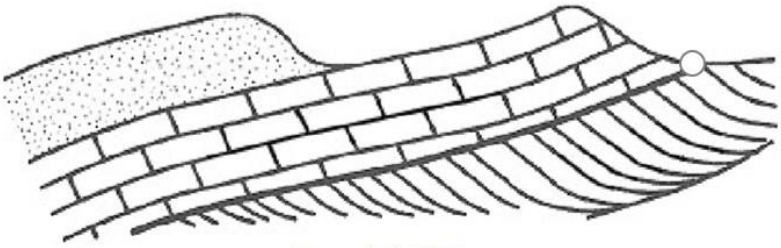
Newsletter of
The Farnham Geological Society

Volume 25, Number 3, August 2022

The "multi-coloured rock stop" on the A838 near Laxford Bridge in Scotland by Bob Rusbridge.

Farnham Geological Society

Farnhamia farnhamensis



Founded 1970

A local group within the GA

Volume 25, No. 3 **Newsletter** August 2022
Issue No. 117

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Editorial

Welcome to the third edition of the FGS Newsletter for 2022. I hope you are all well and enjoying the return to "face-to-face" meetings at The Maltings, as well as our Zoom meetings.

This month's Newsletter brings you some interesting articles, including reports from our monthly lectures for all those who didn't get a chance to view them "live". And don't forget to **zoom-in (only)** on **Friday, 9 September** for **Dr. Jonathon Gammon's "Influence of Geology on the London Underground Railways"** which promises to be an excellent presentation.

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

Front Cover

This month's Front Cover is the runner-up from our recent **Photographic Competition**. Taken by **Bob Rusbridge,** it is a view of an outcrop exposed along the roadcut of the A838 road in NW Scotland just north of Laxford Bridge on the shores of Loch na Fiacail. The outcrop, known as the "multi-coloured rock stop", has become famous because it shows a cross-cutting relationship between some of the oldest rocks in Europe. The outcrop, excavated in the 1980s as part of the A838 road improvements between Laxford Bridge and Rhiconich, provides dramatic exposures of gneisses that give a glimpse of processes that operate in the middle continental crust during mountain building. Various types of metamorphosed igneous rocks are represented that are now various forms of gneiss. The Precambrian Lewisian (or Laxfordian) gneiss (LG), on the far left of the photograph, formed about 3.0 Ga ago. These have been cut by mafic Scourie dykes (SG), around 2.4 to 2.5 Ga ago. Finally, all of the units are cut by granitic intrusions, including coarse-grained pegmatites (GD), much later at 1.855 Ga ago. The whole assembly has experienced metamorphism that has shaped its final look. This outcrop is part of the NW Highlands Geopark and is one of the Geological Societies "100 Great Geosites".

Contents

Farnham Geological Society

Committee 2022

Chair	**Liz Aston**
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Programme Secretary	**Janet Catchpole**
Membership Secretary	**Sally Pritchard**
Field Trip Secretary	**John Williams**
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Web Manager	**Michael Hollington**
Advertising	**Peter Crow**
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Meeting Programme 2022

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

Influence of Geology on the London Underground Railways
Dr. Jonathan Gammon Fri, 9 September
Geotechnical Observations Ltd.

Devonian mass extinctions – What the Old Red Sandstone tells us
Prof. John Marshall Fri, 21 October
NOC, Southampton

"Bite Club": Reconstructing past diet in Ice Age carnivores
Prof. Danielle Shreve Fri, 4 November
RHUL

Lead, Zinc & the North Pennine Orefield
Richard Sutch Fri, 9 December

Field Trip Programme 2022

Our Field Trip Secretary, John Williams, is continuing to put together our programme for the second part of 2022 and into 2023.

Geologists' Association
Lecture Programme 2022

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

The rise and fall of the last British-Irish Ice Sheet
Prof. Chris Clark Fri, 7 October

Volcanic activity up close
Dr. Evgyeniya Ilyinskaya Fri, 2 December

Reading Geological Society
Lecture Programme 2022

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

When Scotland and England collided – the closing of the Iapetus Ocean
Lesley Dunlop Mon, 5 September
Northumbria University

Mole Valley Geological Society
Lecture Programme 2022

http://mvgs.org.uk

Fire, Society & Culture: excavations at the 400,000-year-old site at Barnham, Suffolk
Prof. Nick Ashton *Thu, 10 November*
British Museum, London

Horsham Geological Field Club
Lecture Programme 2022

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

Slow-slip plate tectonics: New Zealand
Dr. Rebecca Bell *Wed, 14 September*
Imperial College, London

Solnhofen
Dr. Chris Duffin, *Wed, 12 October*
Natural History Museum, London

Exceptionally preserved arthropods and their role in understanding arthropod evolution
Dr. Greg Edgecombe, *Wed, 9 November*
Natural History Museum, London

Next Lecture

Friday, 9 September 2022
Zoom only: 7.30 pm for 8.00 pm start

Influence of Geology on the London Underground Railways

Dr. Jonathan Gammon
Advisor/Non-Executive Director, Geotechnical Observations Ltd.

Dr. Gammon has had forty-five years of international ground engineering experience working for consultants and contractors.

In addition to project work in the UK, Europe, Africa, and the Middle East, he has worked in Hong Kong and New Zealand. He was Geotechnical Design Manager and Resident Engineer for West Rail in Hong Kong and Sub Surface Design Manager for Dublin Metro North in Ireland. His experience in London includes the Northern Line Extension, and the Bond Street Station Upgrade.

Lecture Summary

Friday, 17 June 2022

On Friday, 17 June 2022, FGS attendees at The Maltings and via Zoom, together with Reading Geological Society members, welcomed Laura Evanstar in presenting our external lecture.

Why are the Andes so high?

Dr. Laura Evenstar, Brighton University

This study focuses on the Central Andes of South America, the second largest mountain chain in the world, where, despite decades of research, both the timing and formation of this range is still a highly controversial topic.

Numerous scientists have provided different theories on the formation of the Andes and yet, none can account for all the available scientific evidence until now. Current theories on the formation of the Andes range from forming very slowly over the last 40 Ma to very rapidly within the last 10 Ma. The lack of constraint on the timing of its uplift lead to a range of models for its formation being equally valid.

Our study combines new and published datasets on a range of different proxies for uplift across the Central Andes. This allows us to reconstruct the history of Andean uplift and climate over 50 Ma. We show that although initial growth of the Andes stems back at least 50 Ma, this paleo-mountain chain generated precipitation on the windward slopes leading to increased erosion and limited relief, i.e., the mountain belt was forming but had limited elevation. As the mountain range grew eastwards, increasingly dry conditions on the leeward side, reducing erosion and allowed the mountain to both grow and be persevere increasing relief. This difference provides a mechanism that reconciles all the scientific evidence for Andean uplift and unites what previously contradictory models for the timing and causes of uplift. This understanding of how the Andes formed allows us to strengthen our understanding of mountain range development globally.

Dr. Laura Evenstar started her career in geology graduating from the University of Leeds in 2003. She migrated north to the University of Aberdeen to try and understand the relationship between the uplift of the Andean Mountain chain and the Atacama Desert, which runs along its western side. After 3 years they gave her a PhD despite not cracking this mystery. She has spent the last 20 years continuing to work on the problem!

She has undertaken research at the University of Aberdeen, University of Bristol and the University of Brighton where she has been a lecturer for the last 3 years. She now specialises in looking at desert environments all over the world such as Afghanistan, Ethiopia and the USA.

Lecture Summary

Friday, 13 May 2022

On Friday, 13 May 2022, FGS attendees via Zoom, together with Reading Geological Society members, welcomed Lil Stevens in presenting our external lecture.

Carboniferous plants from Coseley: biology, environments, collectors, and the future

Dr. Lil Stevens (Natural History Museum, London) & Dr. Chris Cleal (National Museum Wales, Cardiff)

UK in the Late Carboniferous

In the early part of the late Carboniferous, the UK and a large part of northern Europe were on the forefront of the Variscan Orogeny, caused by the collision of Gondwana and Euramerica (Fig. 1. Scotese, 200). The climate was tropical and the whole area was covered by an uninterrupted tract of lowland forest. This was also the time of the first major glacial period on Earth when vegetation was present to record the changes, so it's an interesting moment to study the effects on diversity, distribution and morphology of the plants.

This area was also an extensive delta system and sediments record fluvial and lacustrine environments as well as the swamps that generated peat and ultimately most of the coal we've mined here. The Mississippi delta is

sometimes used as an analogy, where rivers brought sediments down on top of the peat swamp, depositing coarser sediments in the crevasse splays and finer sediments in the quiet backwater of the delta. The repetition of facies as the swamp environment was replaced by fluvial and lacustrine sediments produces a layering effect that we then see in the resulting lithostratigraphy (Stone et al., 2010). As the seams of coal don't preserve many fossil features, it is the fine sand and siltstone above and below that records the interesting fossil material. Most of the sediments in the Coal Measures are non-marine, but there were occasional incursions

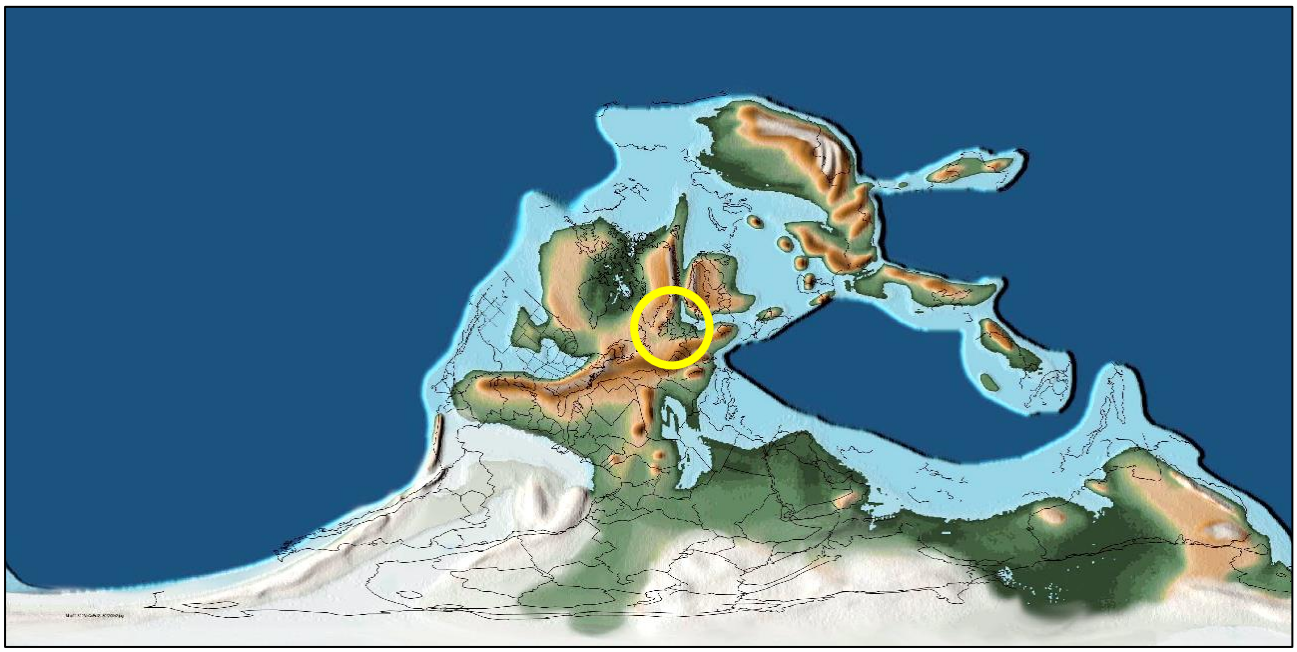

Figure 1: Bashkirian 315 Ma ago - early Pennsylvanian, late Carboniferous showing location of present-day UK. (Image: Scotese.com PALEOMAP Project)

when sea level rose, and these are recorded as carbonate facies.

There were two main settings in the ecology of the delta system. The overbank was higher and drier, adjacent to the water and therefore a major contributor to the fossil record, when whole or fragments of plants were washed away and deposited downstream in the soft river or lake muds. The plants here were dominated by tree ferns, horsetails and seed ferns, with a high proportion of smaller herbaceous plants (Cleal, 2018).

Behind that were the back swamps that formed the peat and eventually the coal. These were dominated by lycopsid trees, which were fast growing and contributed a huge amount of biomass. It takes much, much longer to form a metre of coal than it does a metre of clastic sediment, such as sandstone, so the amount of coal produced in this area goes to show how extensive and long-lived these forests were.

Figure 2: Reconstruction of overbank plant life with swamp forest behind. (Image: Annette Townsend)

In Fig. 2, you can see the big lycopsid, calamite and cordiate trees in the swamp and the smaller bushy and herbaceous plants growing on the overbank deposits, a less stable habitat but with more opportunities for the colonisers. The two together provided the sediments and

floristic diversity we know from the late Carboniferous. The UK and parts of northern Europe are particularly rich in these floras, and they have been studied extensively in the nineteenth and twentieth centuries, largely because of their proximity to the coal measures. Although most of the overbank plant remains were carried away before deposition and most of the swamp plants decayed into peat, occasionally a flooding event killed and buried the trees in life position and these are seen regularly in the roof shales of coal mines, being necessarily where the coal seam stopped, and the clastic sediments brought in by the incursion began.

Lycopsids: There are five main types of plant from this time and the lycopsids or clubmosses are probably the most familiar. They were mostly trees and grew up to 50 m tall, first as a pole and branching at the top only when they reached maturity. They had leaves and cones on the ends of the branches, and those famous leaf scars and root scars that are often found as fossils. The stem and root fossils are usually internal casts, formed when sediment filled the inside of the hollow stem. The shape and arrangement of the leaf scars is used to identify the taxa and draw the different parts of the plant together for a whole plant diagnosis.

Major plant groups

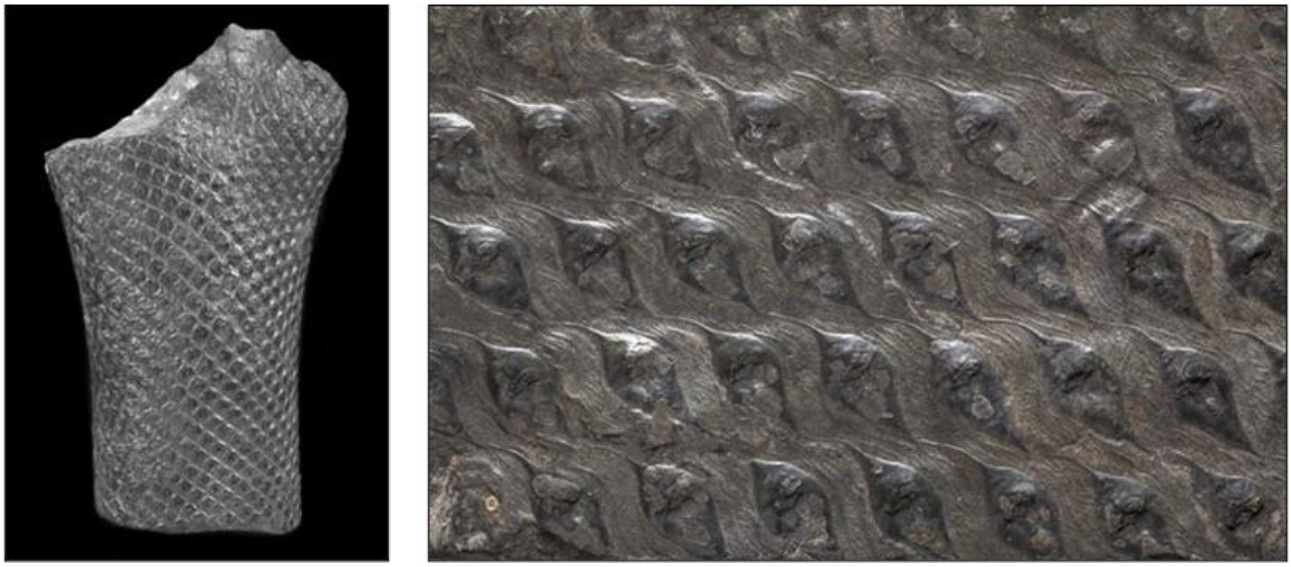

Figure 3: Lepidodendron stem and leaf scars. (Image: © Trustees of the Natural History Museum)

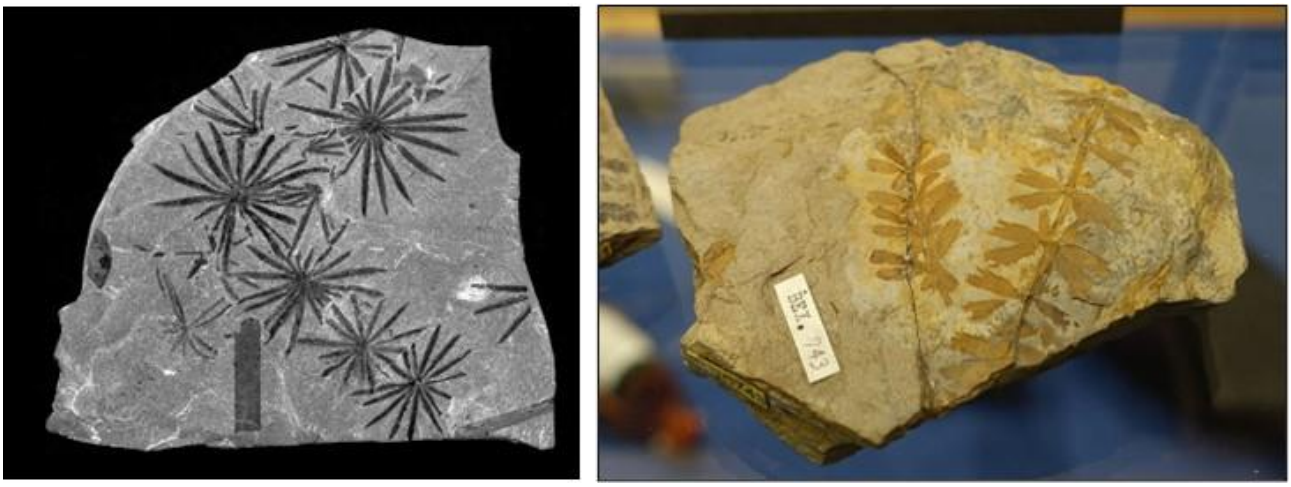

Figure 4: Annularia. (Image: © Trustees of the Natural History Museum) and Sphenophyllum (Image: Daderot)

Sphenopsids: The sphenopsids or horsetails are split into two groups: the calamites were mostly trees with characteristic ridged stems and nodes where whorls of thin leaves were attached, such as the *Annularia* leaves in Fig. 4. The sphenophylls were smaller herbaceous or scrambling plants, which had more wedge-shaped leaves like the *Sphenophyllum* in Fig. 4. They both grew along the edges of water courses, like horsetails do today, spreading with rhizomes across the top or just under the soil. They were great colonisers and I've worked on Permian fossils from China where you can see roots growing from broken stems, showing that even after being flattened and buried they could still grow up and take advantage of the new habitats created by the loss of other plants. I suspect that, like modern species, they also took advantage of river transport to help them colonise new areas.

