? The barren slopes of the Poás volcano in the middle of a rainforest

Which satellite took the photo? Landsat 8

When was it taken? March 5, 2025

At the summit of Poás lies a large crater, which is home to a highly acidic volcanic lake, known as Laguna Caliente. (Image credit: Nano Calvo/VWPics/Universal Images Group via Getty Images)

The main crater of Poás contains a highly acidic volcanic lake, named Laguna Caliente, which has an average pH value of just over 0, which is roughly equivalent to battery acid, according to the Earth Observatory. This crater, which is around 0.8 miles (1.3 km) wide, is also home to sporadic geysers.

While these extreme conditions mean no animals or plants live within the crater, the lake's acidic waters are home to a thriving microbial community dominated by extremophile bacteria in the genus *Acidiphilium*, which feast on metal compounds dissolved in the water.

"We have a very human-centric bias for what a nice, happy, temperate environment is to grow in," Rachel Harris, a microbial ecologist and geochemist at Harvard University who is currently involved in devising NASA's Decadal Astrobiology Research and Exploration Strategy, told the Earth Observatory. "The Poás system may be hostile to most forms of life we are familiar with. But for a microbe adapted to acid, heat and toxic metals, it's paradise," Earth Observatory representatives added.

Researchers are interested in Poás' extreme ecosystem because it is very similar to volcanic environments that likely existed on Mars more than 3 billion years ago, when the Red Planet was more similar to our own.

A 2022 study, for example, revealed that the low biodiversity and high resilience within Laguna Caliente's microbial community is very close to what researchers expect could have developed within potential Martian ecosystems.

Poás is particularly similar to a region of Mars, known as Home Plate, which was surveyed by NASA's Spirit rover in 2009. This 300-foot-wide (90 m) plateau likely had an acidic hydrothermal system that may have been almost identical to Laguna Caliente, according to the Earth Observatory.

Other types of extremophiles may also have once thrived on Mars, including lifeforms similar to lichens or photosynthetic algae. However, despite some promising recent findings from NASA's Perseverance rover, there is no hard evidence that the Red Planet has ever supported alien life.

Reference:

https://www.livescience.com/planet-earth/volcanos/extreme-paradise-volcano-in-costa-rica-is-like-a-piece-of-ancient-mars-on-our-doorstep-earth-from-space?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=F304913A-D718-46CF-A712-86B9734CC925&utm_source=SmartBrief

Evidence of ancient tree-climbing 'drop crocs' found in Australia

Lana Lam, BBC Science, Sydney ***12 November 2025***

Scientists have unearthed Australia's oldest known crocodile eggshells which may have belonged to "drop crocs" - creatures that climbed trees to hunt prey below.

The discovery of the 55-million-year-old eggshells was made in a sheep farmer's backyard in Queensland with the findings published in the **Journal of Vertebrate Paleontology.**

An AI-generated reconstruction of what a 'drop croc', or mekosuchine crocodile, may have looked like. (Image source: Panades et al 2025 (generated with Google Gemini AI))

The eggshells belonged to a long-extinct group of crocodiles known as *mekosuchines*, who lived in inland waters when Australia was part of Antarctica and South America.

Co-author Prof. Michael Archer said, "drop crocs" were a "bizarre idea" but some were "perhaps hunting like leopards - dropping out of trees on any unsuspecting thing they fancied for dinner".

Prof. Archer, a palaeontologist at the University of New South Wales, said *mekosuchine* crocodiles - which could grow to about five metres - were plentiful 55 million years ago, long before their modern saltwater and freshwater cousins arrived in Australia about 3.8 million years ago.

The "drop croc" eggshells were discovered several decades ago but only recently analysed with the help of scientists in Spain.

"It's a bizarre idea," Prof. Archer said of the "drop crocs", but some were probably "terrestrial hunters in the forests".

The findings add to earlier discoveries of younger *mekosuchine* fossils - found in 25-million-year-old deposits in another part of Queensland. "Some were also apparently at least partly semi-arboreal 'drop crocs'," Prof. Archer said.

The clay pit at Murgon holds millions of years of clues to the animals and environments of the past. (Image source: Mina Bassarova via University of NSW)

Since the early 1980s, he has been part of a group of scientists excavating a clay pit in Murgon, a small regional town about 270km (168 miles) north-west of Brisbane.

Over the decades, it has become known as one of Australia's oldest fossil sites as it used to be surrounded by a lush forest. "This forest was also home to the world's oldest-known songbirds, Australia's earliest frogs and snakes, a wide range of small mammals with South American links, as well as one of the world's oldest known bats," Dr. Michael Stein, a co-author of the report, said.

Prof. Archer recalls how in 1983, he and another colleague "drove to Murgon, parked the car on the side of the road, grabbed our shovels, knocked on the door and asked if we could dig up their backyard. After explaining the prehistoric treasures that might lie under their sheep paddock and that fossil turtle shells had already been found in the area, they grinned and said 'of course!'. And, quite clearly, from the many fascinating animals that we've already found in this deposit since 1983, we know that with more digging there will be a lot more surprises to come."

Reference:

https://www.bbc.co.uk/news/articles/c2lpyrnjleeo

How dinosaur fossils were found on an island with 'the wrong rocks'

Barry O'Connor, BBC News NI ***15 November 2025***

Finding dinosaur fossils on the island of Ireland is harder than finding a "needle in a haystack", the curator of geology at National Museums Northern Ireland has said.

But the only two ever to have been found in the proverbial haystack will be on display in Cork for the next six months.

The fossils are from 200 million years ago. (Credit: BBC)

Fossil collector Roger Byrne found fossilised bones of two separate dinosaur species on the same beach in Islandmagee, County Antrim, more than four decades ago. From Sunday, they will be on display as part of an exhibition at **Glucksman Gallery in University**

College Cork (UCC), where for the first time the public can also see nearly 300 fossils from elsewhere.

The fossils are from 200 million years ago, meaning these dinosaurs roamed Earth during the Jurassic period.

Dr Mike Simms, from National Museums Northern Ireland, told BBC News NI that Ireland is an unlikely candidate for dinosaur-related discoveries because "we have the wrong sort of rocks".

"Most of the rocks that would contain dinosaurs that would be of the right age, we don't have," he said.

"They were eroded away long ago, so we're very, very lucky to have these. Most of the rocks we have that are the right age for dinosaurs were deposited out at sea."

The fossils are normally on display at the Ulster Museum, but they are being loaned to UCC.

"There will be big, spectacular, skeleton casts in this exhibition in Cork but alongside them will be these little bits of bone," said Dr Simms. "I think it's a great opportunity because Cork is quite a long way away, so it's great that they get down to Cork for six months and people can appreciate them there."

The exhibit will feature skeleton casts of the only dinosaurs known to have lived on the island of Ireland. (Image source: University College Cork)

One of the bones comes from the tibia (lower leg bone) of a two-legged meat-eater similar to Sarcosaurus. (Credit: Julian Friers/National Museums NI)

Experts suggest Scelidosaurus may have been a coastal animal, perhaps even eating seaweed like modern-day marine iguanas. (Credit: Julian Friers/National Museums NI)

Who was Roger Byrne?

Mr Byrne taught at a school in Carrickfergus, County Antrim, and was "a very keen, enthusiastic fossil collector" who was "meticulous". He found the bones in 1980 and 1981, on a beach near the Gobbins in County Antrim.

Dr Simms, who met him a few times, said he was a talented artist who drew the dinosaur bones he found. "He was a really exceptional fossil collector - a very good eye - because these bones are basically rather rounded black pebbles and he found them on a beach that was covered with black pebbles."

A scientific study involving Dr Simms and the universities of Portsmouth and Queen's in Belfast confirmed the origins of the bones for the first time in 2020. One is part of the lower leg bone of a carnivore similar to *Sarcosaurus*; the other is from the upper leg bone of a *Scelidosaurus*, a four-legged herbivore.