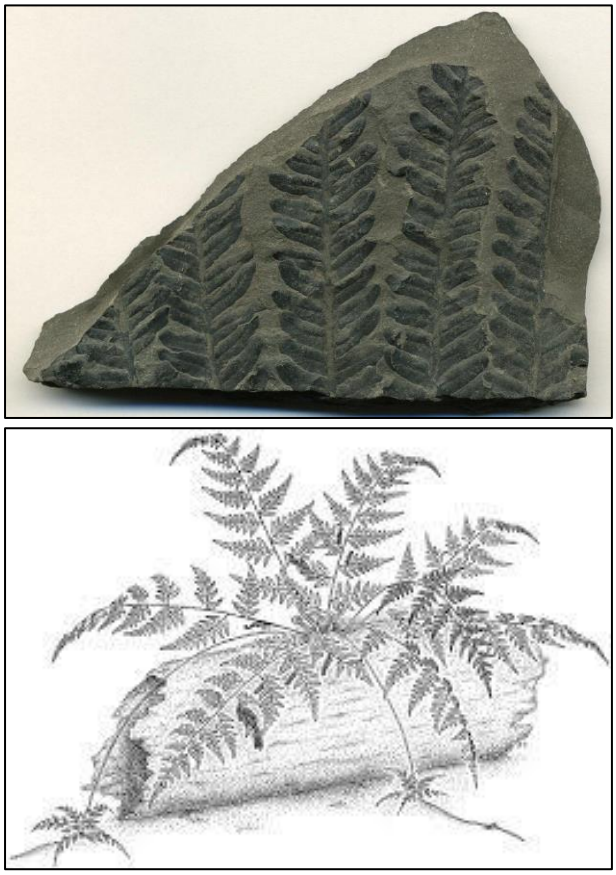

Figure 5: Pecopteris (Image: James St John) and Botryopteris (Reconstruction from Rothwell & Good, 2000)

Ferns: Also, a variable group, the ferns comprise small herbaceous species, epiphytes and trees rather like our scaly tree ferns today. They lived in both the swamps and levees. Ferns are characterised mainly on the shape of the pinnules, the large taxa, like *Pecopteris*, often entire and the smaller taxa, such as *Botryopteris*, much more lobed (Fig. 5). The stems are fairly featureless in compression but sometimes beautifully preserved as permineralisations.

Pteridosperms: the seed ferns, or pteridosperms, can be difficult to separate from the ferns. The foliage is very similar and whole plant reconstructions are sometimes the only method to infer relationships between taxa. The big difference is that these ferns had seeds, like *Trigonocarpus* (Fig. 6), that hung on the underside of the fronds and are often found separately. The seed ferns, such as *Neuropteris* and *Alethopteris* are very common in our coal measures floras – they lived on the levees and were preferentially preserved, so

Figure 6: Neuropteris (Image: © Trustees of the Natural History Museum) and Trigonocarpus (Image: Gyik Toma)

are well represented in museum collections. There are certainly some, like *Neuropteris* (Fig.

6) that have much more robust-looking foliage than some of the more delicate looking ferns.

Cordaites: Relatives of modern conifers, the cordaites were mostly trees and grew up to 30 m tall. They had long, strap-shaped leaves often seen preserved criss-crossed over a whole bedding plane, layers deep (Fig. 7). The plants bore cones which contained heart-shaped winged seeds, such as *Cardiocarpus,* that are commonly found in isolation. And when preserved, the wood is very characteristic, showing rings of secondary xylem.

Figure 7: Cordaite tree reconstruction and Cordaite leaves. (Image: geocraft.com)

Ironstone Concretions

Compression-impression fossils are most commonly found, but sometimes organisms are preserved in ironstone or siderite concretions, and these are particularly interesting because soft tissue structure and cellular detail can be preserved in this way. It is not completely understood what initiates the formation of these concretions, but several factors have to be in place (Clements et al., 2018). Rapid sedimentation in water buries the remains, which reduces aerobic decay and scavenging. Siderite then starts to form around the fossil, forming a proto-concretion, which grows and hardens to protect and preserve the fossil. Other minerals fill in gaps and replace soft tissue so that a 3D replica of the organism is formed. These fossils can be studied by serial sectioning using acetate peels. The peels are made by melting acetate onto a cut and polished section of one of the concretions and then peeling off a very thin layer. Repeating this at regular intervals through the fossil produces a series of peels that record features such as leaves or even tissue types through the fossil. A computer program can be used to reconstruct the whole fossil in 3D, showing how each organ appeared in life. This helps to draw together information from compression fossils to facilitate whole-plant reconstructions.

Ironstone concretions that formed during water incursion and rapid sedimentation in swamp environments are often found in the roof shales of coal mines and were mined alongside the coal for the iron they contained. This means that the fossils contained within the nodules were often found by miners and targeted by collectors. Since at least the 13th century, the South Staffordshire coalfield has been mined extensively. Both open cast and pit mines were used to access the Thick Coal or Ten Yard Seam, which was relatively near the surface. Alongside the coal, ironstone, limestone and fireclay were mined with increasing intensity into the mid-20th century. In Coseley, right in the heart of the Black Country, there was an opencast ironstone mine near the site of the Claycroft Colliery (Fig. 8), which was worked from the late 19th to the early 20th century, and it's from here that an incredible number of exceptionally-preserved siderite concretion fossils were collected.

Collectors at Coseley

At that time there was a great appetite for natural history and geology and there was plenty of opportunity to collect in this area. Fig. 9 is a photograph of a field trip of the Dudley Geological Society, with Professor Lapworth from Birmingham University (in the top hat). The geology in this area is varied and interesting and with so much of the land opened up for mines and associated railways, there was exposure everywhere. The fossil collectors in Dudley made it known that they would buy interesting fossils and so the miners and other workers would come to them with their finds. Alongside the miners, 'pit bank women' or 'pit bank wenches' collected ironstone nodules from the muds that were

brought up to dry in the fields (BCH, 2022) and it was likely that they found much of the fossil material that eventually made its way into private or university or museum collections (Fig. 10).

Figure 8: Claycroft Colliery, 1842-52. (Image: Ordnance Survey Six-inch England and Wales, 1842-1952 https://maps.nls.uk/view/101597510)

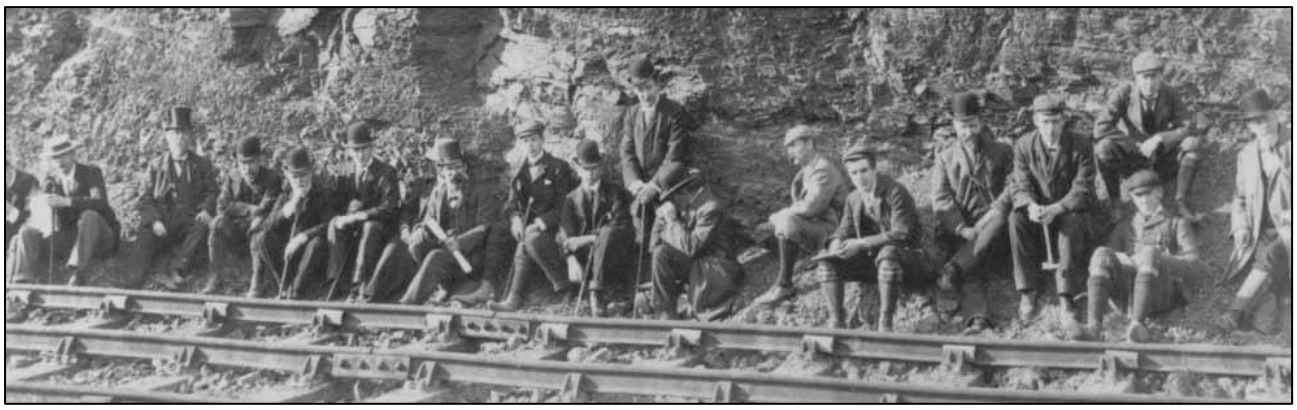

Figure 9: A field trip of the Dudley Geological Society with Professor Lapworth c.1885. (Image: Through Thick and Thin by Sula Rayska www.jpb.co.uk)

Of the collectors who were recorded to have brought the fossils to scientific attention, there were a few notable people. Herbert Hughes is acknowledged by Robert Kidston (an eminent Victorian palaeobotanist) as the person who collected many important specimens including the seed of Neuropteris heterophylla Brongt., and the microsporangia of Sphenopteris (Crossotheca) Höninghausi Brongt. (Kidston, 1914). Hughes was a mining engineer to the Earl of Dudley. He was also a colliery manager, a photographer, a member of the Royal Photographic Society, a Fellow of the Geological Society and Mayor of Dudley from 1920-21. As Kidston acknowledged, it was Hughes who collected most of the fossils from Coseley that were subsequently used to define the flora. He also pioneered the technique of underground photography with a Cornish photographer called Burrows and they worked a lot together to record what life and work was like down the mines (Fig. 11).

Charles Holcroft, an important financial donor to the University of Birmingham, also donated a large collection of fossils that he'd collected to the university. He was a mine owner and landowner with his brother James and spent

Figure 10: Blue Fly Pit Bank Wenches, Wednesbury, c.1890. (Image: The Esther M. Zimmer Lederberg Trust, estherlederberg.com)

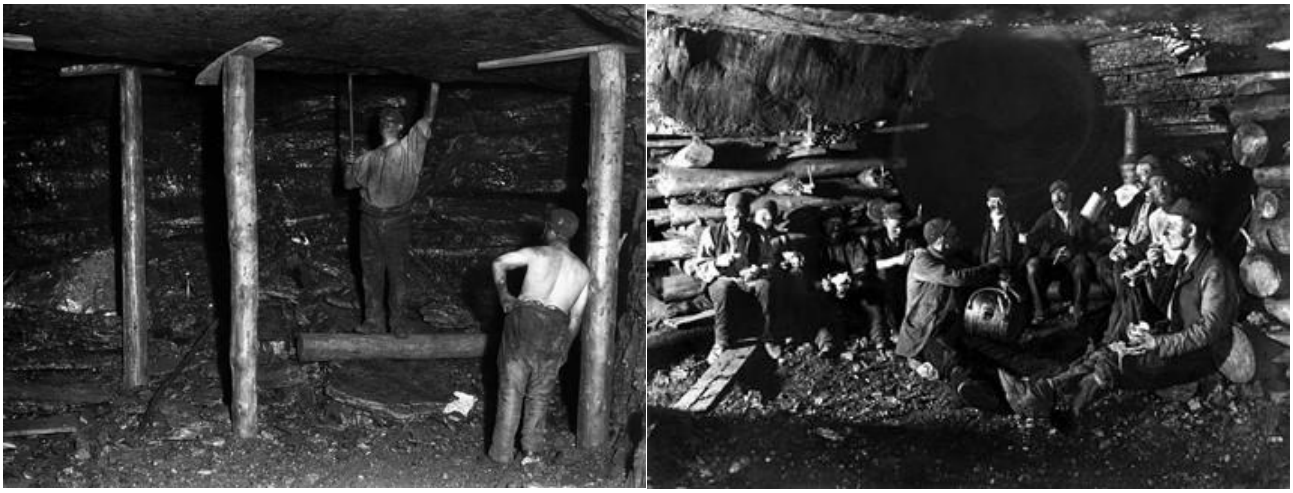

Figure 11: Miners in Ramrod Hall Pit, Staffordshire, c.1890s. (Image: © Science Museum / Science & Society Picture Library)

his free time studying geology and natural history.

Another local collector was Henry Johnson, founder of Johnson Poole and Bloomer, an engineering consultancy that still runs in Dudley (Rayska, 1994). He chronicled his life in diaries which have since been written up into a very absorbing history called Through Thick and Thin ('Through Thick and Thin' - the History of Johnson Poole & Bloomer 1844-1994 (jpb.co.uk)), held on the company's website and available for download. Johnson worked as a surveyor, mine manager, inventor.

Figure 12: Henry Johnson 1823-1885. (Image: Through Thick and Thin by Sula Rayska www.jpb.co.uk)

He set up the Institute of Mining Engineers in South Staffordshire and Warwickshire and worked a great deal on making the mines safer for the miners. He made a large collection of fossils that, after his death, were sold to Robert Damon, the biggest fossil dealer of the time, who in turn sold them to the Natural History Museum in London. They now form a large part of the museum's late Carboniferous collection of fossil plants and there are many important and figured specimens.

Very many of these fossils also made their way to Robert Kidston, a palaeobotanist who was reputedly a very approachable man with palaeontological network across the UK and Europe. Kidston was born in Scotland and studied botany at Edinburgh, eventually becoming an independent scientist. He contributed a huge amount to science, not just taxonomy but also illustration and photography. He left a large collection, including the Coseley fossils, to the British Geological Society. He recognised that the fossils contained in the ironstone nodules at Coseley were exceptional in their preservation

Figure 13: Sphenopteris sp., a fossil from the Johnson Collection at the Natural History Museum, London. (Image: © Trustees of the Natural History Museum)

and included them in his series on the South Staffordshire coalfield fossil flora (Kidston, 1914). He was also able to produce photographs showing extraordinary detail, for the time, such as the pteridosperm (seed fern) seed in Fig. 14.

The Coseley Flora

The ironstone these fossils come from overlies the Thick Coal and is of middle Duckmantian age. It reflects a time of peak diversity across Europe at this time. Because there is a huge amount of material and it shows exceptional preservation, this makes it a ***lagerstätte***, and it's therefore extremely important for understanding coal swamps as well as biotic response to climate change in this cooling period. The floral diversity curve for the South Wales coalfield in Fig. 15 is similar in pattern across the UK in the late Carboniferous

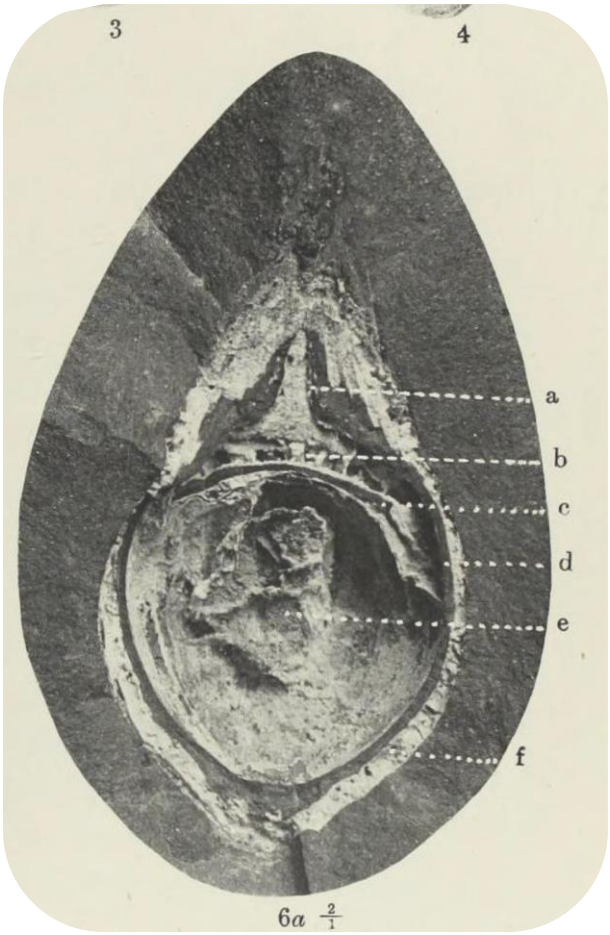

Figure 14: Rhabdocarpus oliveri, a pteridosperm seed showing: a, micropyle; b, pollen chamber; c, upper part of nucellus; d, sclerotesta; e, remains of contorted prothallus; f, cavity left through decay of sarcotesta, now filled with 'lime'. (Image: Kidston, 1914, pl. 16, fig. 6a)

(Pennsylvanian) (Cleal, 2007). Low diversity at the beginning of the Pennsylvanian suddenly peaks in the Duckmantian, indicating the diversity in the coal swamp and the overbank plants. The swamp floras, particularly the lycopsids, decrease in diversity later in the Pennsylvanian as the climate gets cooler and drier, while some of the ferns and seed ferns get more diverse. It's interesting that the peak at the beginning of the Duckmantian (*starred*) corresponds exactly with the Coseley flora. There is currently no ready explanation for this, as it is not explained by a sampling bias and there are no obvious climatic features indicated by the geology.

In comparison with other contemporary floras, Coseley is one of the oldest, which is one of the reasons why it's so interesting. The Mazon Creek fossils are the most familiar flora of this time, and the Montceau-les-mines flora in France is broadly contemporaneous. There are also older floras here in the Black Country, such as at Crockhey and also in Poland, but Coseley is exceptional for its exquisite preservation and bulk of material.

Coseley hasn't been reviewed since Kidston and several other authors characterised it in the early 20th Century, and it has never been published as an individual flora. A review is long overdue and myself and Chris Cleal have been re-examining the material to look for further potential discoveries and links to modern taxonomic treatments. There are also new techniques that can be used to image and reconstruct the internal features of fossils, such as the acetate peel technique and CT scanning, which could be particularly good for this material. The fruiting structures are interesting and could hold some new discoveries, as could the epiphytic ferns. It is unfortunate that this material is ex situ because it would be good to develop our understanding of the diagenesis. This is being done at Mazon Creek and it adds a great deal to the story of the site (Clements et al., 2018).