"It's an extraordinary find really, to find two different dinosaurs in a country which really we shouldn't have," Dr Simms said.

So, could there be more fossils on Islandmagee beaches?

"Quite a few other people and Roger scoured it pretty carefully," Dr Simms said. "I don't think there was really that much left after Roger had been back. He went back many times, and his collection was donated to us after he died."

Taoiseach (Irish Prime Minister) Micheál Martin, who will open the Domain of the Dinosaurs exhibition on Sunday, called it "a fantastic collaboration of science and the arts that truly captures the imagination".

The Islandmagee fossils will be joined by skeletal casts of the eight-metre-long apex predator Megalosaurus, the herbivores Scelidosaurus and Iguanodon, and the marine reptiles Ichthyosaurus and Plesiosaurus.

Reference:

https://www.bbc.co.uk/news/articles/c5y92wg8q8po

Semeru Volcano Erupts In Indonesia, Spewing Powerful Pyroclastic Flows

David Bressan, Senior Contributor, Forbes. ***19 November 2025***

Semeru volcano — the highest volcano on Java at 3,676 meters — erupted on the afternoon of November 19, 2025, with pyroclastic flows racing at high speed more than 8.5 kilometres down its slopes.

In this photo released by the Geological Agency (Badan Geologi) of Indonesia's Ministry of Energy and Mineral Resources, Mount Semeru releases volcanic materials during an eruption in Lumajang, East Java, Indonesia, Wednesday, Nov. 19, 2025. (Credit: Badan Geologi via AP)

Mount Semeru is one of fifteen active volcanoes on Java, one of Indonesia's most densely populated islands. In 2010, an eruption of Mount Merapi generated a series of deadly pyroclastic flows that killed 350 people and forced more than 10,000 residents to flee.

Pyroclastic flows are avalanches of superheated ash, gas, and volcanic rock fragments, with temperatures that can reach up to 1,000 degrees Celsius. They can travel down a volcano's slopes at speeds over 99 mph (160 km/h), destroying everything in their path. These flows are lethal even at distances of six to nine miles (10 to 15 kilometres) from the volcano.

Currently, there are no reports of casualties from the Semeru eruption, but authorities have ordered the evacuation of nearby villages as a precaution.

Indonesia frequently experiences earthquakes and volcanic eruptions because the archipelago sits atop the intersection of various tectonic plates, including the Pacific plate, the Eurasian plate, the Australian plate and the Philippine Sea plate.

The Philippine plate, consisting mostly of heavy oceanic crust, dives under the Eurasian continental plate. When the Philippine plate reaches a depth greater than 100 kilometres, the water it contains lowers the fusion point of the surrounding rocks, which creates magma. This magma is hotter and less dense than the rocks around and therefore starts to migrate towards the surface, where it eventually generates explosive volcanism typical of subduction zones.

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https://www.straitstimes.com/asia/se-asia/update-1-indonesias-semeru-volcano-erupts-alert-level-raised-to-highest

Scientists reveal what triggered Santorini 'earthquake swarm'

Victoria Gill, Science correspondent, BBC News ***21 November 2025***

The "swarm" of tens of thousands of earthquakes near the Greek island of Santorini earlier this year was triggered by molten rock pumping through an underground channel over three months, scientists have discovered.

They used physics and artificial intelligence to work out exactly what caused the more than 25,000 earthquakes, which travelled about 20km (12 miles) horizontally through the Earth's crust. They used each of the tremors as virtual sensors, then used artificial intelligence to analyse patterns associated with them. One of the lead researchers, Dr Stephen Hicks from UCL, said combining physics and machine learning in this way could help forecast volcanic eruptions.

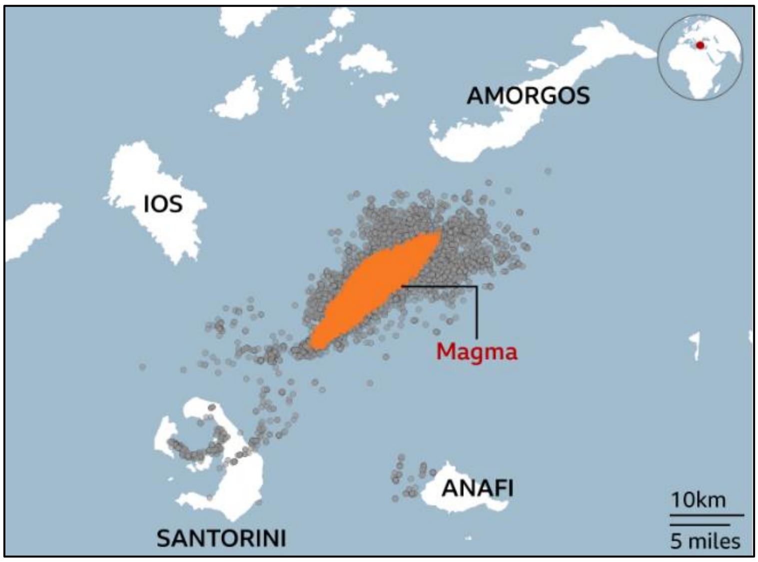
What happened in Santorini?

The seismic activity started to stir beneath the Greek islands of Santorini, Amorgos, and Anafi in January 2025. The islands experienced tens of thousands of earthquakes - many of which were over magnitude 5.0 and could be felt.

Many tourists fled, and locals feared that the nearby underwater volcano, Kolumbo, might be about to erupt - or that this was a seismic prelude to a larger earthquake, like the devastating, magnitude 7.7 quake that struck the same region in 1956.

The scientists, who published their findings in the journal **Science**, created a 3D map of the Earth around Santorini. They then mapped the evolving patterns of seismic activity of each tremor and the movement and stress in the crust. This resulted in a detailed model of exactly what drove this months-long seismic swarm.

The team found that the event was driven by the horizontal movement of magma - from beneath Santorini and the Kolumbo volcano - through a 30km channel that is more than 10km beneath the seafloor between the two islands of Santorini and Anydros.



Source: University College London

The researchers estimated that the volume of magma that moved through the crust could have filled 200,000 Olympic-sized swimming pools. These "magma intrusions", as they are known, smashed through layers of rock, triggering thousands of tremors.

Lead author on the study, Anthony Lomax, a research geophysicist who develops scientific software to analyse seismic activity, explained: "The tremors act as if we had instruments deep in the Earth, and they're telling us something. [When we analyse] the pattern those earthquakes make in our 3D model of the Earth, it matches very, very well what we expect for magma moving horizontally."

Does this mean the Santorini unrest is over?

For now, the researchers say, it appears to be over. "The magma remained quite deep - more than 8km depth - in the crust," explained Dr Hicks. "We know that magma can ascend and erupt at the surface in a matter of hours to days, but because the activity has now died down, we can be almost certain that the melt eventually got stuck and cooled down deep in the crust."

Volcanoes, though, can enter prolonged phases of unrest and unpredictability that can last many years. Recent volcanic activity in south-west Iceland has demonstrated that. And these researchers say using AI, in combination with the fundamental physics of how the Earth's crust moves and responds to stress, could transform the ability to monitor, understand and even forecast volcanic activity. This could help keep people in seismically active parts of the world safe.

"Ultimately, this could be used as a forecasting tool," explained Dr Hicks. Whenever we see a cluster of earthquakes, "that is data that can be used to work out the most likely cause".