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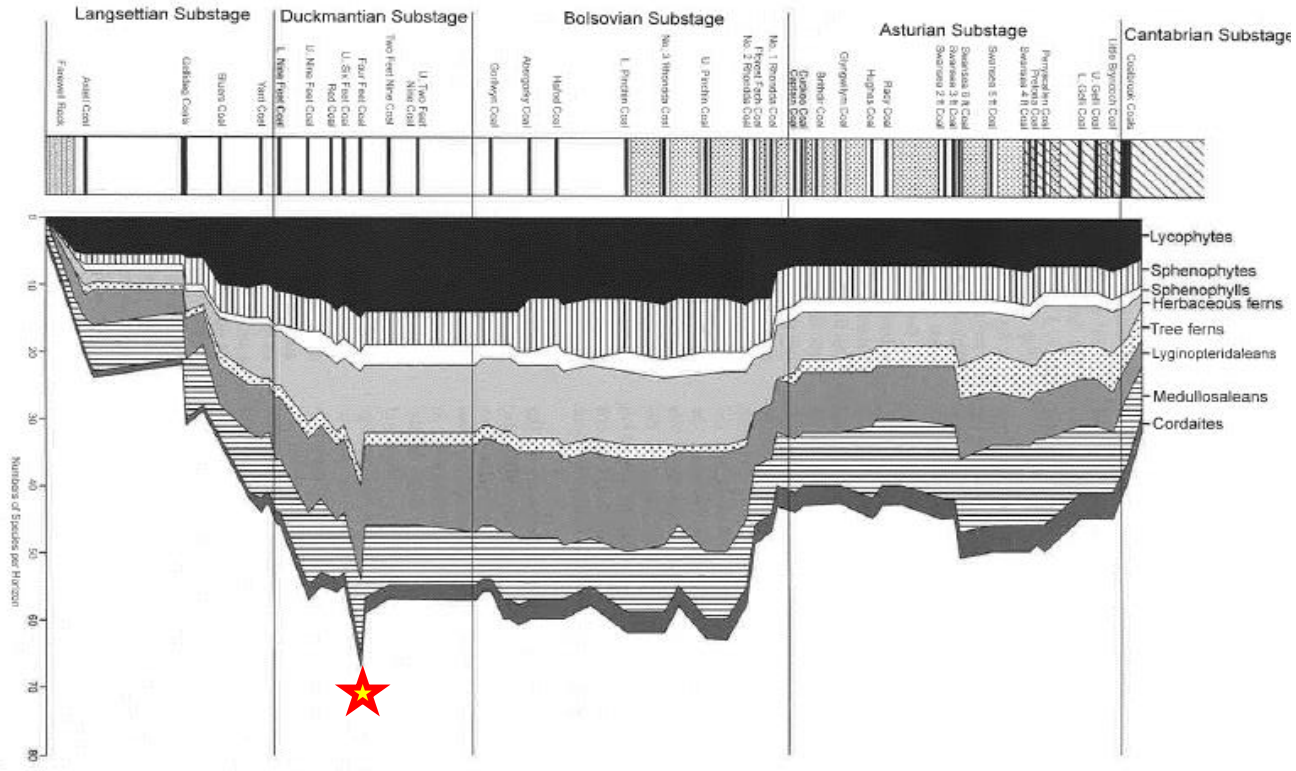

Figure 15: Floral diversity patterns in the Pennsylvanian of the United Kingdom. (From Cleal, 2007)

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Interesting Places 1

NASA's Curiosity Mars rover captured this view of layered, flaky rocks believed to have formed in an ancient stream bed or small pond.

The six images that make up this mosaic were captured using Curiosity's Mast Camera, or Mastcam, on June 2, 2022, the 3,492nd Martian day, or sol, of the mission. *(Photo: NASA)*

UNESCO Geoparks

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

Italian UNESCO Geoparks - 3

In this article, the third of three, **Liz Aston** describes the Italian UNESCO Geoparks.

The Geoparks are representative of the various tectonic regimes of Italy.

Part 3

5. **Southern Italy**: Cilento, Vallo Di Diano E Alburni & Pollino Geoparks.
   a. The Apennines: A Review.
6. **Sicily**: Madonie & Rocca Di Cerere Geoparks.
   a. Volcanicity, Active Tectonics: Faults & Earthquakes.
7. **Classification of Limestones**

5. SOUTHERN ITALY

Southern Italy is subdivided into several entities, clockwise from NE (Fig. 1), these are

- **Ab: Abruzzo** - Geologically akin to Central Apennines; with a mountainous area in the W and a coastal area on the Adriatic Sea in the E.
- **Mo: Molise** - Geologically (55% of area) is part of Central Apennines; has 35km of sandy coastline on the Adriatic Sea to the NE.
- **Ap: Apulia** - Geologically it has always been part of Gondwanan Africa. S peninsular section of Italy, borders Adriatic, Ionian Seas to the E & SE, and the Strait of Otranto and Gulf of Taranto to the S.
- **Ba: Basilicata** - the "instep" of Italy, with Calabria the "toe" and Apulia the "heel" – geologically similar to Pollino and Cilento Geoparks below.
- **Cl: Calabria** – the "toe" of Italy and geologically part of the volcanic arc to Sicily – bordered to W by the Tyrrhenian Sea, and E by the Ionian Sea; Strait of Messina separates it from Sicily.
- **Cm: Campania** – geologically part of the active volcanic chain of S Italy: Mount Vesuvius, Naples Supervolcano and Phlegraean Islands. Tyrrhenian Sea to W, includes Capri; has 10 UNESCO sites (Pompeii, Herculaneum, Royal Palace Caserta, Amalfi Coast).

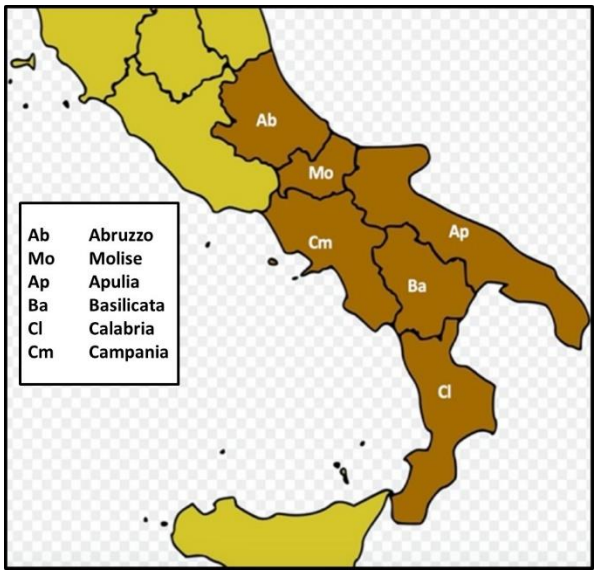


Figure 1: Southern Italy entities. (Source: Wikimedia Commons)

CILENTO, VALLO DI DIANO E ALBURNI GEOPARK *"… a living landscape … in contemporary society"*

The **Cilento, Vallo di Diano e Alburni Geopark** is located in the province of Salerno, Campania, extending from the Tyrrhenian coast to the margin of the Lucania mountains and comprises both carbonate and siliciclastic sedimentary rocks.

The Cilento region belongs to the S Apennines fold-and-thrust belt, which developed between late Cretaceous and Pleistocene, between the European and African plates and spreading of the Tyrrhenian Ocean basin. Several nappes can be distinguished, which are grouped as internal (autochthonous) units and external

(allochthonous) units, according to their original location before the thrusting.

Quaternary post-orogenic deposits include Mesozoic limestone and dolomite (130 Ma old), Mesozoic pelagic deposits and Miocene siliciclastic turbidites, 16-6 Ma old.

POLLINO GEOPARK … *"The only Italian mountain range where you can glimpse 3 seas"*

Pollino Geopark is located in S Italy. The area consists of several massif mountains, between the Ionian and the Tyrrhenian Sea that rise to the high elevations of the S Apennines: the Pollino Massif, the Orsomarso mountains and Mount Alpi.

The Pollino massif consists of 5 summits all >2000 m; the highest is Serra Dolcedorme at 2267 m, also the highest point of S Apennines, and the only massif where one glimpses the Ionian, Tyrrhenian and Adriatic Seas.

The Pollino chain connects the S end of the Apennine limestone chain with the Peloritano Calabrian Arch which has a crystalline metamorphic basement with sedimentary cover rocks. These units are separated by the Sangineto Fault.

The Calabria-Peloritani Orogen is an arcuate segment of the Alpine nappe system and includes all Calabria and the NE sector of Sicily. It comprises the Sila and Catena Costiera Massifs in N Calabria, the Serre and Aspromonte Massifs in central and S Calabria, and the Peloritani Mountains in Sicily.

In the Sila and Catena Costiera Massifs, three tectonic units are recognisable:

a) **Basal Apennine Complex**: passive continental margin carbonates.
b) **Intermediate Liguride Complex**: oceanic units, affected by UHP metamorphism; emplaced during the closure of the Tethys Ocean in Late Cretaceous to Oligocene.
c) **Upper Calabride Complex**: an almost entire section of continental crust.

The Serre Massif represents an almost entire segment of Variscan continental crust unaffected by Alpine metamorphism. Further S, the Aspromonte Massif and the Peloritani Mountains include the nappes of Variscan metamorphic units, Variscan units with Alpine overprint and continental units with Alpine metamorphism.

The geological evolution of the various chains indicates that the Calabria-Peloritani Orogen is a 'composite terrane' derived by amalgamation of crustal blocks from different continental areas.

N Calabria represents a section of the Adria margin, whereas S Calabria and NE Sicily are relics of an accretionary wedge from the European continental margin. Thus, a segment of the Europe-Adria collisional suture crops out in central Calabria.

Figure 2: The Italian Peninsula showing the Italian Alps & the Apennine Mountains. (Ref: https://brainly.com)

The Apennines – A Review

The Apennine Mountains (Fig. 2) consist of parallel smaller chains extending c.1,200 km along the length of the Italian Peninsular. In NW they join with the Ligurian Alps at Altare. In SW they end at the tip of the peninsula, but the mountain range extends W to N Sicily, a total distance of 1,500 km. The system forms an arc enclosing the E side of the Ligurian & Tyrrhenian Seas.

N Apennines

Geologically it is divided into the Outer N Apennines (ONA) and the Inner ones (INA) and consist of the sub-chains:

- the Ligurian Apennines

- Bordering the Ligurian Sea in the Gulf of Genoa.
- With Ligurian Alps along the coast in W and the Ligurian Apennines to E.
- Monte Maggiorasca is the highest point, at 1,800 m.
- SE border is the Fiume Magra, which projects into Tyrrhenian Sea, S of La Spezia.

- Tuscan-Emilian Apennines
  - From Cisa Pass, the mountains run SE.
  - Also, W of the Futa pass and they extend to the upper Tiber River.
  - The highest point is Monte Cimone at 2,165 m.
  - Tuscan Apennines divide the peninsula between the Po Valley, the plains of Tuscany and Lazio.
  - A separate branch, the Apuan (marble) Alps, goes SW bordering the coast S of La Spezia.
  - The river Serchio separates the Apuan Alps from the Apennines.

- Central Apennines
  - The Apennine System forms an irregular arc with centres of curvature located in the Tyrrhenian Sea.
  - N & S segments comprise parallel chains, such as the Ligurian Mountains.
  - The centre is thicker and more complex and divided into an inner and an outer arc.
  - The Central Apennines are divided into the Umbrian–Marchean or Roman Apennines in the N and the Abruzzi Apennines in S.
  - It extends from Bocca Serriola pass in N to Forlì pass in S.

- Umbria-Marche Apennines
  - W border runs through Cagli.
  - They extend S to the Tronto River, the S border of the ONA.
  - The highest peak is Monte Vettore, at 2,478 m.

Abruzzi Apennines

These are located in Abruzzo, Molise & SE Lazio; they contain the highest peaks and most rugged terrain of the Apennines.

- They exist in 3 parallel chains which extend NW-SE from the River Tronto to the River Sangro.
- The E coast hills extend from San Benedetto del Tronto in the N and Torino di Sangro in the S.
- E chain comprises S part of the Monti Sibillini, the Monti della Laga, the Gran Sasso d'Italia Massif and the Majella Massif.
- Gran Sasso contains Corno Grande, the highest peak of the Apennines at 2,912 m.
- Between W & central ranges are the Rieti plain, Salto valley & Lago Fucino; while between the central & E ranges are the Aquila & Sulmona valleys.

Southern Apennines

- The Daunian mountains, in Apulia and Cilento hills in W are connected with the Apennine range.
- Mount Gargano, on E and the Campanian volcanic arc near Naples, are not part of the Apennines.
- The S Apennines extend from Forlì S and are divided into 4 major regions:

  1. **Samnite Apennines**.
  2. **Campanian Apennines**, 3 parallel chains are broken up into smaller groups.
  3. **Lucan Apennines** running E-W; the second range runs N-S; the highest point is the Monte Pollino 2,233 m; width of the peninsula is just 64 km.
  4. **Calabrian Apennines** - includes the Sicilian Apennines. Limestone Apennines cease and the granite mountains of Calabria begin; highest point is 1,930 m; Calabrian S Apennine Mountains extend along the N coast of Sicily; highest peak is 1,979 m.

  Distinct orogenic segments from central Apennines to Sicily show that, in the Tyrrhenian domain, contraction is roughly equal to extension, and the variable

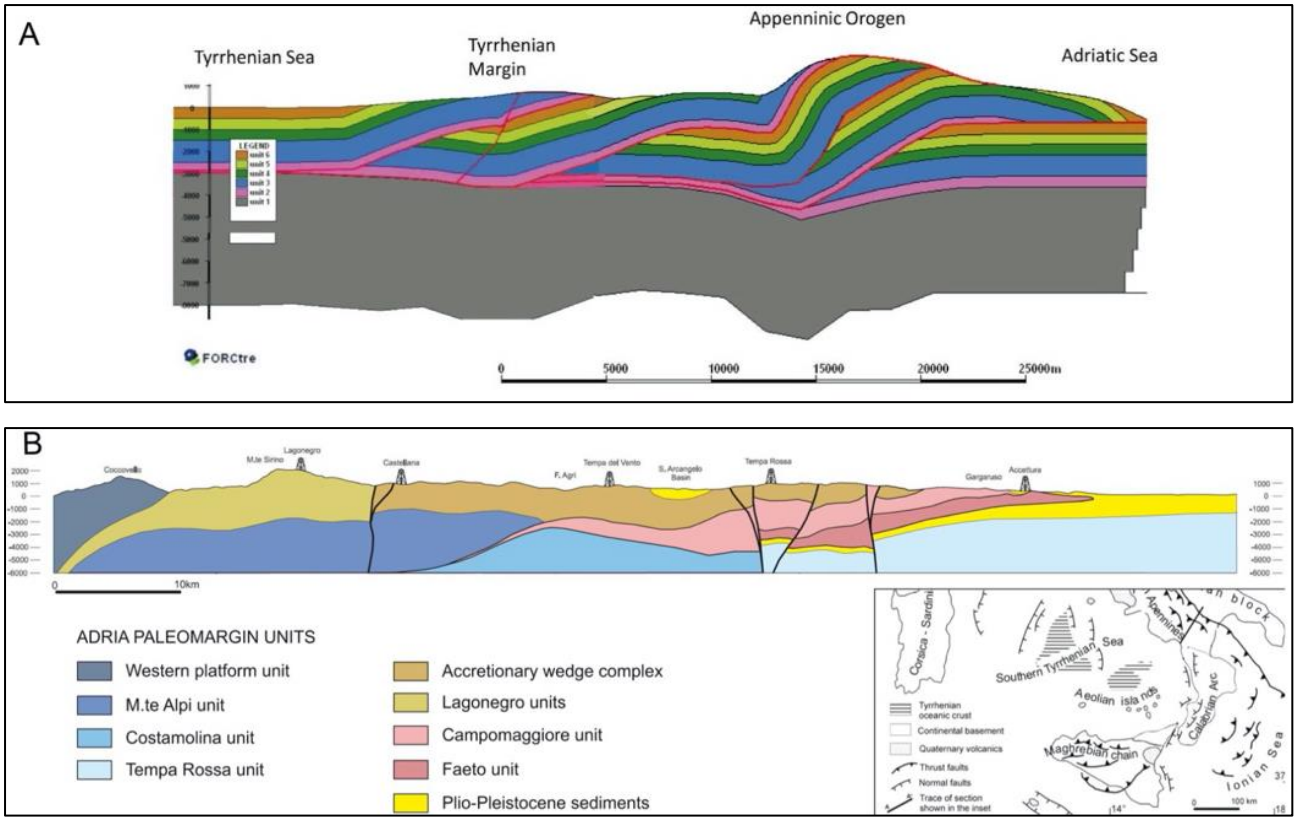


Figure 3: Geological cross-sections across the Apennines: ***cross-section A*** *is in Central Apennines along a W-E transect from the Tyrrhenian to the Adriatic Sea, showing the best fit of the lithosphere flexure and present-day topography;* ***cross-section B*** *shows the main tectonic complexes of S Apennines along a NW-SE transect (Image: Ref 1).*

orientation of the compression across the Calabrian arc is from the Nubia-Eurasia convergence plus radial motion in the Tyrrhenian region.

There was Africa - Europe convergence at rates of ~1 cm/a to NNW, whilst there was rifting in Tyrrhenian Basin and lateral movement of the Calabrian arc, at ~4-5 cm/a.

The S Apennines has 4 main tectonic slices of carbonate units from the Adria basin. They underlie exotic pelagic sequences, which form 3 distinct NE-thrusting wedges.

The European continental plate collapsed in S Tyrrhenian basin, causing the abrupt end of turbidite deposition before the onset of thrusting within the Adria margin.

Subsequent deformation saw huge horizontal displacements of pelagic tectonic wedges (>50 km in the last 0.35 Ma).

6. SICILY … MADONIE UNESCO GLOBAL GEOPARK … ***"****The rich cultural heritage of Sicily is built upon the island's fascinating geology".*

The **Madonie Geopark** is located in the central Sicilian Apennines; there are 40+ geosites in ~400 km^2. It lies amongst recent tectonics and current geo-hazards.

The geology of Sicily is complex (Fig. 4, inset A); it is a segment of the Apenninic-Tyrrhenian system the result of convergence between Africa and a complex 'European' crust. The orogen is located in the centre of the Mediterranean, at the NE corner of the Pelagian platform of N Africa and is connected across the straits of Messina with the Apennine-Alpine orogenic system of Europe.

The structures are the result of, first, the opening of the Ligurian / Provencal basin in N Italy and then, the opening of the Tyrrhenian Sea (immediately N of Sicily) as the African

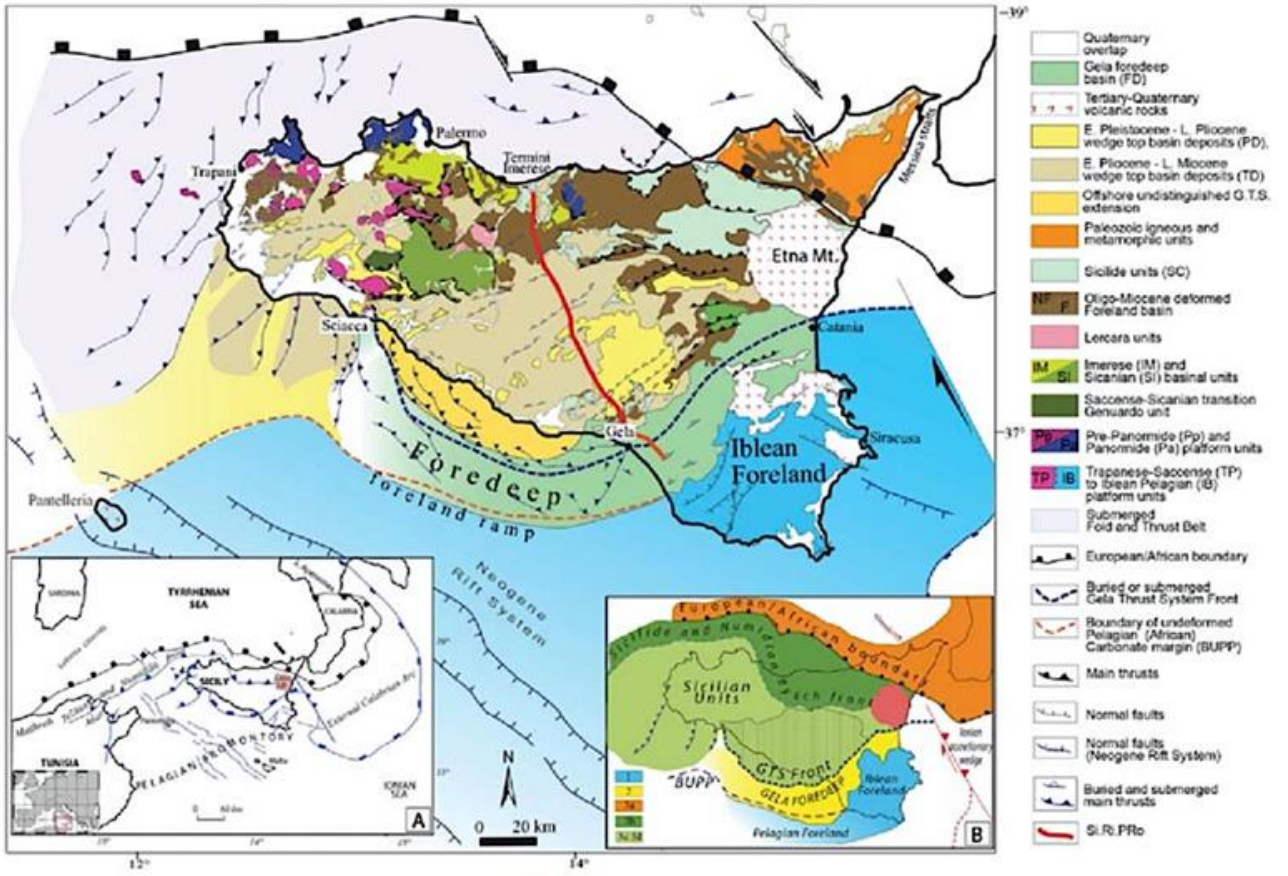


Figure 4: Geological-structural map of Sicily and surrounding areas. ***Inset (A)*** *shows the schematic structural map of the central Mediterranean.* ***Inset (B)*** *illustrates the main tectonic elements characterizing the collisional complex of Sicily: (1) the undeformed Pelagian-Iblean foreland, (2) the present-day foredeep; (3) the orogenic wedge: the Calabrian-Peloritani units (3a), the main FTB (3b-c) southwards buried by the Gela Thrust System (3d) in its turn partially covered by the Gela foredeep. BUPP: boundary of the Undeformed Pelagian Platform. (Image: Ref. 3)*

plate drifted slowly N. The openings represent extension associated with rollback of the subduction zone.

Its geological history started >220 Ma ago (Permian) with dolomitic limestones, which are fossiliferous and have interesting surface and underground karstic features, which developed ~23.5 Ma ago.

Sicily links Italy & Europe to Africa by joining the S Apennine - Calabrian Arc to the Tellian & Atlas systems, N Africa (Fig. 4, Inset A). The collisional complex of Sicily and its offshore continuation (Fig. 4, Inset B) comprises:

1. Undeformed Pelagian-Iblean foreland, submerged in Pelagian Sea.
2. Present-day foredeep (subduction zone); a narrow NW-dipping recent foredeep, weakly deformed and partly buried on land and in the off-shore Gela Basin
3. Orogenic wedge: formed by the Kabilian-Calabrian units and the Sicilian units stacked on the Iblean-Pelagian foreland.

The Sicilian tectonostratigraphic units (Fig. 5) are similar to other units across the central Mediterranean.

Sicily comprises an accretionary wedge of deep-water Mesozoic – Cenozoic carbonates, thrust over a >10km thick wedge of Permian platform carbonates which in turn overly crystalline basement.

The orogen of Sicily has 4 main structural levels (Fig. 6) which are stacked above the submerged areas offshore SW Sicily & Iblean foreland overlying crystalline crust.

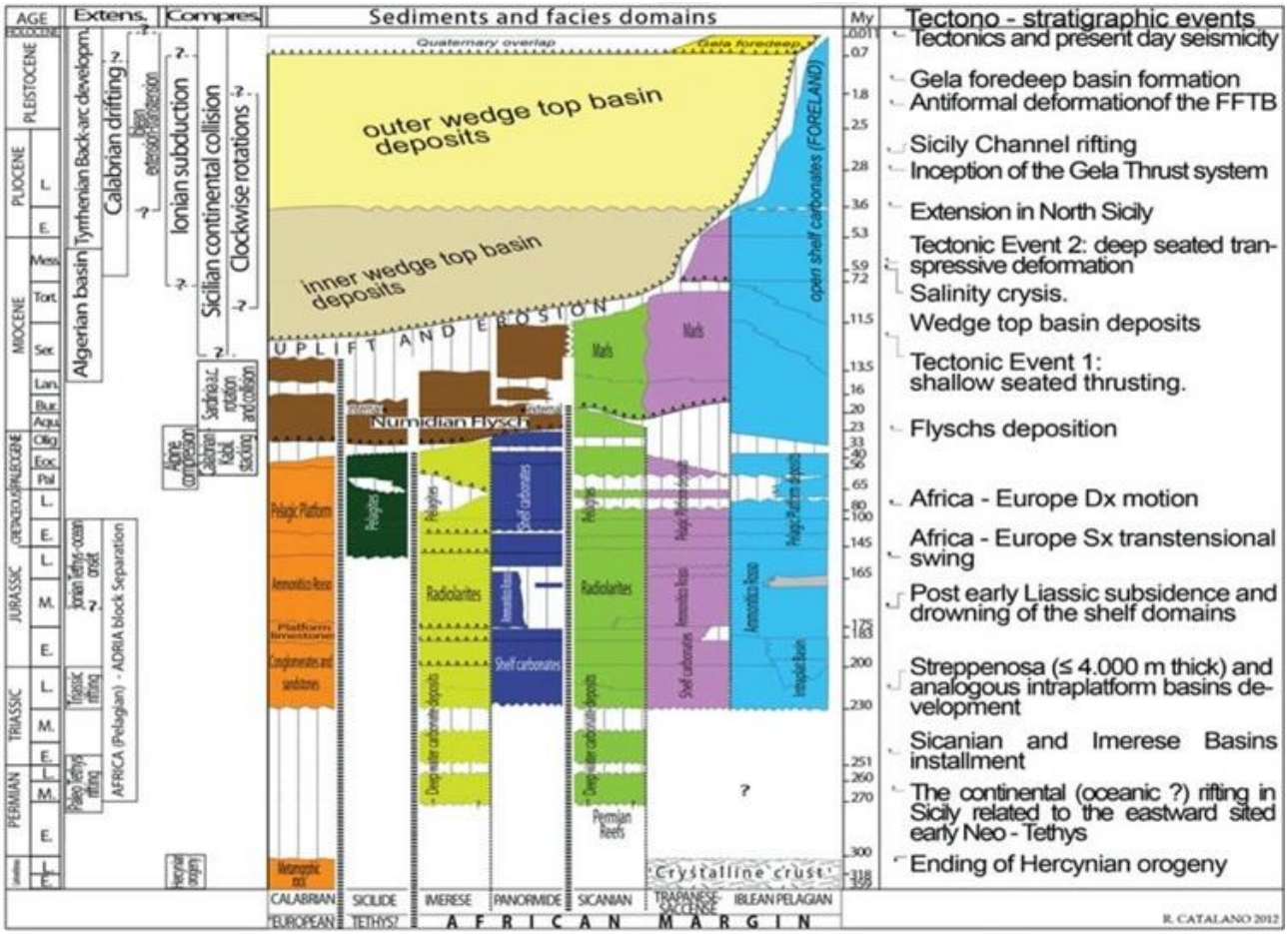


Figure 5: Stratigraphy and original facies of the Mesozoic and Cenozoic rocks deposited prior to Miocene deformation. (Image: Ref. 8)

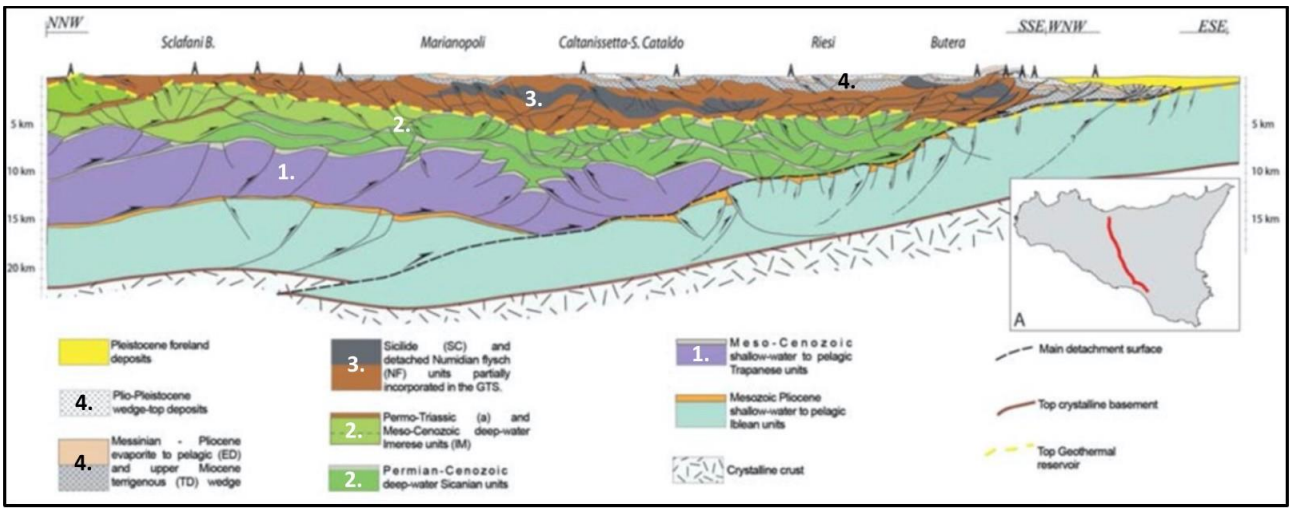


Figure 6: Structural cross-section. (Image: Ref. 9)

1. The lowest level is a Meso-Cenozoic carbonate fan (mauve) and forms the bulk of the chain.
2. The overlying wedge (bright green) comprises warped thrust sheets of Meso-Cenozoic deep water carbonates which have been thrust over the deformed carbonate platform (1) and over the Iblean foreland.
3. The overlying level (brown-grey) is a wedge formed by the Sicilide nappes stacked over deformed terrigenous Oligo-Miocene deep water flysch.

4. These units appear to underlie the Calabrian 'backstop' units (the pale grey-brown, 4th and highest structural level).

The tectonic wedge results from underthrusting of the carbonate units, through deep-seated younger thrusts giving late-stage refolding and further shortening of the previously emplaced nappes. This thrusting occurred between Miocene and middle Pleistocene. The flysch nappes were decoupled from their substrate and transported over the Sicilian domains.

Similarly, the Mesozoic-Cenozoic deep water carbonate units were detached from their basement and transported above still rooted carbonate platform units during the middle-late Miocene. This duplexing took place during the latest Miocene, middle Pleistocene, with younger faults offsetting earlier structures.

During the Pliocene and younger times, renewed movements along the faults were associated with dextral strike-slip movements (Fig. 7)

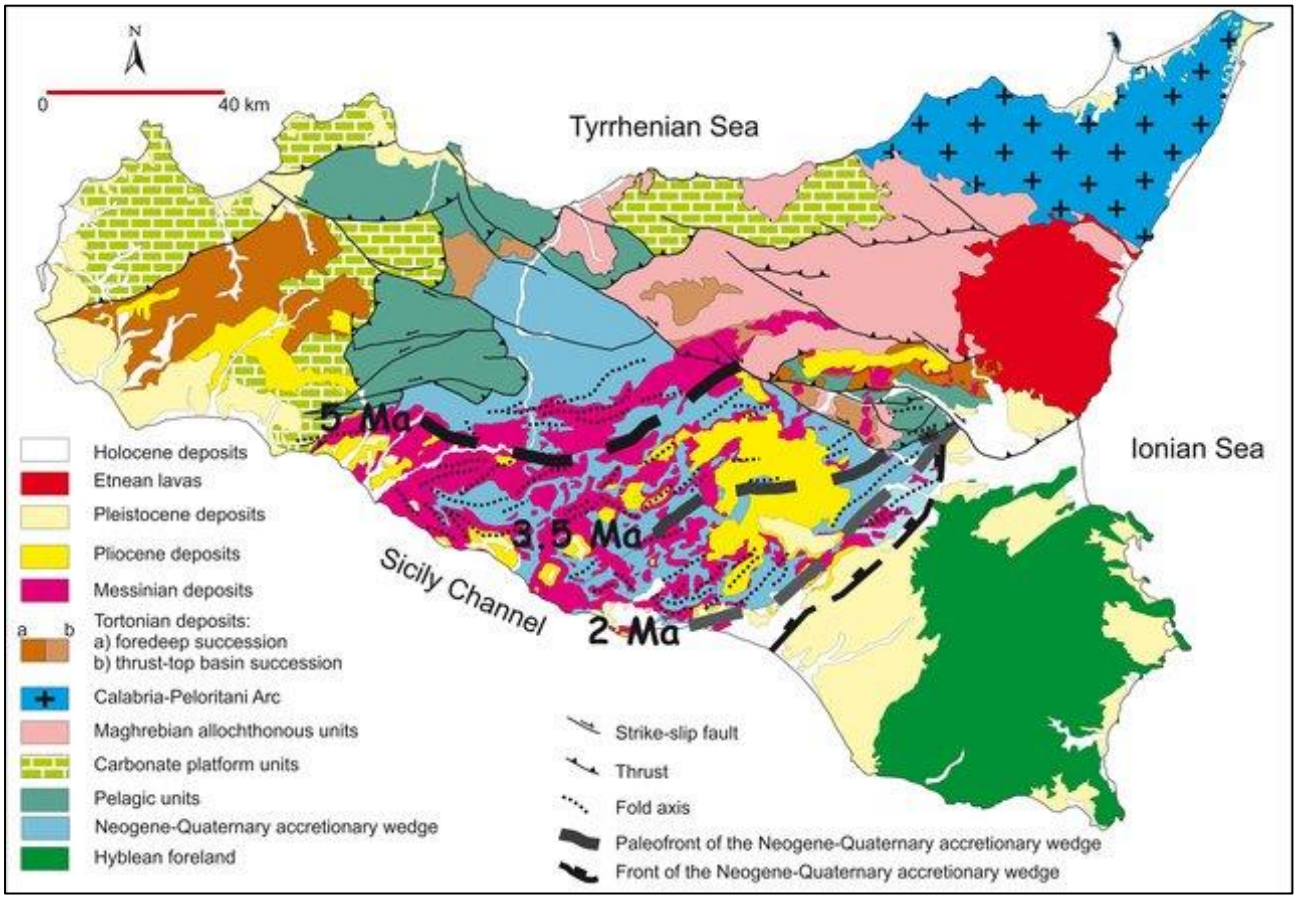


Figure 7: Tectonic map of Sicily, showing the effect of the strike-slip deformation on the geometry of the collision belt. (Image: Ref. 1)

The strike-slip deformation caused the progressive SE-ward shifting, relative to the African margin, of the internal domains of the mountain belt. In Sicily, >120 km of dextral offset is estimated along the major WNW-ESE oriented shear-zone at a rate of 2.4 cm/a.

The shortening-rate for Sicily is consistent with a convergence-rate (5 mm/a), measured along the Nubia-Eurasia plate boundary across Sicily, by GPS data.