Reference:

https://www.bbc.co.uk/news/articles/cz7p783g2j5o

Scotland fans shook the earth in win over Denmark

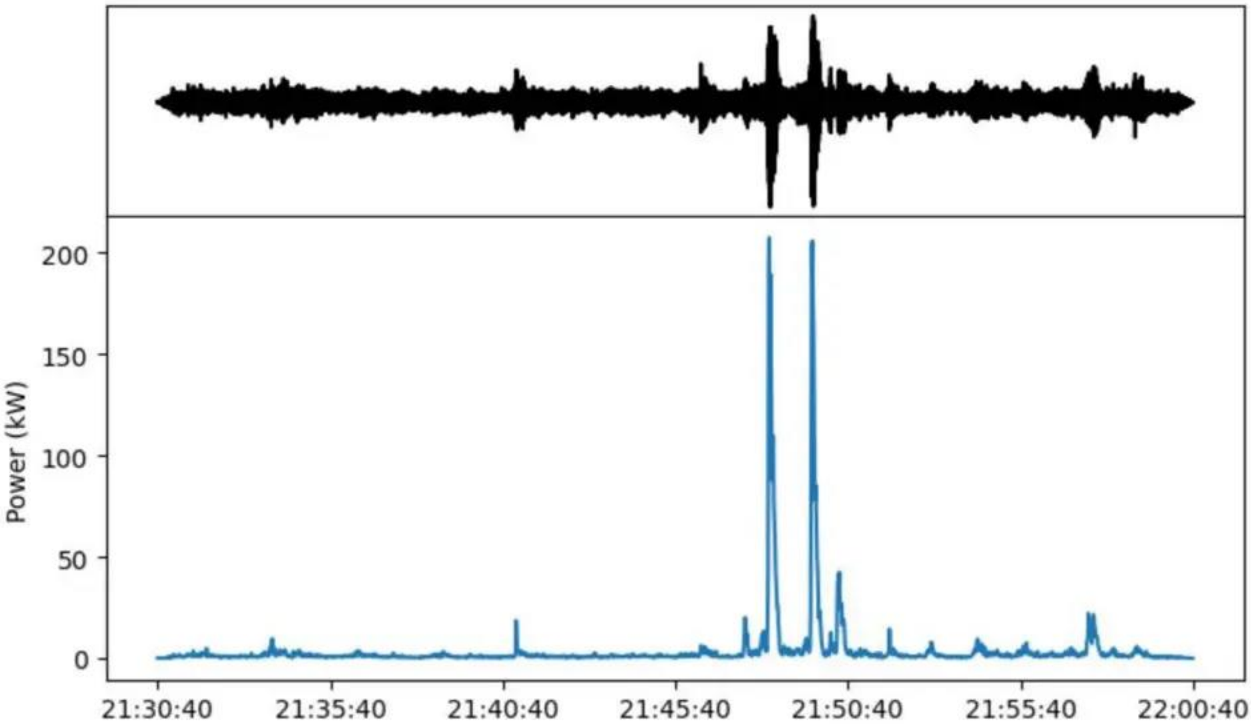
BBC News ***22 November 2025***

The Tartan Army shook the earth as they celebrated Scotland's men qualifying for a first World Cup in 28 years. The British Geological Survey (BGS) recorded the equivalent to an "extremely small earthquake" after Kenny McLean lobbed Denmark goalkeeper Kasper Schmeichel to secure a 4-2 win. A second significant amount of seismic activity came moments later when the final whistle sounded on Wednesday night.

Readings were recorded at the BGS station at Glasgow Geothermal Observatory in Dalmarnock – about 2km (1.2 miles) from Hampden Park.

A small surge was also detected around the time Kieran Tierney curled in Scotland's third, three minutes into injury time.

However, the BGS said the main peak of activity came between 21:48 and 21:50 – right as McLean scored from the halfway line.



The BGS recorded surges of seismic activity after the fourth goal and again after the final whistle. (Image source: British Geological Survey)

An official attendance of 49,587 was recorded at the game. The activity registered between magnitude -1 and zero on the Richter Scale and produced the equivalent of 200kW of power, enough to power between 25 and 40 car batteries.

The BGS said it is also the same as blasting a football at about 900 m/s (2,013 mph). That is about 15 times faster than the fastest a ball has ever been struck, thought to be about 131.2 mph (58 m/s) by the Brazilian defender Ronny Heberson in Sporting Club de Portugal's win over Naval in 2007.

Taylor Swift fans were also recorded as making the earth move during last summer's trio of concerts at Murrayfield Stadium in Edinburgh. But the BGS said it was unable to directly compare the two events due to "different site conditions".

The BGS said about 300 naturally occurring earthquakes happen in the UK every year, but only about 30 are of significant power to be felt by people. A 3.3 magnitude earthquake was felt in homes across Perthshire last month.

Reference:

https://www.bbc.co.uk/news/articles/ckgd2nywde4o

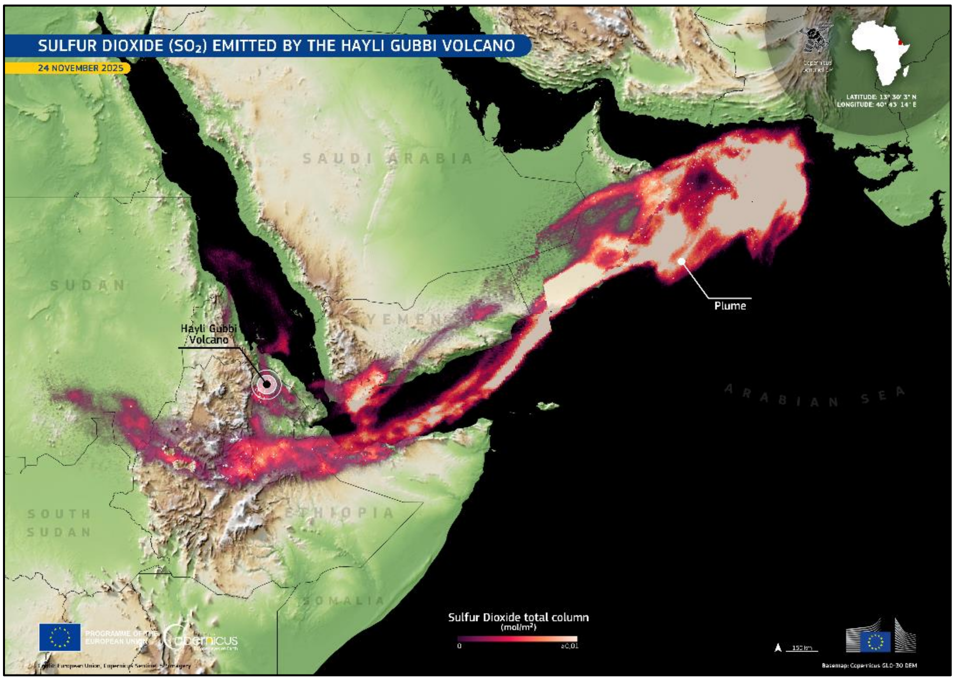
Image of the Day 4

Eruption of Hayli Gubbi volcano, Ethiopia

Date: 25/11/2025

Location: Ethiopia

Credit: European Union, Copernicus Sentinel-5P imagery



On 23 November 2025, the Hayli Gubbi volcano in Ethiopia, located approximately 800 kilometres north-east of Addis Ababa, erupted for the first time in nearly 12,000 years.

As a result of the eruption, a large sulfur dioxide (SO_2) plume was emitted into the atmosphere. This image, derived from data acquired by the Copernicus Sentinel-5P satellite on 24 November, shows the plume extending for approximately 3,700 kilometres from Ethiopia to the Arabian Sea.

The atmospheric monitoring capabilities of Copernicus Sentinel-5P support the detection and tracking of volcanic gas emissions, which are important for aviation safety, air quality assessments, and climate monitoring.

Reference:

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News

Labour is still in a muddle on North Sea oil and gas

Nils Pratley, The Guardian ***26 November 2025***

Maintaining existing drilling sites for longer is sensible but doesn't square with plans to keep the energy profits levy

Labour's manifesto commitment on North Sea oil and gas production was a fudge. On one hand, it said no new licences "to explore new fields" would be granted. On the other, it said existing fields would be managed "for the entirety of their lifespan" in a way "that does not jeopardise jobs".

The formulation raised many questions. Where, exactly, would the line be drawn between a new field and an existing field? What would be the approach to protecting workers when, as now, North Sea jobs are estimated to be going at a rate of 1,000 a month according to analysis by Robert Gordon University?