ROCCA DI CERERE UNESCO GLOBAL GEOPARK … *"Gypsum, Sulphur and Myth"*

The Rocca di Cerere Geopark area is located in central Sicily and is located on a gypsum-sulphur plateau with sandstone peaks. This geopark straddles the central part of the basin between the Apennine chain in the N and the Iblean Mts in SE Sicily. A thrust belt within the Erei Mountains, Central Sicily, was formed during collision of Africa and Europe.

The area is significant for its gypsum and sulphur deposits. Abandoned sulphur mines and the history of sulphur extraction are present in the Floristella-Grottacalda Mining Park (Fig. 8).

The gypsum deposits were laid down during the Messinian Salinity Crisis (5.96 - 5.33 Ma ago) during the desiccation of the Mediterranean Sea when the Straits of Gibraltar closed. The crisis ended with the return of the sea and the deposition of 'shallow marine' deposits.

Here deep mines penetrate the greatest thickness of Messinian evaporites across the entire Mediterranean basin.

Figure 8: A chapel carved in the salt mines beneath Sicily. (Image: Ref. 11)

These deposits are so thick they could be mined for over a million years!!

The sandstone peaks of the Geopark have been inhabited since the Palaeolithic.

Active Tectonics - Earthquakes and Volcanicity

We cannot ignore the major active volcanoes of Italy – notably

1. The Supervolcano Campi Flegrei under Naples.
2. The volcanoes with violent 'Plinian' eruptions Stromboli, Vesuvius, and Etna.

The Phlegraean Fields – a gently breathing supervolcano under Naples

The Phlegraean Fields (Figs 9 & 10) represent one enormous caldera, that of a dangerous 'supervolcano'. It comprises 24 craters and volcanic mounts, most of which lie under water and form one of the largest volcanic systems on Earth. The area is continuously monitored by the Vesuvius Laboratory, Italy. *A fuller article is presented in FGS Newsletter, October 2019.*

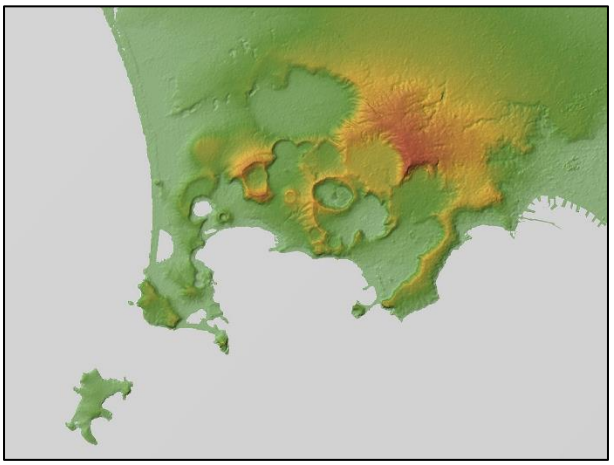


Figure 9: Topographic relief map. (Image: NASA SRTM-1/Wikipedia)

These features can be seen in Fig. 9 which shows the caldera edges of many multiple small explosions which have occurred over the years.

Figure 10: The town of Pozzuoli.

There have been 3 periods of activity within the Phlegraean Fields:

1. Eruption of Archiflegreo volcano ~38,000 yrs B.P.
2. 35,000 to 10,500 yrs B.P., yellow tuff (remains of immense underwater volcano, ~15 km diam.; Pozzuoli, at centre); ~12,000 yrs B.P. a major eruption formed a smaller caldera inside the main caldera, centred on town of Pozzuoli (Fig. 10).
3. 8,000 - 500 yrs B.P., with white pozzolana (cement of fine volcanic particles), found in most of these volcanoes. 10,000 - 8,000 yrs B.P.: activity at Bacoli / Baiae; 8,000 - 3,900 yrs B.P.: intermediate activity centred between Pozzuoli, Spaccata Mountain and Agnano; 3,800 - 500 yrs B.P.: activity in W, forms Lake Avernus & Monte Nuovo.

Latest/Current Activity:

- The caldera, now at ground level, contains many fumaroles and >150 pools of boiling mud.
- Several subsidiary cones and tuff craters lie within the caldera; one is filled by Lake Avernus.
- In 1538, an 8-day eruption deposited enough material to create Monte Nuovo; this has risen ~2 m since 1970.
- Today, the Phlegraean Fields comprise the Naples districts of Agnano and Fuorigrotta, the area of Pozzuoli, Bacoli, Monte di Procida, Quarto, the Phlegraean Islands (Ischia, Procida and Vivara).
- A study from the Istituto Nazionale di Geofisica e Vulcanologia shows that the volcanic unrest of the Campi Flegrei caldera from January 2012 to June 2013 was characterised by rapid ground uplift of about 11 cm with a peak rate of about 3 cm / month during December.
- From 1985 to 2011 the dynamics of ground uplift were mostly linked to the caldera's hydrothermal system, but this relation broke down in 2012.
- The ground uplift was driven by periodic emplacement of magma within a flat sill-shaped magma reservoir ~3,000 m deep, 500 m S from the port of Pozzuoli.
- In December 2016, activity became so great that an eruption was feared.
- In May 2017 a new study revealed that the geographical unrest since the 1950s has a cumulative effect, causing a build-up of energy in the crust and making the volcano more susceptible to eruption; thus, an eruption may be earlier than originally expected.
- On 21 August 2017 there was a magnitude 4 earthquake on the W edge of the Campi Flegrei area. 2 people were killed and many injured in Casamicciola on the N coast of the island of Ischia, which is S of the epicentre.

It has been suggested that inflation of the caldera centre near Pozzuoli might result in an eruption event within decades. Plans to drill down 3.5 km to monitor the massive molten rock chamber have been reinstated.

Currently there is significant volcanic activity around the dormant Solfatara volcano shallow crater at Pozzoli. It is emitting steam and sulphurous gases in bubbling mud pools and fumaroles – and is a potentially serious threat to the inhabitants of the area. Hydrothermal activity can be observed at Lucrino, Agnano and the town of Pozzuoli.

Tracking and predicting Solfatara's activity is extremely difficult due to the interactions between magmatic gases, water & steam. But the research project identified in the title of this summary has scientists, who have produced a 3-D map of the caldera with details of water, gas bearing tunnels & chambers to hopefully predict future explosions.

Single 'Plinian' Volcanoes

'Plinian' volcanoes are the classic 'volcano cone' such as Etna (Fig. 11) and they develop in areas where the magma is contaminated by water and other volatiles, excess Si, alkalis and other elements. The release of pressure as the magma rises (Fig. 12) causes gas bubbles to expand which in turn creates a powerful erosive force to blast through the 'lid' holding the gaseous magma. This type of volcano, e.g., Stromboli (Fig. 13), is classically found in the back arcs of subduction zones, where the melting of the oceanic crust has provided these elements to the virgin magma.

Figure 11: Mount Etna, Sicily. (Image: Ref. 10)

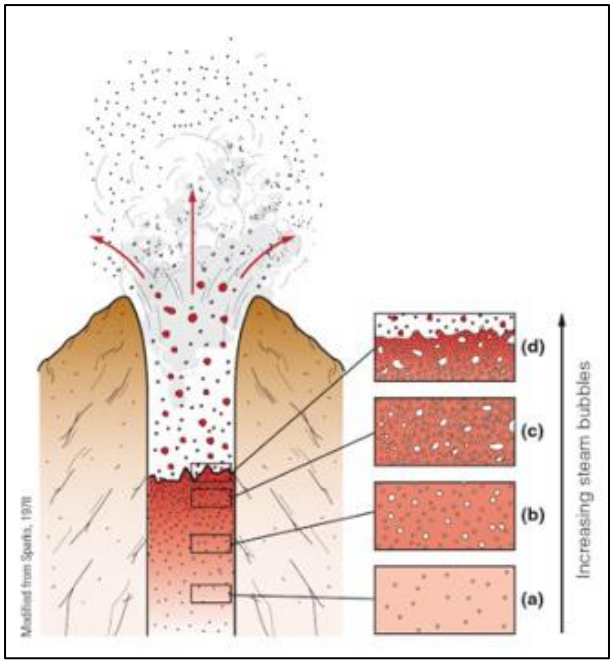


Figure 12: Schematic illustrating the release of pressure & gas bubbles as magma rises to the surface.

Figure 13: Stromboli, Aeolian Islands. (Credit; Wikimedia Commons)

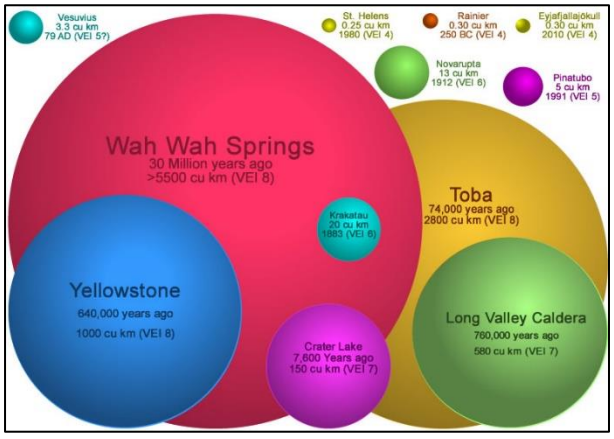


Figure 14: Volcanic Explosive Index (VEI). The spheres in the illustration above represent the volume of erupted tephra for some of the most widely-known explosive volcanic eruptions. Although most people believe that ***Vesuvius*** *(79 AD - the Pompeii eruption), Mount St. Helens (1980), & Mount Pinatubo (1991) were enormous, they are very small compared to ancient eruptions such as Wah Springs, Toba, Yellowstone, or Long Valley Caldera. (Image: Ref. 7)*

DATE	EVENT
3580 BC	Pyroclastic flows cover current area of Naples.
1800 BC	Pyroclastic flows kill many people in Pompeii and cover much of the area of present-day Naples.
AD 79	Destruction of Pompeii and Herculaneum kills about 4000.
1631	Heavy pyroclastic flows and ash falls kill 4000.
1906	More than 500 are killed.
1944	Lava flows partly destroy two communities.

Figure 15: Notable eruptions of Mt. Vesuvius

Etna on Sicily is extremely active and could have a potentially large eruption (Fig. 16).

When Etna erupted in February 2017 ash thrown into the atmosphere travelled NE towards the Black Sea causing cancellations of flights and effecting air quality for a number of days (Fig. 17).

Figure 16: Mount Etna erupts.

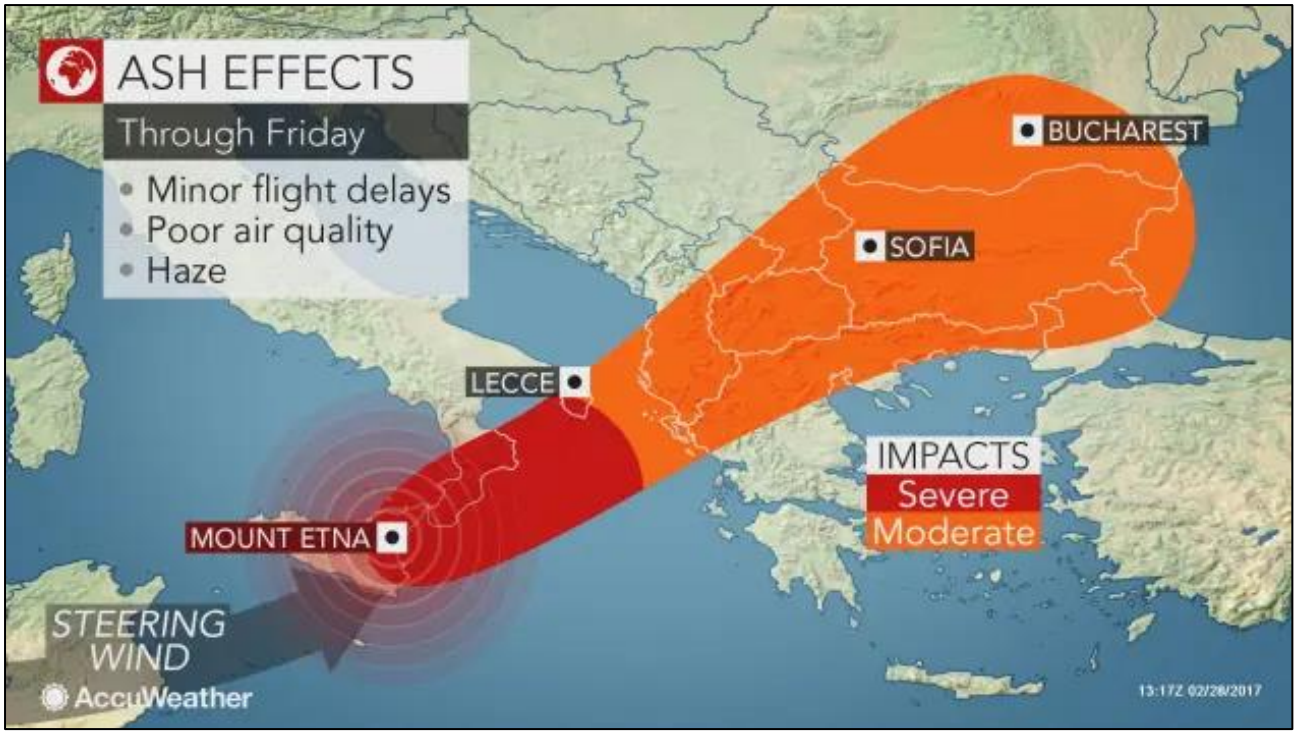


Figure 17: SW wind generates large ash cloud from Mount Etna to the NE towards the Black Sea. (Credit: Daily Express)

Ash Thickness at 16 km	
VEI	**Thickness**
0	nil
1	dusting
2	a few centimeters
3	several centimeters
4	a few tens of centimeters
5	about 1/2 meter
6	about three meters
7	at least several meters
Data from USGS	

Figure 18: Ash thickness. (Credit: USGS)

Figure 19: Actual deposit of Etna's ash with 'clasts' of semi molten lava and 'clasts' of solid lava from an earlier eruption from Etna. The range in size clasts is typical of a violent Plinian type eruption. Width of rock image is 50cm. (Credit: Author)

Earthquakes

It is impossible to predict earthquakes and the Apennines in Italy are prone to quakes. Italy has experienced 125 'significant' earthquakes since 1900 ranging from a M3.5 in 1973 to M7.9 in 1905. At M6.2, the earthquake on 24 August 2016 was the 8th strongest in the region since the turn of the last century. The 2009 L'Aquila quake measured M6.3. A US database lists 318 significant earthquakes in

Italy since 1450 BC, including one at Pompeii in 63 AD.

Central Italy has been struck by several damaging earthquakes, most recently the Abruzzo, Lazio and Umbria regions were damaged during the 2016 earthquake. From August to October 2016, there were 3 major earthquakes; the first occurred on 24 August, ~300 people lost their lives and the town of Amatrice was badly damaged. Several other smaller villages in the surrounding region experienced near total collapse and damage of residential buildings. Subsequent earthquakes on the 26 and 30 October caused further damage to property and infrastructure, but no further fatalities.

Earthquakes are generated by slip on fault planes, with multiple earthquakes, offsets can accumulate and form fault scarps that can be several meters high. In central Italy, normal faults are well exposed at the surface as sloping, smooth, limestone fault scarps, which can be seen across hillsides throughout the region; these have formed in the last ~15,000 years when erosion rates reduced, and the slip rate was faster. Most faults are orientated NW-SE i.e., perpendicular to the extension direction, which is NE-SW across the Italian peninsula.

Recent work at scales of mm or cm have measured striations indicating the direction on movement and whether the faults are behaving as a single fault or as multiple strands. By combining the throw of the fault with the age of the scarps, the throw rate can be calculated - these values are typically ~0.5–2 mm/a. The higher the throw rate the more frequently the fault is likely to move.

These days the intensity of shaking for each town can be determined and plotted on a map. The towns with the highest shaking usually cluster around the hanging wall of the fault that moves. There have been 34 earthquakes with M>5.5 since 1349 A.D. in the central region of Italy. Underneath the brittle faults in Italy, there are ductile shear zones that slip incrementally each year.

Summary of an article in FGS Newsletter October 2018.

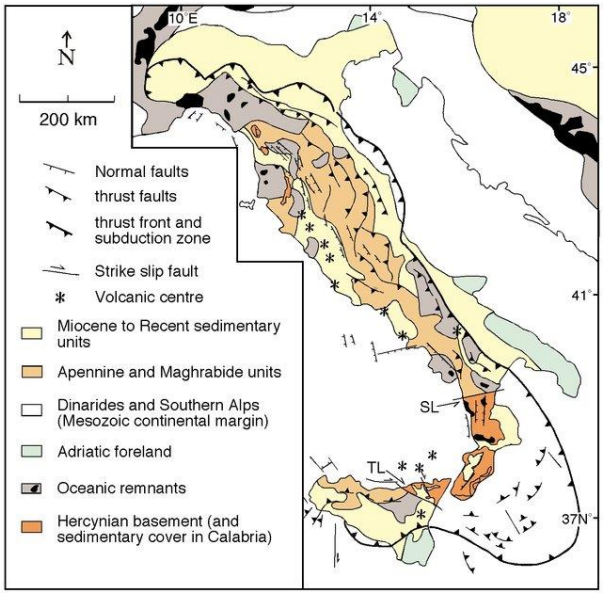


Figure 20: Simplified geology map of the Italian Peninsula and Sicily modified after Channell et al. (1979) and Patacca et al. (1993). SL = Sagiento Line; TL = Taormina Line. (Image: Ref. 4).