The thinking is only slightly easier to understand now. The clear part is that Ed Miliband's energy security and net zero department will create "transitional energy certificates" for "limited" oil and gas drilling in areas that are part of an existing field or adjacent to a licensed field. The idea is to keep those sites economically viable for longer by using existing rigs and pipelines.

The approach sounds sensibly practical. The UK's current reliance on imported oil and gas is doing little to reduce emissions (shipments of liquefied gas from the US and Qatar are far more polluting than domestic production) or protect jobs in a supply chain that will be needed to build renewables infrastructure.

The risk in not allowing "tiebacks" is that decline in the North Sea accelerates even faster at a time when oil and gas still provides three-quarters of the UK's energy needs and imports are running at 40%. Miliband has proved to be more pragmatic on licensing than his industry critics made out. And, yes, his policy reads as manifesto-compliant.

But here's the rub: the chancellor didn't budge an inch on the windfall tax, the energy profits levy (EPL) introduced during the price spikes of 2022. The Treasury intends to keep the EPL in place until its scheduled end in 2030. Oil and gas companies say the levy is the real reason they're cutting investment: the UK is simply uncompetitive when the marginal rate of tax in the North Sea is 78% and 2022's sky-high prices for oil and gas have reversed.

"If the levy stays in place beyond 2026, projects will stall and jobs will vanish, no matter how pragmatic licensing policy becomes," argued the trade lobby group Offshore Energies UK.

One could take the view that the industry is exaggerating and that producers in practice will leap at the chance to get their hands on tieback licences, perhaps in the expectation that the EPL will disappear early anyway when oil and gas prices fall far enough to trigger automatic cut-offs (the oil price is there already, but both have to happen for six months). Well, maybe – but that prospect is obviously highly uncertain.

The position therefore is a muddle of a different type. The energy department's looser licensing regime and the Treasury's tight tax policy are pulling in opposite directions. It makes it hard to understand what the government is trying to achieve. Certainly, nobody is talking about actual production targets for the North Sea, which you'd think would be a basic requirement of a "fair, managed and prosperous" strategy for transition. The thinking does not look joined-up.

Missed opportunity of the budget? Proper reform of stamp duty on shares. Rachel Reeves opted instead for the token gesture of a three-year stamp duty holiday for new listings on the London Stock Exchange.

A bolder move would have been to cut, or abolish, the 0.5% charge on all share transactions. It would have shown real commitment to reviving the London market and would have sat perfectly alongside the cut to £12,000 in cash Isa limits.

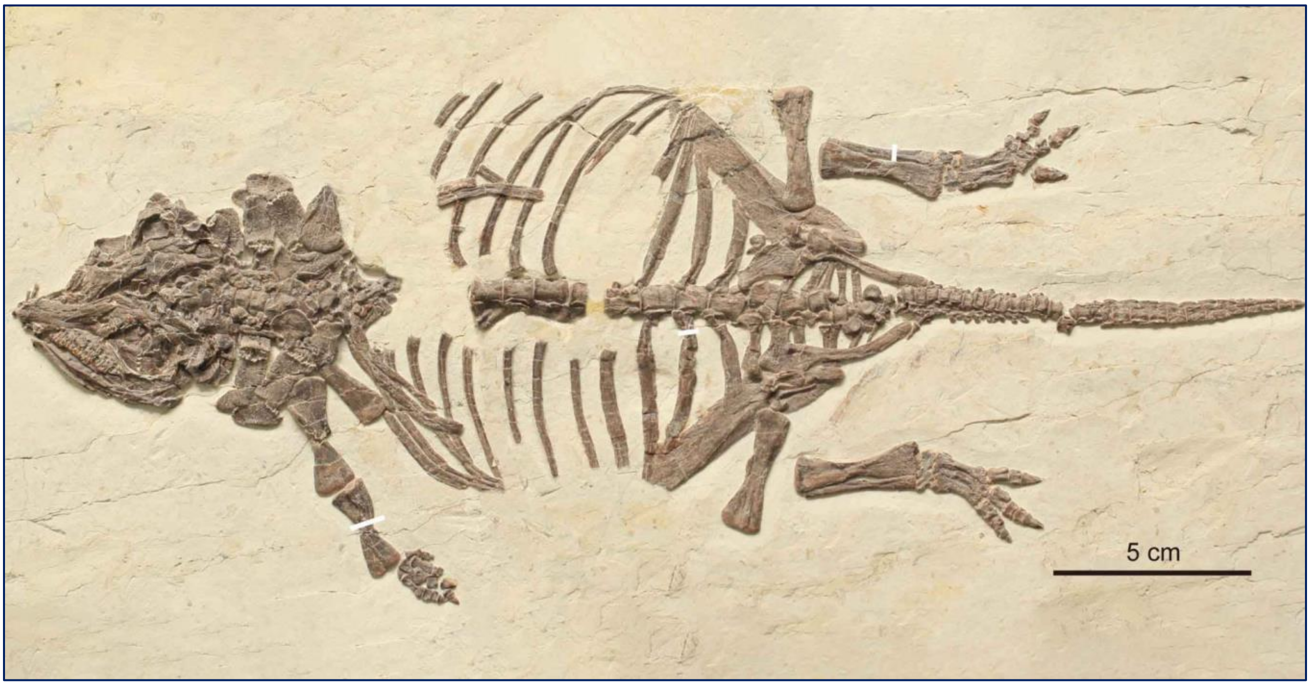
The chancellor added she will "continue to evaluate" stamp taxes on shares to support "the competitiveness of our world-leading capital markets". Come on, this dance has already gone on too long. No other major financial centre charges 0.5% and AstraZeneca, the biggest company in town, has already found a way around it.

Reference:

https://www.theguardian.com/business/nils-pratley-on-finance/2025/nov/26/labour-is-still-in-a-muddle-on-north-sea-oil-and-gas

First armoured dinosaur hatchling discovered in China

Emma Caton, NHM ***12 December 2025***



Numerous fossils of Liaoningosaurus paradoxus have so far been discovered. © Zheng et al. 2025

The mystery surrounding dozens of small dinosaur fossils has finally been solved. Remains previously thought to belong to miniature armoured dinosaurs are actually baby ankylosaurs, offering scientists new insight into how these remarkable dinosaurs developed.

Paradox in name and in nature, fossils belonging to a dinosaur called *Liaoningosaurus paradoxus* have puzzled scientists for more than two decades.

First described in 2001, the dinosaur was first identified as a type of armoured dinosaur known as an ***ankylosaur***. Since then, multiple *Liaoningosaurus* fossils have been discovered, but strangely none are more than 40 centimetres long. This is remarkably small compared to other fully grown ankylosaurs, which normally reach lengths of three metres or more.

As no remains belonging to a larger individuals have been discovered, some scientists considered the possibility that the dinosaur could be the first example of a miniature ankylosaur. Others have even hypothesised that they were semi-aquatic.

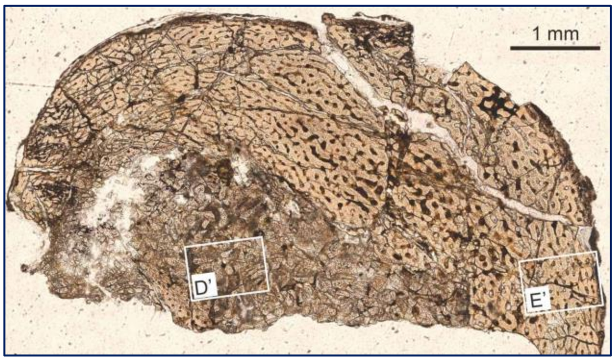
But new research published in the **Journal of Vertebrate Palaeontology** has overturned these theories. Instead, the tiny reptiles are probably baby ankylosaurs. One of the fossils even showed signs that it had recently hatched, which would make this the youngest ankylosaur ever discovered.

Professor Paul Barrett, one of our dinosaur experts and a coauthor of the study, says, "*Liaoningosaurus* has caused a lot of debate because there is a lot we don't know about this species and we haven't managed to identify an adult. But our research confirms that these are baby dinosaurs rather than small adults. Fossils of young ankylosaurs are rare, so there is a lot that these remains can tell us about the early development of armoured dinosaurs."

How do we know the fossils are young ankylosaurs?

Because the remains of *Liaoningosaurus* were all similar in size, it was hard to rule out the possibility that they were miniature adult ankylosaurs based on their body size alone. To get an idea of how old these dinosaurs were at the time of death, researchers had to look in detail at their bone structure.

Bone tissue contains growth lines that can be read in a similar way to growth rings in trees, with each line representing a year in the animal's life. The number of lines and the distance of the gap between them can tell us how old an individual was and how fast it was growing.



Carefully analysing the bone structure of the fossils, such as this leg bone, can tell us how old the ankylosaurs were when they died. © Zheng et al. 2025

Researchers took samples from the bones of two *Liaoningosaurus* fossils to test this. One of them was the largest specimen discovered so far, while the other was one of the smallest.

The team found no growth lines in either individual, suggesting that both were less than a year old. The bone microstructure of the smaller specimen was also similar to that of other dinosaurs in an early stage of development.

"The smaller fossil showed characteristics that we can see in other newborn dinosaurs, such as the presence of a hatching line," says Paul. "This is a small, ring-like feature in the bone that is laid down at the time the animal hatches from the egg. So, we can say that this individual had very recently hatched at the time of its death, which would make it the first hatchling ankylosaur we've ever discovered."

What do we know about these dinosaurs?

All *Liaoningosaurus* specimens come from Liaoning Province in northeastern China. Many remarkable fossils from the Cretaceous Period, between 145 and 66 million years ago, have been unearthed in this area, including feathered dinosaurs such as *Microraptor* and *Sinornithosaurus.*

Like their feathery contemporaries, the *Liaoningosaurus* fossils were preserved after the remains of the animals sunk to the bottom of a shallow lake. With lots of active volcanoes in the region, the lake beds were exceptionally well preserved under the ashfall. This has given us an incredibly detailed snapshot of life during this time. But while the lack of adult *Liaoningosaurus* specimens means we know very little about what these dinosaurs were like in later life, we can still learn a lot about how ankylosaurs in general developed.

Fossils of young ankylosaurs are rare, and those that do exist don't have the armour that is a prominent feature in the adults. This has led some researchers to suggest that armour is not something they are born with but develops as they age. *Liaoningosaurus*, however, shows that they had some armour from early in their life.

"As we have found so few fossil babies, *Liaoningosaurus* is really the only good window we have into what ankylosaurs are like just after they hatch," says Paul. "The *Liaoningosaurus* fossils had already developed some armour. Now that we know they are babies and not miniature adults, we can say that these kinds of features came in quite early during the animal's growth. But what would give us even bigger insights is if we also found an adult. Then we can find the differences between the adults and babies of the same species and see how these features are developing."

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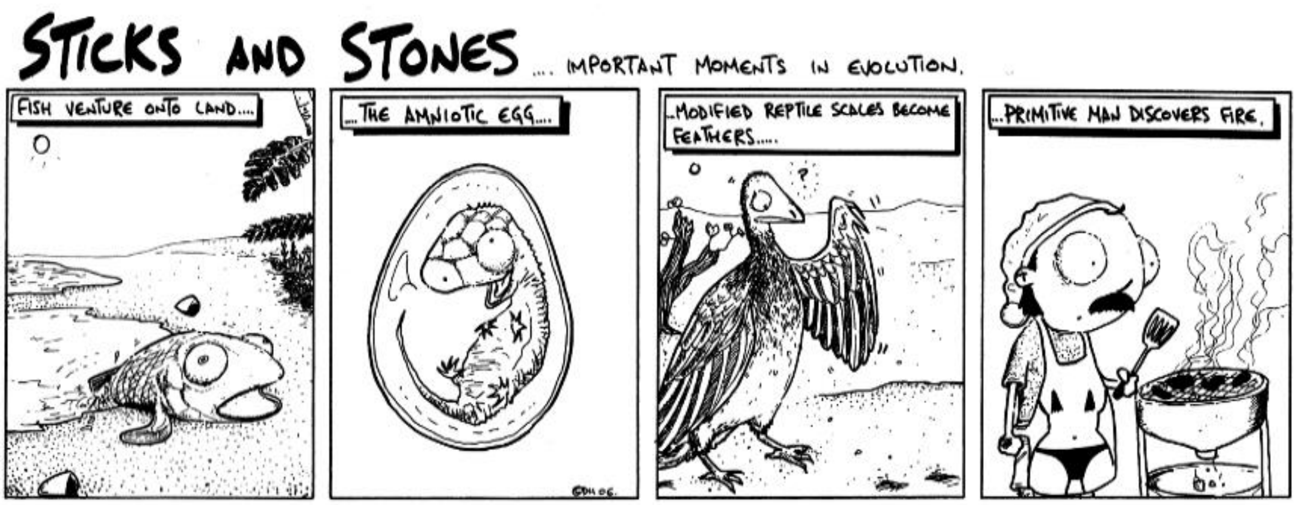
And Finally

As suggested by Janet Catchpole.

GEOSCIENTIST

The magazine of the Geological Society of London

Geoscientist magazine, Vol. 17, No. 3 … March 2007



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Further Reading

GeologyToday

Airborne LiDAR reveals a spectacular landform record

Jonathan L. Carrivick, Jenna L. Sutherland, David J.A. Evans

First published: 18 September 2025

Abstract

Long-term preservation of landforms produces a geological record that can be used to unravel past Earth surface processes in space and time. Identification and analysis of landforms has been revolutionized by the availability of high-resolution (metre-scale) topographic survey data covering extensive areas, using Light Detection and Ranging (LiDAR). Airborne LiDAR has been in widespread use for over two decades; but due to increasing availability of data, some regions are only just beginning to be 'explored' in this way. In this article, we showcase high-resolution topography derived from airborne LiDAR survey data across South Island, New Zealand. We evidence a variety of tectonic, glacial, fluvial, hillslope and other landforms hitherto undetected within mountainous areas and beneath forests. We discuss how the characteristics of shape, size, position and association can differentiate landforms from one another, and how combinations of landforms enable land systems to be identified that are diagnostic of past environmental conditions.

https://onlinelibrary.wiley.com/doi/full/10.1111/gto.12525?campaign=woletoc

https://doi.org/10.1111/gto.12525

Satellites detected strange gravity signal coming from deep within Earth almost 20 years ago, study reveals

Patrick Pester, LiveScience 9 October 2025

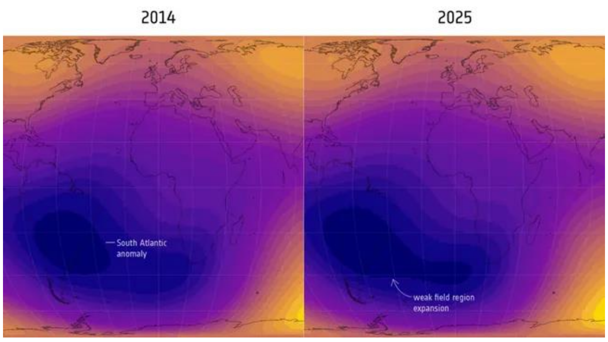
Researchers have discovered there was an anomaly in Earth's gravitational field between 2006 and 2008, potentially caused by a mineral shift deep within Earth's mantle. GRACE satellites detected a strange gravity signal at the time.

https://www.livescience.com/planet-earth/geology/satellites-detected-strange-gravity-signal-coming-from-deep-within-earth-almost-20-years-ago-study-reveals?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=207333B4-644F-4461-B136-1F5485287048&utm_source=SmartBrief

A massive weak spot in Earth's magnetic field is growing, scientists discover

Sascha Pare, LiveScience 14 October 2025

The South Atlantic Anomaly, a huge weak spot in the geomagnetic field off South America, has expanded and sprouted a lobe in the direction of Africa over the past decade.