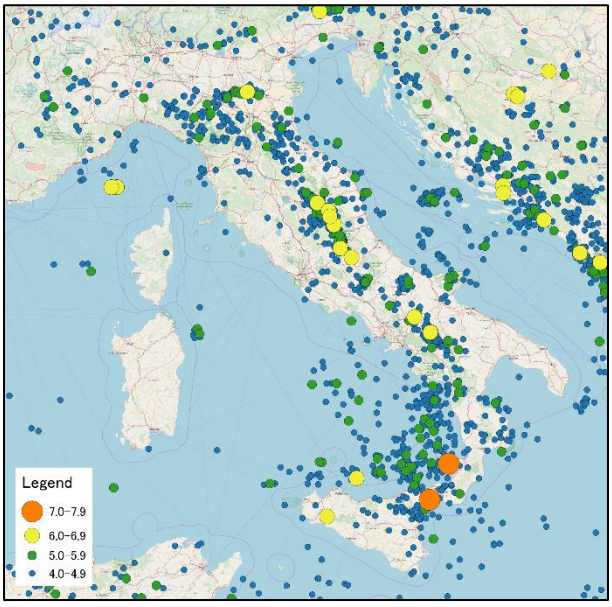


Figure 21: Distribution of earthquakes across Italy between 1900 to 2017. The Density of earthquakes in the Central Apennines reflects the density of faults in that area. Legend is Magnitude. (Source: USGS)

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

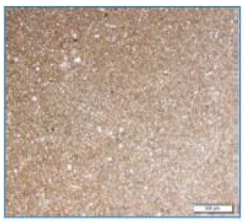
Classification of Limestones

Limestones are so common in the geoparks that I felt a note of their classification would be helpful. They were classified in the 1960s by means of their fabrics by Dunham; since then the classification has been modified by others to that shown below.

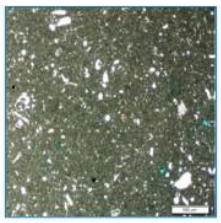
The classification is similar to that of clastic rocks (clays-silts-sandstones-cobbles), but the clasts are carbonate not siliceous:

<table>
<tr><th colspan="9">Modified Dunham Classification (Dunham, 1962;[1] Embry and Klovan, 1971[2])</th></tr>
<tr><td colspan="5">Allochthonous Limestones - No evidence that the original components were bound together at the time of deposition</td><td colspan="4" rowspan="2">Autochthonous Limestones - Original components were organically-bound during deposition</td></tr>
<tr><td colspan="3">Less that 10% of the components are > 2 mm</td><td colspan="2" rowspan="2">Greater that 10% of the components are > 2 mm</td></tr>
<tr><td colspan="2">Contains lime mud (<30 µm)</td><td>No lime mud</td><td rowspan="3">Bound by organisms that act as baffles</td><td rowspan="3">Bound by organisms that encrust and bind - the rock is supported by the matrix</td><td rowspan="3">Bound by organisms that build a rigid framework - the rock is supported by the fossil framework</td></tr>
<tr><td colspan="2">Mud-supported</td><td rowspan="2" colspan="2">Grain-supported</td><td rowspan="2">Matrix-supported</td><td rowspan="2">Grain-supported by the >2 mm size fraction</td></tr>
<tr><td>Less than 10% grains (>30 µm - 2 mm)</td><td>Greater than 10% grains (>30 µm - 2 mm)</td></tr>
<tr><td>Mudstone</td><td>Wackestone</td><td>Packstone</td><td>Grainstone</td><td>Floatstone</td><td>Rudstone</td><td>Bafflestone</td><td>Bindstone</td><td>Framestone</td></tr>
</table>

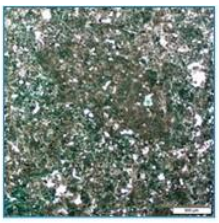
Photomicrograph images of the limestone rocks:



Lime Mudstone: all particles are of mud size $CaCO_3$

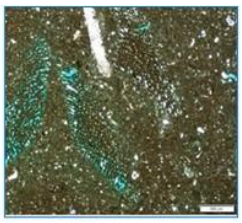


Wackestone: lime mud supports $CaCO_3$ particles (>10%)



Packstone: grains of $CaCO_3$ support themselves; clasts <2mm

Grainstone: $CaCO_3$ grains >2mm self support (no mud support). Now the large pores filled with $CaCO_3$ cement.



Floatstone: large forams supported by matrix of a packstone of small $CaCO_3$ bioclasts.

(Source: Wikipedia)

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First images from Nasa's James Webb space telescope reveal ancient galaxies

Oliver Milman and Ian Sample,
The Guardian science
12 July 2022

The pictures show elements of the universe as they were 13 Ga ago, reshaping our understanding of the cosmos

The first full-colour image from Nasa's James Webb space telescope shows the galaxy cluster SMACS 0723. (Photograph: EyePress News/REX/Shutterstock)

Nasa has released an image of far-flung galaxies as they were 13 Ga ago, the first glimpse from the most powerful telescope ever launched into space, which promises to reshape our understanding of the dawn of the universe.

The small slice of the universe, called SMACS 0723, has been captured in sharp detail by the **James Webb space telescope** (JWST), showing the light from many different twinkling galaxies, among the oldest in the universe. Joe Biden, who unveiled the image at a White House event, called the moment "historic" and said it provided "a new window into the history of our universe".

"It's hard to even fathom," said the US president. "It's astounding. It's an historic moment for science and technology, for America and all of humanity."

Bill Nelson, administrator of Nasa, said the image showed the light of galaxies bending around other galaxies, traveling for billions of years before reaching the telescope. "We are looking back more than 13 Ga," he said, adding that more images to be released by the space agency would reach back further, to about 13.5 Ga, close to the estimated start point of the

Technicians lift the mirror of the James Webb space telescope in 2017. (Photograph: Laura Betz/AP)

universe itself. “We are going back almost to the beginning,” he said.

The release of the image is a preview of a series of high-resolution colour pictures from JWST that will be shown off by Nasa on Tuesday. They will include “the deepest image of our universe that has ever been taken”, according to Nelson.

Experts have said the telescope, three decades in the making and launched last year, could revolutionize our understanding of the cosmos by providing detailed infrared images of the universe.

The $10bn telescope is able to peek inside the atmospheres of exoplanets and observe some of the oldest galaxies in the universe by using a system of lenses, filters, and prisms to detect signals in the infrared spectrum, which is invisible to the human eye. The system has so far “performed flawlessly”, according to Marcia Rieke, professor of astronomy at University of Arizona.

“Webb can see backwards in time just after the big bang by looking for galaxies that are so far away, the light has taken many billions of years to get from those galaxies to ourselves,” said Jonathan Gardner, deputy senior project scientist at Nasa, during a recent news conference. “Webb is bigger than Hubble so that it can see fainter galaxies that are further away.”

The telescope, which is a joint endeavour with the European Space Agency, has been in development since the mid-1990s and was finally propelled into space in December. It is described as the most powerful telescope ever to be sent into space and is currently about 1m miles from Earth, performing its task of scanning ancient galaxies.

The initial goal of the project was to see the first stars and galaxies formed following the big bang, watching “the universe turns the lights on for the first time”, as Eric Smith, Webb program scientist, put it. The telescope should be considered “one of humanity’s great engineering achievements”, said Kamala Harris, the US vice-president.

“The whole observatory is performing stunningly well,” said Gillian Wright, director of the UK Astronomy Technology Centre in Edinburgh, also principal investigator for the mid-infrared (Miri) instrument on JWST.

“It’s hard to take in how fantastic it has turned out to be. It is utterly amazing.”

Nasa said JWST has five initial cosmic targets for observation, including the Carina nebula, a sort of celestial nursery where stars form. The nebula is about 7,600 light years away and is home to many enormous stars, several times larger than the sun.

Other areas of focus include WASP-96 b, a giant planet outside our solar system that is made mainly of gas; the southern ring nebula, an expanding cloud of gas surrounding a dying star that’s 2,000 light years from Earth; and Stephan’s quintet, notable for being the first compact galaxy group discovered in 1877. Images from these targets will be unveiled by Nasa on Tuesday.

“It’s exhilarating to see the fantastic James Webb space telescope image released today,” said Richard Ellis, professor of astrophysics at University College London who was part of the committee that first conceived the telescope.

“As we are ourselves made of the material synthesized in stars over the past 13 Ga, JWST has the unique ability to trace back to our own origins in this remarkable universe. Everyone can take part in this amazing adventure.”

See also Page 56

Reference:

https://www.theguardian.com/science/2022/jul/11/nasa-james-webb-telescope-ancient-galaxy-images

New Geologic Map of The Moon released online

David Bressan, Forbes Contributor
16 June 2022

A research team led by the Chinese Academy of Sciences has released a new high-resolution geologic map of the Moon. The map includes discoveries made in the last ten years, like an updated chronology for the age of lunar features, high-resolution mapping of the lunar surface done from orbit, and detailed chemical analysis of Moon rocks.

A new high-resolution geological map of the Moon was recently released online. (Credit: JI ET AL. 2022/SCIENCE BULLETIN)

The first geological maps of the Moon were created during the Moon Race era from the late 1950s to mid-1970s.

To assure the safety of a manned exploration, it was necessary to know in detail the terrain and the composition of the lunar surface. A photogeologic survey was initiated from 1966 to 1968 by the Soviets, using space probes in orbit around the Moon to map its surface. Between 1959 and 1964 the Americans initiated the Ranger project, followed by the Lunar Orbiter, dedicated to the same goal. The Surveyor project also included some probes landing on the Moon. The surveys showed that there were also fairly soft and rolling terrains, where a spaceship could safely land.

When Neil Armstrong and Edwin 'Buzz' Aldrin became the first humans to geologize on the Moon in 1969, the most detailed map of the Moon was a 1:5,000,000-scale geological map published by the USGS. The new map supersedes that with a resolution of 1:2,500,000.

Since the 1990s, the lunar exploration has entered a new booming phase and nearly 20 spacecrafts have been launched to the Moon from not only the U.S. but also new agencies such as China, India, and Japan. To create the new map, the researchers digitized a number of previously released maps with varying scales and combined them thanks to RADAR and satellite images taken by China's Chang'e-5 lunar exploration mission in one globally consistent large-scale map.

The map shows 12,341 impact craters, 81 impact basins, 17 rock types, and 14 types of lunar structures, like lava flows and fault systems. The map also includes the geological discoveries made at the sampling sites of the historic 1969-1972 Apollo missions and the 2020 landing site of the Chang'e rover, where the youngest lunar rock known so far was found.

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Earliest evidence of wildfire found in Wales

Jonathan Amos, BBC Science correspondent
27 June 2022

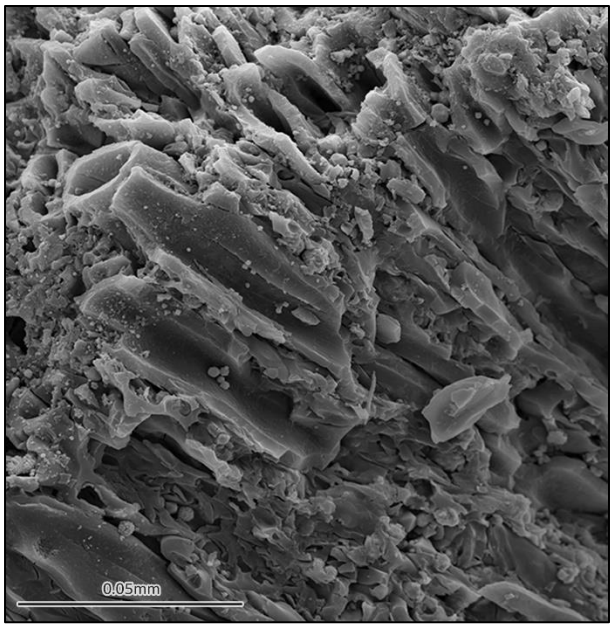
The oldest evidence of wildfire has been identified in South Wales. It takes the form of some truly ancient, charred remnants trapped in some truly ancient mudstone. And by

ancient we're talking 430 Ma ago, during the Silurian Period of Earth history.

Back then, only a few pioneering plants had made it on to land, so what was it that caught fire and produced the charcoal? Most likely it was a forest of giant fungi.

"The Silurian vegetation was very different to what it is today," explained palaeobotanist Ian Glasspool. "There were no woody plants at this time; most of the vegetation was very small. However, there was one giant that dwarfed the landscape. There's a very enigmatic fossil called *Prototaxites*.

"It grew anything up to 8 m in height, and about a metre in diameter. A sort of funky, humongous fungus; erect, very phallic structures; pillars of fungus that could weigh up to 10 metric tonnes," he told the *Science In Action* programme on the BBC World Service.



The charcoal retains wonderful detail of the cellular structure of Prototaxites. (Image Source, Ian Glasspool)

It's these strange organisms that went up in flames and left the blackened traces, Dr Glasspool believes.

His Welsh mudstone was drilled from deep under Rumney on the outskirts of Cardiff. These sediments were laid down when what is now the British Isles would have been in the Southern Hemisphere.

The rock records a nearshore marine setting, meaning the tiny fragments (2-3 mm in length) of charcoal were being washed out to sea. That in itself is instructive because to have left their mark, it suggests the *Prototaxites* fires on land were sufficiently large and widespread. Dr Glasspool has similar evidence from Winnica, in the Kielce region of Poland.

Together, the observations push the earliest evidence for wildfire on Earth back by about 10 Ma. And in doing so, this science reveals something else about Earth during the Silurian: the amount of oxygen in the atmosphere.

The concentration of O_2 in the air today is about 21%, but early in Earth's history it was much less. It took photosynthetic algae in the oceans millions of years to terraform the planet.

Dr Glasspool said: "For fires to propagate, you really need three things: a source of fuel, which, surprisingly, we seem to have in sufficient amounts in the Silurian; you need a source of ignition, which is lightning strikes as the most likely source; and then you need at least 16% atmospheric oxygen.

"There are many geochemical proxy models that look at atmospheric oxygen, but there's quite a large discrepancy between many of them. So, our charcoal data helps proof these models, and with enough data points, we can then get a better feel for how atmospheric oxygen was trending during this time interval."

Ian Glasspool reports the fire evidence with colleague Robert Gastaldo in the journal *Geology*. Both scientists are affiliated to Colby College in Maine, US.

Reference:

https://www.bbc.co.uk/news/science-environment-61929966

Afghan earthquake: at least 1,000 people killed and 1,500 injured

By Leo Sands & Malu Cursino, BBC News 22 June 2022

A powerful earthquake has killed at least 1,000 people and injured 1,500 in eastern Afghanistan, an official of the ruling Taliban told the BBC.

Pictures show landslides and ruined mud-built homes in the province of Paktika, where rescuers have been scrambling to treat the injured.

The quake struck shortly after 01:30 (21:00 GMT Tuesday) as people slept. Hundreds of houses were destroyed by the **magnitude 6.1 event**, which occurred at a depth of 51 km.

It is the deadliest earthquake to strike Afghanistan in two decades and a major challenge for the Taliban, the Islamist movement which regained power last year after the Western-backed government collapsed.

The earthquake struck about 44 km from the city of **Khost,** and tremors were felt as far away as Pakistan and India. Witnesses reported feeling the quake in both Afghanistan's capital, Kabul, and Pakistan's capital, Islamabad.

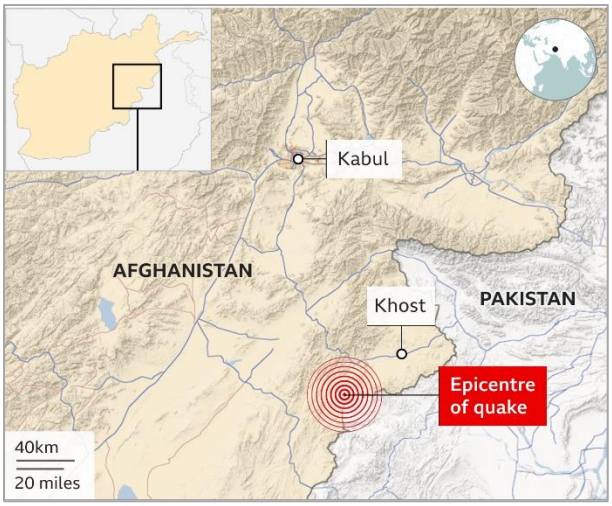
Taliban officials appealed to foreign aid agencies for help. They asked the UN to "support them in terms of assessing the needs and responding to those affected", Sam Mort from Unicef's Kabul unit told the BBC.

The UK's special representative to Afghanistan, Nigel Casey, said the UK was in touch with the UN and was "ready to contribute to the international response".

Earthquakes tend to cause significant damage in Afghanistan, where dwellings in many rural areas are unstable or poorly built.

Speaking to Reuters news agency, locals described horrific scenes of death and destruction in the aftermath of the late-night earthquake. "The kids and I screamed," said Fatima. "One of our rooms was destroyed. Our neighbours screamed and we saw everyone's rooms."

"It destroyed the houses of our neighbours," Faisal said. "When we arrived, there were many dead and wounded. They sent us to the hospital. I also saw many dead bodies."



Powerful earthquake strikes Afghanistan. (Source: USGS)

"Every street you go, you hear people mourning the deaths of their beloved ones," a journalist in Paktika province told the BBC.

Local farmer Alem Wafa cried as he told the BBC that official rescue teams had yet to reach the remote village of Gyan - one of the worst hit. "There are no official aid workers, but people from neighbouring cities and villages came here to rescue people," he said. "I arrived this morning, and I - myself - found 40 dead bodies."

Most of the dead, he said, were "very young children". The local hospital just did not have the capacity to deal with such a disaster, the farmer added.

In remote areas, helicopters have been ferrying victims to hospitals.

Even before the Taliban takeover, Afghanistan's emergency services were stretched to deal with natural disasters - with few aircraft and helicopters available to rescuers.

Speaking to the BBC, a doctor in Paktika said medical workers were among the victims. "We didn't have enough people and facilities before the earthquake, and now the earthquake has ruined the little we had," they said. "I don't know how many of our colleagues are still alive."

Communication following the quake is difficult because of damage to mobile phone towers and the death toll could rise further still, another local journalist in the area told the BBC.

"Many people are not aware of the well-being of their relatives because their phones are not working," he said. "My brother and his family died, and I just learned it after many hours. Many villages have been destroyed." Most of the casualties so far have been in the Gayan and Barmal districts in Paktika, a local doctor told the BBC. Local media site Etilaat-e Roz reported a whole village in Gayan had been destroyed.

There were no immediate reports of casualties or significant damage in Pakistan, according to BBC Urdu.

Decades of conflict have made it difficult for the impoverished country to improve its protections against earthquakes and other natural disasters - despite efforts by aid agencies to reinforce some buildings over the years.