A massive weak spot in Earth's magnetic field has grown and changed shape since 2014. (Image credit: ESA (Data source: Finlay, C.C. et al., 2025))

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Radio 4

09 July 2025 ***Series 33***

Technofossils - Sarah Gabbott, Mark Miodownik and Aurie Styla

Brian Cox and Robin Ince dig deep into the strata of an imagined human history to unearth the curious concept of technofossils. Joined by paleobiologist Sarah Gabbott, material scientist Mark Miodownik and comedian and tech enthusiast Aurie Styla the panel unearth how the everyday objects that we throw away today compare to fossils of the past.

Together, the panel investigates how these modern artifacts could degrade over time to become the fossils of the future. From old smartphones buried in bedside drawers to sprawling landfill sites, they imagine how these remnants of the Anthropocene might puzzle future archaeologists—and speculate on what these researchers might infer about our technology, customs, and way of life.

https://www.bbc.co.uk/sounds/play/m002fxn2

23 October 2025

Tom Herring on High-Precision Geodesy

There are three main types of geodetic measurement systems — satellite-based systems such as GPS, very long baseline interferometry (VLBI), and interferometric synthetic-aperture radar (InSAR). While each type of systems has its particular strengths, the cost of satellite-based receivers has plummeted. Millimetre-level accuracy will soon be incorporated into phones. This has broadened the kinds of geological questions we can now address with such systems. In the podcast, Tom Herring describes impressive geological applications as well as applications in civil engineering, such as dams and tall buildings, and agriculture.

Herring is a pioneer in high-precision geodetic analytical methods and applications for satellite-based navigation systems to study the Earth's surface. He is a Professor in the Earth, Atmospheric, and Planetary Sciences department at the Massachusetts Institute of Technology.

https://www.geologybites.com/tom-herring

12 November 2025

Keith Klepeis on How Plutons Form

Plutons are bodies of igneous rock that crystallize from magma at depth below the Earth's surface. But even though this magma never makes it to the surface, it still has to travel many kilometres up from its source near the base of the crust to the upper crust where plutons form. In the podcast, Keith Klepeis explains how it makes that journey and describes the shape of the resulting structures. Many of his findings come from one region in particular that provides an exceptional window into the origin, evolution, and structure of plutons — the Southern Fiordland region of New Zealand's South Island.

Klepeis is a Professor in the Department of Geography and Geosciences at the University of Vermont.

https://www.geologybites.com/keith-klepeis

2 December 2025

Anat Shahar on What Makes a Planet Habitable

Over 6,000 exoplanets have now been found, and the number is constantly rising. This has galvanized research into whether one of them might host life. A key requirement for life is the presence of liquid water. In the podcast, Anat Shahar describes her theoretical and experimental work showing how hydrogen atmospheres observed on exoplanets react with magma oceans thought to prevail during planet formation to form water. The Earth could have produced enough water in this way to fill the oceans and also supply the mantle with another oceans' worth of water.

Shahar is a Staff Scientist and Deputy for Research Advancement at the Earth and Planets Laboratory at the Carnegie Institution for Science in Washington, DC.

https://www.geologybites.com/anat-shahar

24 December 2025

Carina Hoorn on the Evolution of the Amazon Basin

The Amazon Basin is the most biodiverse region on Earth. How did this come about? In the podcast Carina Hoorn explains that to answer this question, we need to go back at least 23 million years to two key geologically-caused drivers of biodiversity — the rise of the Andes and marine incursions.

Hoorn is an Associate Professor in the Institute for Biodiversity and Ecosystem Dynamics at the University of Amsterdam and Research Associate at the Negaunee Integrative Research Center, Earth Science Section, Field Museum of Natural History, Chicago.

https://www.geologybites.com/carina-hoorn

The Sedimentary Record

Research Article

Vol. 23, Issue 1, 2025

September 30, 2025

Geology's Grip on Baseball: Investigating the Sedimentology, Mineralogy, and Physical Properties of Baseball Rubbing Mud

Dallin P Laycock, Ph.D., Emily Vanderstaal, Bsc., Erin A Pemberton, Ph.D., Paul M Bremner, Ph.D., Richard Mackenzie III, Han Byul Woo, Ph.D., Cory Twemlow, BSc., Sean Fletcher, MSc.

Abstract

Major League Baseball (MLB) prepares a minimum of 156 baseballs for each game by rubbing them with mud, sourced from the same company since the 1950's (Baseball Rubbing Mud, n.d.). This mud is intended to add grip and colour to the baseball in a way that

ensures competitive consistency across the league. Despite its long-standing use, the geologic characteristics of this mud and its precise effects on the baseball are still poorly understood. In this study, we analyse the mineralogy and physical properties of the baseball rubbing mud in the context of its depositional environment in a tributary of the Delaware River near Philadelphia.

Samples of game-used and new baseballs were analysed with Scanning Electron Microscopy (SEM), along with SEM analysis of the un-applied mud. These data were supplemented with X-Ray Diffraction (XRD), Particle Size Distribution (PSD), and Rock-Eval of the mud itself. Results show that the mud is composed primarily of non-swelling clays (Kaolinite, Chlorite, and Illite/Mica) and quartz, with minor amounts of other components. SEM images show that the clays primarily accumulate in the pores, adding the desired colour to the baseball, while the coarser quartz grains serve as a scouring material, inducing scratches, micro-cracks, patches of erosion, and occasional flaking of the leather. This provides minor grip enhancement to the ball without significantly altering ball aerodynamics. The lack of swelling clays also prevent overly slippery or inconsistent grip in the presence of moisture. While muds could be sourced from different locations, changing the location of mud collection would result in variations in composition, grain size, and colour that could alter the grip and colour uniformity in ways that could provide competitive inconsistencies.

https://doi.org/10.2110/001c.144870

https://thesedimentaryrecord.scholasticahq.com/article/144870-geology-s-grip-on-baseball-investigating-the-sedimentology-mineralogy-and-physical-properties-of-baseball-rubbing-mud

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Scientists discover first direct evidence that slivers of 'proto-Earth' may survive today

Sascha Pare, LiveScience

21 October 2025

In a first, researchers have discovered fragments of Earth's precursor that contain distinctive chemical fingerprints in ancient rocks from Greenland, Canada and Hawaii.

https://www.livescience.com/planet-earth/geology/scientists-discover-first-direct-evidence-that-slivers-of-proto-earth-may-survive-today?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=A2370809-85A1-4C45-91E1-B8D1F4EC5F91&utm_source=SmartBrief

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Fossil lichen from Devonian era shows how fungi-algae alliance paved way for terrestrial life

The Australian National University
Edited by Lisa Lock, reviewed by Robert Egan

30 October 2025

(Credit: J. Lacerda)

https://phys.org/news/2025-10-fossil-lichen-devonian-era-fungi.html?fbclid=IwY2xjawNxd1xleHRuA2FlbQIxMQABHpTef3MQ6TFhfNcafgSCaJxGewqPck4CI0PUERMiW--rLUye7jdgPI-PQIBz_aem_7EVij_rYWMZwoXqIxM8y4A

Survey results spotlight need for oil & gas windfall tax reform, OUEK says

Melisa Cavcic, Offshore Energy
30 October 2025

Source: Offshore Energies UK (OEUK)

Britain's trade body for the offshore energy industry, Offshore Energies UK (OEUK), has disclosed the results of its survey, which indicate that the Energy Profits Levy (EPL) needs to be tweaked from next year to unlock investments in the offshore energy arena.

https://www.offshore-energy.biz/survey-results-spotlight-need-for-oil-gas-windfall-tax-reform-ouek-says/?utm_placeholder_value=&utm_source=dailynews&utm_medium=email&utm_campaign=OffshoreEnergy_DailyNewsletter&cdmwt=AQkEAhhQkeLWCRCVEJC2VniSEsMbIhacS0OK