Afghanistan is prone to quakes, as it's located in a tectonically active region, over a number of fault lines including the Chaman fault, the Hari Rud fault, the Central Badakhshan fault and the Darvaz fault.

Over the past decade more than 7,000 people have been killed in earthquakes in the country, the UN's Office for the Co-ordination of Humanitarian Affairs reports. There are an average of 560 deaths a year from earthquakes.

Most recently, back-to-back earthquakes in the country's west in January killed more than 20 people and destroyed hundreds of houses.

Reference:

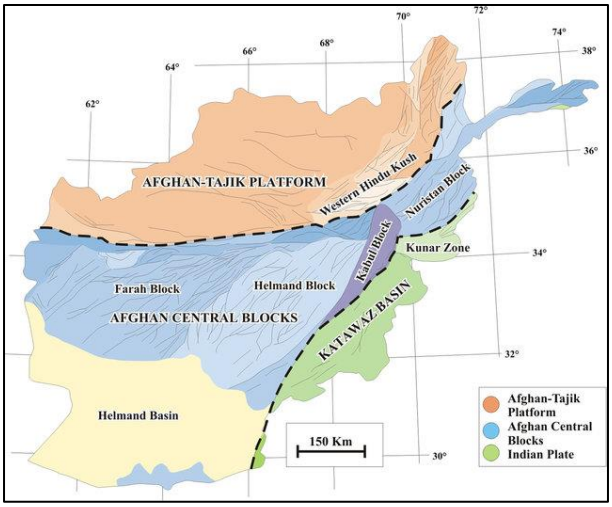
https://www.bbc.co.uk/news/world-asia-61890804

USGS tectonic background to the latest earthquake:

“Earthquakes and active faults in eastern Afghanistan and western and northern Pakistan are the result of the India plate moving northward at a rate of about 40 mm/yr and colliding with the Eurasia plate.

Along the northern edge of the Indian subcontinent, the India plate is subducting beneath the Eurasia plate, causing uplift that produces the highest mountain peaks in the world, including the Himalayan, the Karakoram, the Pamir and the Hindu Kush ranges. West and south of the Himalayan front, the relative motion between the two plates is oblique, which results in strike-slip, reverse-slip, and oblique-slip earthquakes. The pattern of elastic waves that were radiated by the 21 June 2022 earthquake indicate the event was predominantly strike-slip faulting, either left-lateral slip on a northeast-striking fault or right-lateral slip on a northwest-striking fault.

The 21 June 2022 earthquake is about 500 km north-northeast of a deadly magnitude 6.4 earthquake that occurred on 10 October 2008 in western Pakistan that killed 166 people and destroyed several villages from triggered landslides.



Simplified tectonic outline of Afghanistan. The country can be divided into three tectonic zones: the Eurasian zone contains the Afghan-Tajik Platform and the Western Hindu Kush. In the Southeast the Katawaz basin represents the furthest extent of the Indian Plate. The Afghan Central Blocks, Kabul Block, and Nuristan Block indicate the Eurasian-India boundary. (Ref: 2015, Collett, s, Faryad, SW, Mosazai AM_Polymetamorphic evolution of the granulite-facies Paleoproterozoic basement of the Kabul Block, Afghanistan. ResearchGate, Miner Petrol, DOI 10.1007/s00710-015-0371-9)

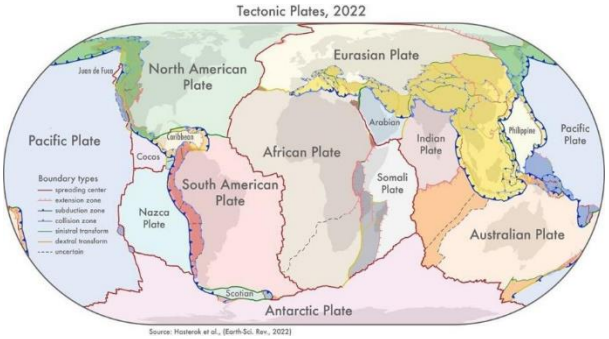
Reference:

https://www.usgs.gov/news/featured-story/magnitude-59-earthquake-khost-afghanistan

New study shows updated map of Earth's tectonic plates

David Bressan, Forbes Contributor
9 June 2022

Based on a series of models considering how the continents were assembled over time, a team of researchers at the **University of Adelaide** created an updated map of Earth's tectonic plates. The map will help provide a better understanding of natural hazards like earthquakes and volcanoes occurring along plate boundaries.



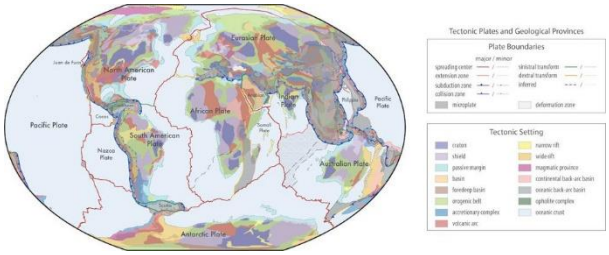
Tectonic map of the Earth. (Hasterok et al. 2022/Earth-Sci.Rev.)

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

The cratons of our modern continents - the continental cores with the oldest and thickest crust - formed more than 3.2 Ga ago. Over time, more and more crustal fragments formed, pushed together by convection currents in Earth's mantle, forming the first supercontinent called ***Vaalbara.*** These collisions were accompanied by mountain-building processes along the boundaries of the tectonic plates. Eventually, Vaalbara broke apart, forming a subset of smaller continents. In the last 3 Ga a number of supercontinents formed and broke apart again, with the most recent being ***Pangea***, a supercontinent existing from 335 to 65 Ma ago. Today Earth's crust consists of eight large tectonic plates and various microplates.

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

To create the map, the team combined three geological models: a plate model based on already known plate boundaries, a province model based on the geology of the Earth's surface, and an orogeny model with areas deformed by mountain-building processes.



Geological map showing mountain-building zones and updated plate boundaries. (Hasterok et al. 2022/Earth-Sci.Rev.)

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

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

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

"To further enrich the model, we added more accurate information about the boundaries of deformation zones: previous models showed

these as discrete areas rather than wide zones," said Hasterok.

The biggest changes to the plate model have been in western North America, which often has the boundary with the Pacific Plate drawn as the San Andreas and Queen Charlotte Faults. But the newly delineated boundary is much wider, approximately 1,500 km, than the previously drawn narrow zone.

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

The team's work provides a more accurate representation of the Earth's structure and has other important practical applications.

"Our new model for tectonic plates better explains the spatial distribution of 90% of earthquakes and 80% of volcanoes from the past 2 Ma, whereas existing models only capture 65% of earthquakes.

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

The paper *"New maps of global geological provinces and tectonic plates"* is published in the journal *Earth-Science Reviews (2022). Materials provided by the University of Adelaide.*

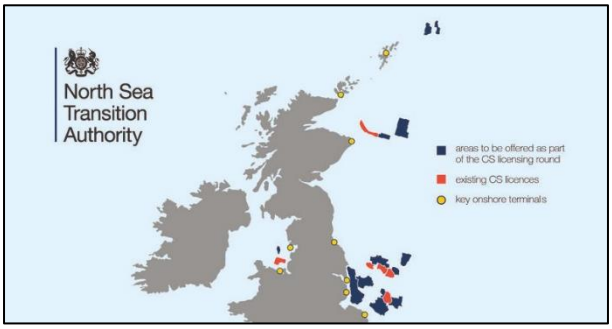
Reference:
https://www.forbes.com/sites/davidbressan/2022/06/09/new-map-shows-earths-tectonic-plates-in-unprecedented-detail/

First UK carbon storage licencing round opens for bids

14 June 2022
by Nadja Skopljak

The North Sea Transition Authority (NSTA) has launched the UK's first-ever carbon storage licencing round, with 13 areas available for bids.

The areas being offered for licensing are off the coast of Aberdeen, Teesside, Liverpool and Lincolnshire in the Southern North Sea, Central North Sea, Northern North Sea, and East Irish Sea and are made up of a mixture of saline aquifers and depleted oil and gas field storage opportunities.



Source: NSTA

According to NSTA, the offered areas have a combination of attributes such as the right geological conditions, proximity to existing infrastructure which could be re-purposed, and links to industrial clusters which are targeting carbon storage to help meet their decarbonisation goals.

In choosing suitable areas, the UK regulator said it had considered issues including co-location with offshore wind – whether there are any familiar challenges and mitigations around existing or future offshore wind developments – environmental issues, potential overlaps with existing or future petroleum licences, and other activities to ensure key technologies can all be taken forward.

The application window is open for 90 days, closing on 13 September, and will be evaluated on technical and financial criteria.

It is expected that any new licences will be awarded in early 2023. The size and scale of the licensed stores mean that they are likely to proceed at different paces, but first injection of CO_2 could come as early as four to six years after the award.

So far, the level of interest suggests there will be strong competition meaning that prospective licensees will need to produce high-quality bids to win licences, NSTA added.

"This is an important day on the path to net-zero emissions. In addition to the huge environmental benefits of significantly reducing carbon dioxide emissions into the atmosphere, the facilities will provide opportunities for many

thousands of highly-skilled jobs," said Andy Samuel, NSTA chief executive.

"Carbon storage is going to be needed across the world. There is growing investor appetite and we are keen to accelerate development of the carbon storage sector so that UK is well-positioned to be a global leader. The NSTA is ready to work with industry, government, regulators and others to deliver these exciting projects at pace."

The new carbon storage areas, alongside the six previously issued, could have the ability to make a significant contribution towards the aim of storing 20-30 million tonnes of CO_2 by 2030, NSTA said.

This round is said to be the first of many as it is estimated that as many as 100 CO_2 stores could be required in order to meet the net-zero by 2050 target.

The Government's **Ten-Point Plan**, published in November 2020, supported the establishment of carbon capture, usage and storage in four clusters – in areas such as the Northeast, the Humber, Northwest, Scotland and Wales – encouraging private sector investment.

NSTA, The Crown Estate and Crown Estate Scotland recently issued a joint statement explaining how they intend to work together and the NSTA has separately signed a Memorandum of Understanding (MoU) with Ofgem, which will act as the economic regulator for the transportation and storage of carbon dioxide.

Besides being awarded a licence from the NSTA, successful applicants will also need to obtain a lease from The Crown Estate or Crown Estate Scotland, depending on location, before they can progress a project.

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Europe's largest land predator unearthed on the Isle of Wight

University Of Southampton

9 June 2022

Research led by palaeontologists at the **University of Southampton** has identified the remains of one of Europe's largest ever land-based hunters: a dinosaur that measured over 10 m long and lived around 125 Ma ago.

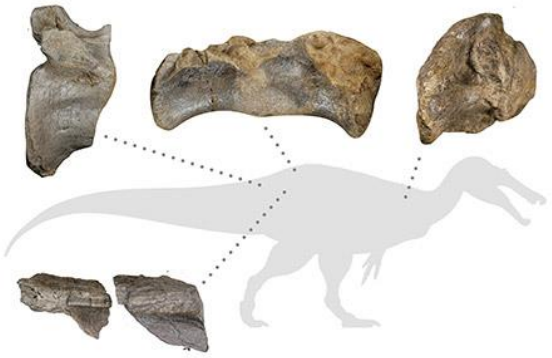
Illustration of White Rock spinosaurid by Anthony Hutchings. (Credit: UoS/A Hutchings)

Several prehistoric bones, uncovered on the Isle of Wight, on the south coast of England, and housed at Dinosaur Isle Museum in Sandown, belonged to a type of two-legged, crocodile-faced predatory dinosaur known as spinosaurids. Dubbed the **'White Rock spinosaurid'** – after the geological layer in which it was found – it was a predator of impressive proportions.

"This was a huge animal, exceeding 10 m in length and probably several tonnes in weight. Judging from some of the dimensions, it appears to represent one of the largest predatory dinosaurs ever found in Europe – maybe even the biggest yet known", said PhD student Chris Barker, who led the study. "It's a shame it's only known from a small amount of material, but these are enough to show it was an immense creature."

The discovery follows previous work on spinosaurids by the University of Southampton team, which published a study on the discovery of two new species in 2021.

The bones of the 'White Rock spinosaurid', which include huge pelvic and tail vertebrae, amongst other pieces, were discovered near Compton Chine, on the southwest coast of the Isle of Wight. The Cretaceous rocks are famous for their dinosaurs, but little appreciated is the fact that the Island's fossil record preserves dinosaurs from more than one section of history – and some of those sections, even today, are poorly known.



Position of best-preserved bones. (Credit: Chris Barker/Dan Folkes)

“Unusually, this specimen eroded out of the **Vectis Formation**, which is notoriously poor in dinosaur fossils”, said corresponding author Dr Neil Gostling, who teaches evolution and palaeobiology at the University of Southampton. “It’s likely to be the youngest spinosaur material yet known from the UK.”

The 125 Ma Vectis Formation preserves the beginning of a period of rising sea levels, where the ‘White Rock spinosaurid’ stalked lagoonal waters and sandflats in search of food.

“Because it's only known from fragments at the moment, we haven't given it a formal scientific name” said co-author Darren Naish. He added: “We hope that additional remains will turn up in time. This new animal bolsters our previous argument - published last year - that spinosaurid dinosaurs originated and diversified in western Europe before becoming more widespread.”

Marks on the bone also showed how, even after death, the body of this giant probably supported a range of scavengers and decomposers.

“Most of these amazing fossils were found by Nick Chase, one of Britain’s most skilled dinosaur hunters, who sadly died just before the Covid epidemic”, said co-author Jeremy Lockwood, a PhD student at the University of Portsmouth and Natural History Museum. “I was searching for remains of this dinosaur with Nick and found a lump of pelvis with tunnels bored into it, each about the size of my index finger. We think they were caused by bone eating larvae of a type of scavenging beetle. It’s an interesting thought that this giant killer wound up becoming a meal for a host of insects.”

The researchers hope to generate thin sections of the material to look at the microscopic internal properties of the bones in the near future, which may provide information about its growth rate and possible age.

References:

- The paper ‘A European giant: a large spinosaurid (Dinosauria: Theropoda) from the Vectis Formation (Wealden Group, Early Cretaceous)’, UK is published in the journal ***PeerJ.***
- https://www.southampton.ac.uk/news/2022/06/dino-bones.page
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Mary Anning: Lyme Regis fossil hunter's statue unveiled

21 May 2022
BBC Science

A seafront statue of palaeontologist Mary Anning has been unveiled in her hometown of Lyme Regis, Dorset.

Anning's discoveries in the early 19th Century helped shape scientific understanding of prehistoric life, but her work was never properly recognised.

Crowds turned out for the unveiling, carried out by Prof Alice Roberts.

Evie Swire, 15, campaigned for four years for the memorial, which was unveiled on what would have been Anning's 223rd birthday.

The fossil hunter lived in Lyme Regis, part of what is now called the **Jurassic Coast**, and began searching the coastline as a child. She was the first person to discover a complete plesiosaurus, in 1823.

During the ceremony, crowds cheered as Prof Roberts said: "Mary Anning - welcome back to Lyme Regis." She added: "It makes Mary Anning visible as a role model for any woman wanting to get into science. This is her place, where she was from and where she made all her discoveries. But she also represents the change we need in our society - we need to push further and bring more people into science," she said.

Anning, whose life inspired the feature film **Ammonite**, was never fully credited for her discoveries due to the fact she was woman and because of her social status.

In 1811, aged 12, Mary Anning discovered a 5.2 m skeleton, now known to be an ichthyosaur

Evie said: "It's taken a very long time, I'm not as big a fossil fan; the main reason I wanted to do it was to make sure she got the recognition she deserved."

The teenager's mum, Anya Pearson, said of the four years it has taken to realise her ambition: "It's not how I expected; I genuinely thought in-out in a year, not a problem. Obviously a pandemic in the middle didn't help, but it's been a life-affirming thing to be involved with."

Mary Anning statue.

Artist Denise Dutton, creator of the Land Girls monument at the National Arboretum, was commissioned to create the sculpture, which has been installed close to Anning's birthplace.

References:

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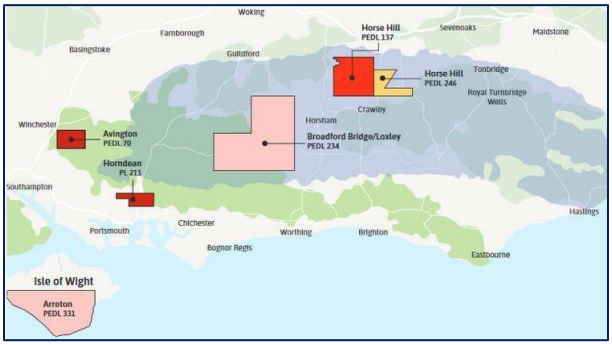
https://lovelymeregis.co.uk/maryanningstatue

UKOG granted one-year work programme extension on PEDL137 Horse Hill

13 May 2022
energy-pedia development and production

AIM-listed UK Oil & Gas (UKOG) has announced that the North Sea Transition Authority (formerly the Oil and Gas Authority) has granted a one-year extension to the agreed Retention Area work programme of the Company's operated PEDL137 licence (UKOG 85.635%) containing the producing Horse Hill oil field and its underlying Kimmeridge oil pool.



UKOG granted one-year work programme extension on PEDL137 Horse Hill.

The extension grants an additional year in which to drill a second Horse Hill Kimmeridge well, with the commencement of drilling to be prior to 30th September 2023.

Reference

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Shell's Jackdaw gas field given go-ahead by regulators

By Justin Rowlatt, BBC Climate editor
31 May 2022

Development of a major North Sea gas field has been approved by regulators. The **Jackdaw Field**, east of Aberdeen, has the potential to produce 6.5% of Britain's gas output.

The regulatory approval comes as the UK government seeks to boost domestic energy output following Russia's invasion of Ukraine.

Shell's proposals were initially rejected on environmental grounds in October. UK Business Minister Kwasi Kwarteng welcomed the decision.

"We're turbocharging renewables and nuclear, but we are also realistic about our energy needs now," he said on *Twitter*. "Let's source more of the gas we need from British waters to protect energy security."