What are the signs that nature is telling us?' Scientists are triggering earthquakes in the Alps to find out what happens before one hits

Stephanie Pappas, LiveScience
3 November 2025

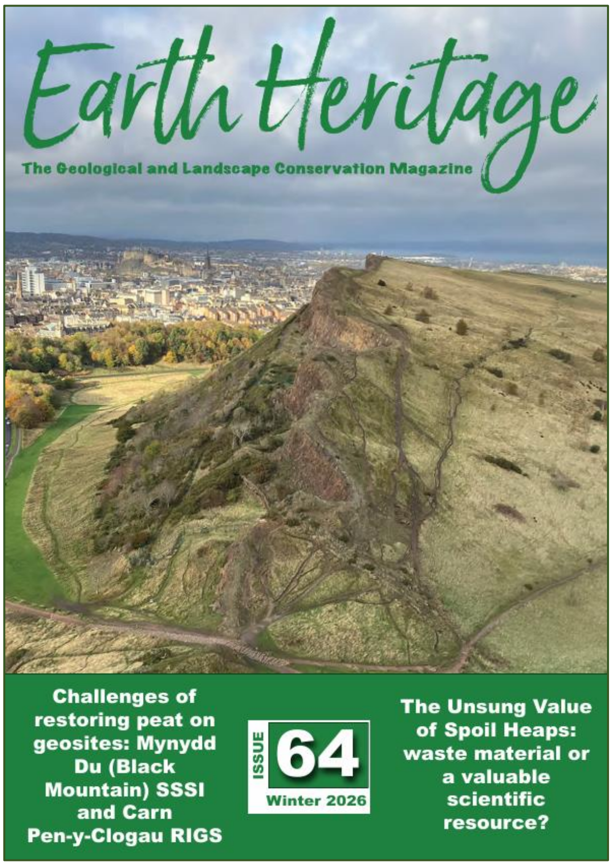
Researchers are deliberately setting off real (small) earthquakes to understand how to gauge the danger of a fault line before it breaks.

https://www.livescience.com/planet-earth/earthquakes/what-are-the-signs-that-nature-is-telling-us-scientists-are-triggering-earthquakes-in-the-alps-to-find-out-what-happens-before-one-hits?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=04E73BF9-983B-4610-A7A8-0831E94B1AC1&utm_source=SmartBrief

Earth Heritage

Issue 64, Winter 2025

https://www.earthheritage.org.uk/



Breakup of ancient supercontinent Nuna created 'incubators' for complex life, study finds

Sascha Pare, LiveScience

10 November 2025

Ancient supercontinent Nuna's breakup around 1.5 billion years ago set off a chain of events that made Earth more habitable, new research suggests.

https://www.livescience.com/planet-earth/geology/breakup-of-ancient-supercontinent-nuna-created-incubators-for-complex-life-study-finds?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=6FF9CAAF-4A36-43E6-A5B3-888381B3AF8A&utm_source=SmartBrief

Rockwatch is the UK's Nationwide Geology Club for children and young people. It is the junior club of the Geologists' Association – a charity and the UK-based Society for amateur and professional geologists and earth scientists.

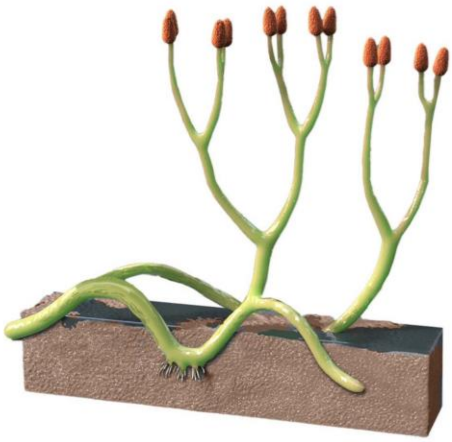
Rockwatch is the club for children and young people who are interested in things geological – rocks, fossils, minerals and landscape. Our activities are aimed at junior members under the age of 16 and for older young people between 16-18 years old. Our vision is for Rockwatch to inspire young people to study, interpret and understand planet Earth and its processes.

https://www.youtube.com/@rockwatchgeologyclub

Ancient fossil reveals how plants and fungi first developed on land

James Ashworth, NHM

12 November 2025



The new species of fungus, Rugososporomyces lavoisierae, grows in the above-ground sections of the ancient plant Aglaophyton majus (pictured). (Adapted from © Victor O Leshyk)

Plants and fungi have lived together for hundreds of millions of years – sometimes as allies, and sometimes as enemies.

A new fossil fungus discovered in Scotland has revealed early evidence of this relationship, as plants and fungi shared nutrients to survive on land.

https://www.nhm.ac.uk/discover/news/2025/november/ancient-fossil-reveals-how-plants-fungi-first-developed-land.html

"Weird" new species of ancient fossil snake discovered in southern England

James Ashworth, NHM

10 November 2025

The new fossil snake species, Paradoxophidion richardoweni, lived in a much warmer England over 37 million years ago. (© Jaime Chirinos)

An extinct snake has slithered its way out of obscurity over four decades after its discovery.

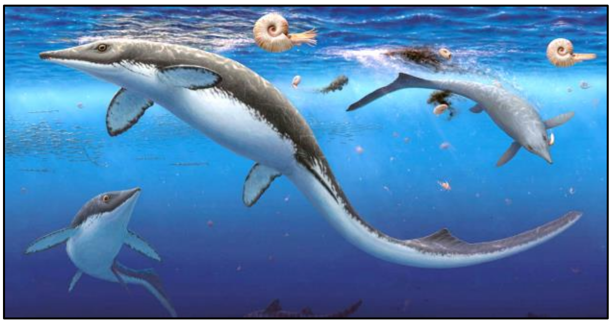
The newly described species of reptile, *Paradoxophidion richardoweni*, is offering new clues in the search for the origin of 'advanced' snakes.

https://www.nhm.ac.uk/discover/news/2025/november/weird-new-species-ancient-fossil-snake-discovered-southern-england.html

Fossils of ancient marine predators have been discovered on an Arctic mountain

James Ashworth, NHM

13 November 2025



The Svalbard bonebed is much more diverse than any other known site of the same age. (© Robert Back)

Over 250 million years ago the planet went through the worst mass extinction in history.

In the aftermath, life took millions of years to recover. But newly uncovered fossils on an Arctic island suggest that, in some places, it bounced back much quicker than expected.

https://www.nhm.ac.uk/discover/news/2025/november/fossils-ancient-marine-predators-discovered-arctic-mountain.html

Earthquake recorded off Anglesey coast

Epicentre of the 0.4-magnitude event was at a depth of 17km

Andrew Forgrave, Countryside and tourism editor, NorthWalesLive

14 November 2025

A minor earthquake occurred off Anglesey's western coast earlier this month, the British

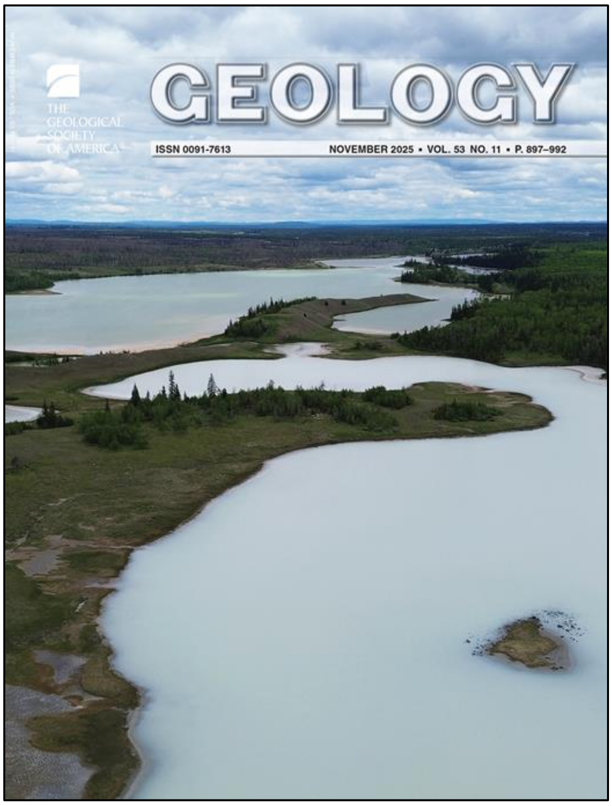
Epicentre of the 0.4-magnitude tremor was 5.6 miles (9km) southwest of Rhosneigr in the Irish Sea.

It was registered at 7.55am on Sunday, November 2, at a depth of 17km. The BGS has not been notified of any on-land impacts.

https://www.dailypost.co.uk/news/north-wales-news/earthquake-recorded-off-anglesey-coast-32873601

Geology (GSA) November issue

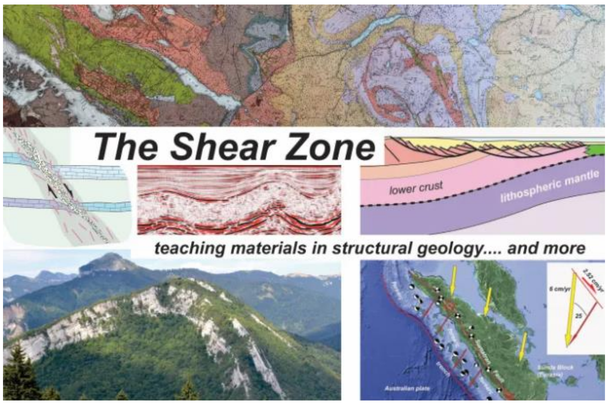
Topics include "Evolution of skeletal mineralogy in cheilostome bryozoans from calcite to aragonite seas" and "Unique leaf mimicry in Jurassic insects."



https://pubs.geoscienceworld.org/geology/issue/53/11?fbclid=IwY2xjawOMG6hleHRuA2FlbQIxMABicmlkETBTeENXTEtPbkkxc0NBRFRWc3J0YwZhcHBfaWQQMjIyMDM5MTc4ODIwMDg5MgABHpvTWdF-hClbkkCsc3FlgJ5j1YFPvS1ZLDB4r-OSdYE_uqmnsAz8PZYu5eiS_aem_X8ufpru1HzCNWxyz1UrwZA

Welcome to **"The Shear Zone"** - a hub for videos on geology, developed by me, Rob Butler of the University of Aberdeen. I am emeritus professor of tectonics having taught and researched across a broad range of earth science for over 40 years. This channel was created (as many were) through the Covid19 pandemic, initially to support university-level teaching, but also to reach out to interested others - professional and amateur. Here you can find videos on the interpretation of geological maps, 2D seismic profiles of the subsurface alongside developing ideas on how deformation structures, sedimentary basins, mountain belts and tectonic plates work. Supporting materials (maps, images, seismic profiles) are available on the companion website (linked from this channel homepage). And there are films on great geological locations and key concepts in earth science. I hope you find them enjoyable!

https://www.youtube.com/channel/UCIUYjr1yPCZQWYI9cJCO1mA



https://theshearzone.wordpress.com/

South West minerals have 'huge amount to offer UK'

George Thorpe, South West & Seb Noble, Cornwall political reporter, BBC
25 November 2025

Minerals from the South West could play a big part in a strategy to reduce the UK's reliance on using foreign material, the government says.

Industry Minister Chris McDonald visited Cornwall to launch the Critical Minerals Strategy, which aims to produce 10% of the UK's mineral needs domestically, along with a further 20% through recycling products by 2035.

https://www.bbc.co.uk/news/articles/cm207eyyq32o

Earth's crust hides enough 'gold' hydrogen to power the world for tens of thousands of years, emerging research suggests

Reservoirs of hydrogen gas that form naturally in Earth's crust could help humans decarbonize. The challenge now is finding these accumulations and working out how best to mine them, experts say.

Sascha Pare, LiveScience
9 December 2025

https://www.livescience.com/planet-earth/geology/earths-crust-hides-enough-gold-hydrogen-to-power-the-world-for-tens-of-thousands-of-years-emerging-research-suggests?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=8998D35F-87E2-441A-B633-C1753D00B43D&utm_source=SmartBrief

'It is the most exciting discovery in my 40-year career': Archaeologists uncover evidence that Neanderthals made fire 400,000 years ago in England

Kristina Killgrove, LiveScience
10 December 2025

Archaeologists have found the earliest evidence yet of fire technology — and it was created by Neanderthals in England more than 400,000 years ago.

https://www.livescience.com/archaeology/human-evolution/it-is-the-most-exciting-discovery-in-my-40-year-career-archaeologists-uncover-evidence-that-neanderthals-made-fire-400-000-years-ago-in-england?utm_term=8DEBC9E5-6C7F-4337-AFFF-D9A51CC6C2C0&lrh=840a98cbe34ba22d824f6df096d90a0be8fe4763876a779b0361304855882d8f&utm_campaign=368B3745-DDE0-4A69-A2E8-62503D85375D&utm_medium=email&utm_content=862386CA-E0AA-4F7C-BB2A-C3F3359CF113&utm_source=SmartBrief

Scientists claim 'Lucy' may not be our direct ancestor after all, stoking fierce debate

Sophie Berdugo, LiveScience
22 December 2025

Recent fossil finds could mean that "Lucy" wasn't our direct ancestor, some scientists say. Others strongly disagree.

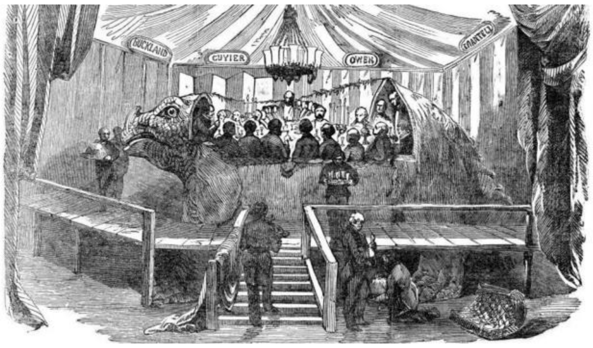
For a half century, the iconic "Lucy" fossil species, *Australopithecus afarensis*, has held the title of being the most likely direct ancestor of all humans.

But as the list of ancient human relatives has grown and more fossils have been discovered, Lucy's position has increasingly been called into question. Now, a key paper published last month in the journal **Nature** could overturn that theory entirely, some scientists say.

They argue that, given the new evidence, an older species, *Australopithecus anamensis*, was our direct ancestor, not Lucy.

https://www.livescience.com/archaeology/human-evolution/scientists-claim-lucy-may-not-be-our-direct-ancestor-after-all-stoking-fierce-debate

Seeing in the new year with dinner in a dinosaur



The Illustrated London News

The iguanodon mould held dignitaries, scientists and a seven-course feast. (Image source: Hulton Archive via Getty Images)

Bethan Bell, BBC ***31 December 2025***

As New Year's Eve invitations go, the one received by 20 men in December 1853 was unusual.

Apart from the fact that presumably none of the attendees wanted to spend the turning of the year with any of their womenfolk, the location was specified as "in the mould of the Iguanodon at the Crystal Palace".

The distinguished guests, invited by Benjamin Waterhouse Hawkins, included Richard Owen (who came up with the word "dinosaur"), Edward Forbes (a naturalist and expert on British starfish), John Gould (an ornithologist and illustrator) and Joseph Prestwich (geologist and pioneer of modern scientific archaeology).

Hawkins's plan was to launch his dinosaur sculptures to the world and encourage people to visit the newly relocated Crystal Palace and its park - so a reporter or two were also invited, along with local bigwigs, owners and investors in the exhibition centre.

https://www.bbc.co.uk/news/articles/cx2pgwj19plo

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

Can you help?

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