Under the new plan, Shell plans to start production from the field in the second half of 2025. The oil and gas company said the approval came "at a time when UK energy security is critically required."

Shell said it expected to spend £500m in the UK to develop the new facility. It said the Jackdaw field should be able to provide gas to 1.4m British homes, and its carbon emissions should eventually be captured for storage, if a large project in Peterhead secures funding.

But environmental campaigners have condemned the move. The activist group Greenpeace said it believed the approval could be unlawful and it was considering legal action.

"Approving Jackdaw is a desperate and destructive decision from Johnson's government, and proves there is no long-term plan," said Ami McCarthy, a political campaigner for Greenpeace.

'Lower carbon footprint'

The approval comes as Britain struggles with soaring energy prices in the wake of the Russian invasion of Ukraine on the 24 February.

Energy independence was a major theme of the UK energy strategy announced by Prime Minister Boris Johnson in early April.

The main focus was investing in renewable and nuclear power, but it also promised new licences for gas projects in the North Sea arguing that producing gas in UK waters has a lower carbon footprint than doing so abroad.

It is understood that Shell has changed the way it processes natural gas before it brings it onshore.

The plan had been to vent excess gas at an offshore hub to reduce the corrosive CO_2 content in the pipes. Natural gas is methane, a powerful greenhouse gas.

The UK was one of 100 countries that pledged to cut methane gas emissions by 30% over the next 10 years.

Under the new plan Shell will bring a higher percentage of gas ashore.

Analysis

by Douglas Fraser, business and economy editor, Scotland

It was the **Cambo oilfield**, west of Shetland, that got the attention as world leaders gathered in Glasgow seven months ago to show their commitment to tackling climate change.

Cambo was the test of how serious the UK government really was. As minority partner in the development, Shell pulled out. It was expensive, in deep water, and the politics of it made it a riskier investment.

It had other projects to consider first. Jackdaw, a gas field close to existing infrastructure, was what Shell describes as a "vanilla" project - relatively, very straight forward.

Permission to install a tie-back (subsea link) to a nearby platform had been refused last year, on the grounds that production would raise emissions unacceptably.

Shell appealed. It wants to capture those emissions at the carbon capture and storage plant it is helping to plan for St Fergus in Aberdeenshire (but which the UK government put on the back burner). And it plans also to re-power its offshore platforms with renewable electricity rather than burning gas.

Along with the sudden rise in concern about energy security that followed Russia's invasion of Ukraine, those arguments appear to have won over the UK government and its regulator.

The fight doesn't stop here. The industry saw Jackdaw as a test of whether the UK government is serious about energy security: but for environmental campaigners, it's a test of whether the UK government is serious about climate change.

References:

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https://www.energyvoice.com/oilandgas/north-sea/416535/breaking-shell-given-thumbs-up-by-regulators-to-develop-jackdaw-gas-field/

Megalodon shark extinction may have been linked to great white competition

By Helen Briggs, BBC Environment correspondent
31 May 2022

A prehistoric food fight may have spelled the end for the megalodon, the largest shark that ever lived.

The megalodon roamed the oceans from about 22 Ma to 3 Ma ago. (Image Source: Getty Images)

A study of the ocean giant's fossil teeth suggests it had to compete for food with another ferocious predator, the great white shark.

The battle for diminishing stocks of whales and other prey may have pushed the megalodon to extinction 3 Ma ago. Environmental pressures, such as sea level changes, also played a role.

The extinction of the megalodon has been an enduring mystery. Many different factors have been proposed, from habitat loss due to changes in sea level to reduction of prey.

In the latest study, international researchers used zinc isotopes in the teeth of living and extinct sharks as a tool to understand the diet of long-dead animals.

Chemical clues in the teeth of living sharks and 13 fossil megalodon teeth suggest the great white shark and the megalodon once had similar positions in the food web and may have competed for the same food, including whales, dolphins and porpoises.

Megalodon (left) and great white (right) shark teeth. (Image Source: Getty Images)

This may have been a factor in the demise of the megalodon alongside climate change and other environmental pressures, the scientists said.

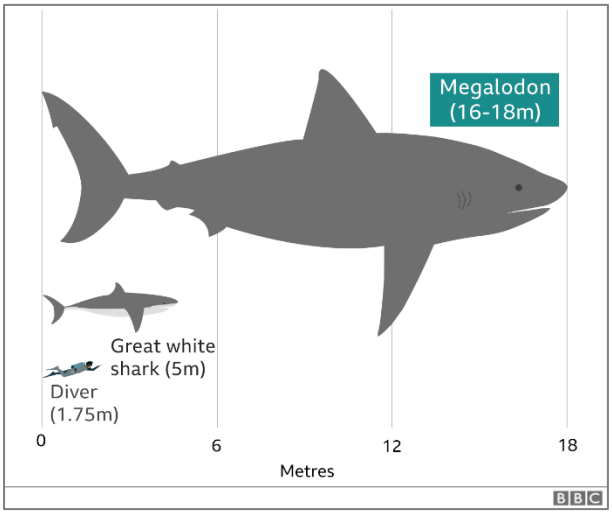
"This is a piece in the puzzle of evidence that there was competition between the modern great white and the megalodon on aquatic food resources in the oceans at the time when both were still alive," said Prof. Thomas Tutken of Johannes Gutenberg University in Mainz, Germany, who led the study.

Commenting on the research, published in **Nature Communications**, Catalina Pimiento of Swansea University said more work was needed to solve the mystery of what happened to the megalodon.

The extinction has been studied from many different angles over the last decade, she said, with studies suggesting multiple factors.

"The mystery of what did megalodon eat and the extent to which it competed with other sharks remains," she said.

How big was Megalodon?



The megalodon (*Otodus megalodon*) was a megatooth shark, which roamed the oceans from about 22 Ma ago until about three million years ago. Its name means "big tooth".

Three times bigger than the great white shark, the megalodon could grow up to 18 m in length and weigh up to 60 tonnes.

The megalodon hit the news recently when a six-year-old boy found a shark tooth belonging to a giant prehistoric megalodon in Suffolk. Sammy Shelton found the 10cm-long tooth on Bawdsey beach during a bank holiday break.

Reference:

https://www.bbc.co.uk/news/science-environment-61644215

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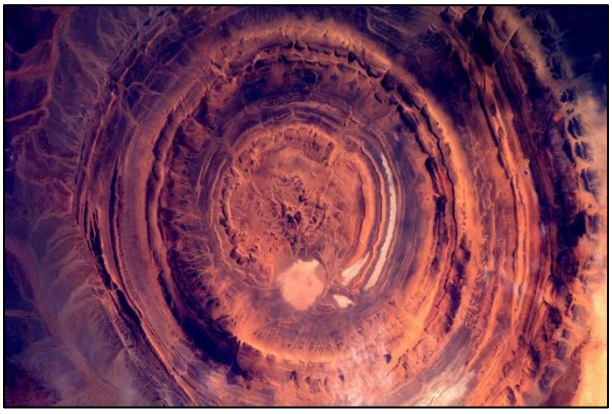
Interesting Places 2

Earth

This spectacular image of **Earth** was captured by the Meteosat Second Generation series of missions on 23 March 2022. *(Photo: ESA)*

The Eye of the Sahara

The **Eye of the Sahara** in Mauritania, also known as the **Richat Structure**, resembles a bull's-eye 50 km wide. The mysterious formation is large enough for early space missions to have used it as a landmark. Scientists think it is the result of uplifted earth worn down over time by wind and water, with different rates of erosion on the varying rock types forming concentric ridges.



Dutch astronaut Andre Kuipers snapped this photo from the International Space Station. (Image credit: ESA/NASA)

Tenoumer Crater

Deep within the Sahara Desert lies one of the best-preserved craters on Earth.

Tenoumer Crater is 1.9 km wide. The rims of the crater rise some 110 m high above the base, but the bottom of the crater is covered with approximately 200 to 300 m thick layer of sediments.

Tenoumer Crater, Mauritania as seen by Sentinel-2 (*Source: ESA)*

New North Sea projects targeting 1.3 billion barrels of oil and gas

EXPLORATION & PRODUCTION

Nermina Kulovic
29 April 2022

The annual performance review for the UK's top producers highlighted 33 new projects targeting 1.3 billion barrels of oil and gas, which will significantly bolster the country's energy security, the country's regulator has revealed.

The North Sea Transition Authority (NSTA) revealed on Thursday that a total of 890 million barrels of those resources could be sanctioned as early as next year and the regulator expects operators to rapidly deliver projects, in line with its effective net zero test, in the interest of UK supply resilience.

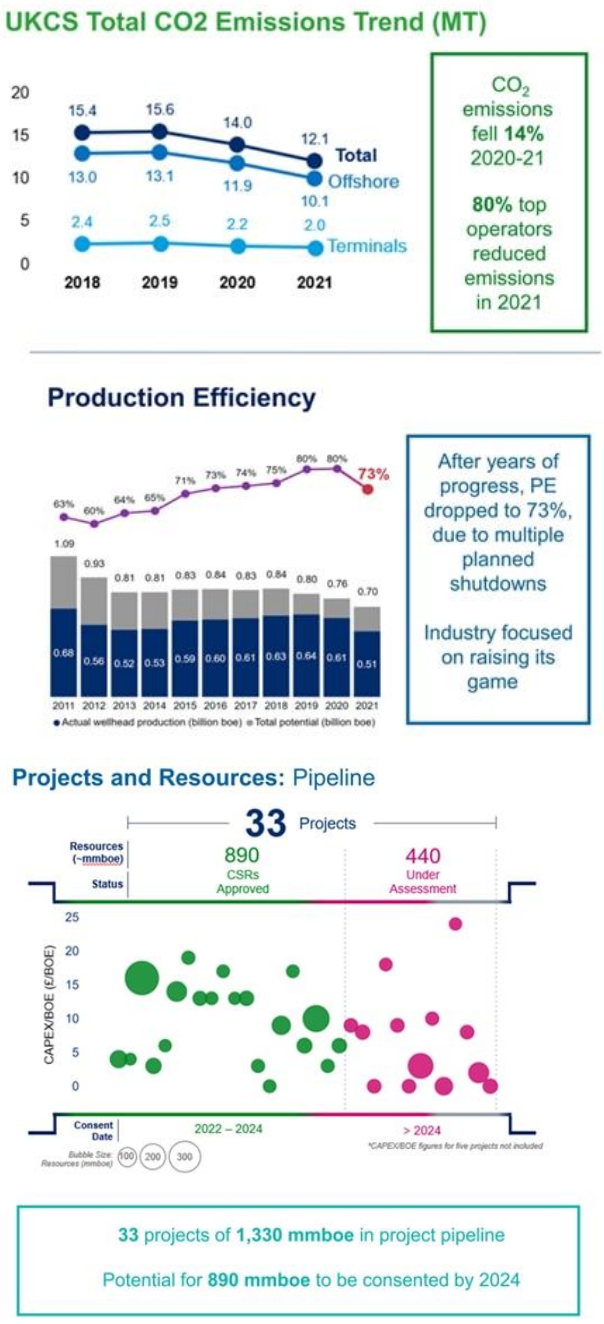
Furthermore, the regulator said that exploration and appraisal activity is expected to return to pre-pandemic levels, with 20 wells per year forecast from 2022-24. The appetite for exploration remains, and bodes well for NSTA's plans to hold a new licensing round later this year, subject to the Climate Compatibility Checkpoint.

The NSTA also used the **28 April Tier Zero** meeting to stress that an ongoing proactive approach is essential to surpass the emissions reduction targets agreed in the North Sea Transition Deal.

Held in Q2 every year, the Tier Zero gathers the managing directors of the sector's 22 largest operators to review the performance of the basin.

Data, including from the annual UKCS Stewardship Survey, is used to show operators how they compare with peers across a series of benchmarking metrics, with a view to sharing best practice and driving improvement.

CO_2 emissions for the UK upstream oil and gas industry fell 14 per cent to 12.1 megatonnes in 2021. Furthermore, flaring across the basin fell by 19 per cent year-on-year and venting was down by 24 per cent. The NSTA challenged



UK NSTA - North Sea (Source: NSTA)

industry chiefs to sustain these lower levels in 2022 when gas production is expected to rise.

Eighty per cent of Tier Zero operators have forward plans covering asset upgrades, emissions reduction and platform electrification, which will be crucial to meeting, and exceeding, Deal targets.

"Indeed, the sector already has well-developed proposals for electrification projects and a number of operators are involved in government-backed industrial decarbonisation clusters focused on carbon capture and

storage (CCS) and hydrogen, currently being progressed," the NSTA said.

As a reminder, the NSTA last March rebranded and changed its name from the Oil and Gas Authority (OGA) to reflect its expanding role in energy transition, including as the carbon storage licence and permitting authority, monitoring of emissions, assessing a net-zero test for new developments, and stewarding domestic production.

One of the areas highlighted in last year's meeting was the need for a step-change in well decommissioning and highly positive signs are now evident, with campaign contracting models gaining traction and the NSTA Energy Pathfinder portal listing 470 wells awaiting decommissioning.

The discussion this year also covered opportunities to repurpose infrastructure for decarbonisation projects, such as CCS and H2, which are now a key area of focus. The NSTA will be launching a Carbon Storage licensing round shortly.

The NSTA urged companies to get production efficiency back on track, which slipped last year due to the large number of planned maintenance shutdowns on multiple installations, many of which were postponed the previous year due to Covid.

Following years of improvement in production efficiency, culminating in the 80 per cent target being met in 2019, the metric dropped to 73 per cent in 2021.

However, this indicator has long been a focus for the NSTA and industry and the managing directors confirmed their commitment to restore production efficiency to 80 per cent.

Dr Andy Samuel, NSTA Chief Executive, said: "This meeting once again provided a good platform for positive action, supported by our suite of benchmarks and data insights. I am encouraged by the open, frank and productive dialogue. Many best practices and learnings were shared across the different operators.

"Companies are now progressing new projects that will strengthen energy security while generating tax revenues, and creating and safeguarding thousands of UK jobs as part of an orderly transition to net zero. Importantly the industry reconfirmed commitment to halve production emissions by 2030 with progress well underway. The growing momentum on clean power to offshore installations, CCS and hydrogen was also very evident."

As recently reported, Samuel will be leaving his role at the end of the year and the NSTA is looking to appoint a successor in the summer so that the appointee can take up the role in time to allow for a period of handover.

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Supermountains controlled the evolution of life on Earth

GeologyPage
4 February 2022

Giant mountain ranges at least as high as the Himalayas and stretching up to 8,000 kilometres across entire supercontinents played a crucial role in the evolution of early life on Earth, according to a new study by researchers at **The Australian National University** (ANU).

The researchers tracked the formation of these supermountains throughout Earth's history using traces of zircon with low lutetium content — a combination of mineral and rare earth element only found in the roots of high mountains where they form under intense pressure.

The study found the most giant of these supermountains only formed twice in Earth's history — the first between 2,000 and 1,800 Ma ago and the second between 650 and 500 Ma

ago. Both mountain ranges rose during periods of supercontinent formation.

Lead author, ANU PhD candidate Ziyi Zhu, said there are links between these two instances of supermountains and the two most important periods of evolution in Earth's history.

"There's nothing like these two supermountains today. It's not just their height — if you can imagine the 2,400 km long Himalayas repeated three or four times you get an idea of the scale," she said. "We call the first example the *Nuna Supermountain*. It coincides with the likely appearance of eukaryotes, organisms that later gave rise to plants and animals.

"The second, known as the *Transgondwanan Supermountain*, coincides with the appearance of the first large animals 575 Ma ago and the Cambrian explosion 45 Ma later, when most animal groups appeared in the fossil record."

Co-author Professor Jochen Brocks said: "What's stunning is the entire record of mountain building through time is so clear. It shows these two huge spikes: one is linked to the emergence of animals and the other to the emergence of complex big cells."

When the mountains eroded they provided essential nutrients like phosphorus and iron to the oceans, supercharging biological cycles and driving evolution to greater complexity.

The supermountains may also have boosted oxygen levels in the atmosphere, needed for complex life to breathe.

"The early Earth's atmosphere contained almost no oxygen. Atmospheric oxygen levels are thought to have increased in a series of steps, two of which coincide with the supermountains," Ms Zhu said. "The increase in atmospheric oxygen associated with the erosion of the Transgondwanan Supermountain is the largest in Earth's history and was an essential prerequisite for the appearance of animals."

There is no evidence of other supermountains forming at any stage between these two events, making them even more significant.

"The time interval between 1,800 and 800 Ma ago is known as the Boring Billion, because there was little or no advance in evolution," co-author Professor Ian Campbell said. "The slowing of evolution is attributed to the absence of supermountains during that period, reducing the supply of nutrients to the oceans.

"This study gives us markers, so we can better understand the evolution of early, complex life."

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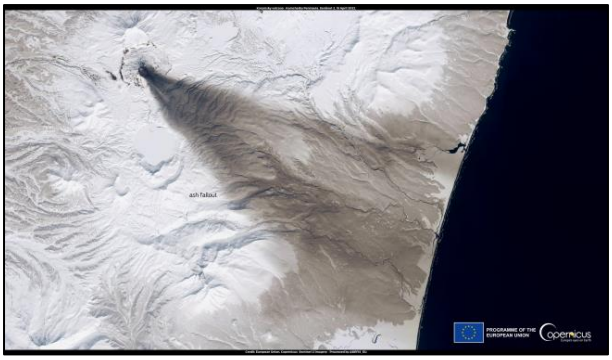
Note: The above post is reprinted from materials provided by Australian National University.

Ongoing eruption of the Karymsky volcano



Date: 22 April 2022
Location: Kamchatka Peninsula

This image, acquired by one of the Copernicus Sentinel-2 satellites on 19 April 2022, shows the ashfall traces resulting from the ongoing eruption of the Karymsky volcano.

Karymsky is the most volcano active in the eastern part of the Kamchatka Peninsula and has had a persistent activity for 500 years. On 21 April 2022, a few days after the acquisition of this image, a massive emission of ash reached an altitude of almost 10 km, as a result of the ongoing eruption. The volcanic ash plume is now moving northeast at a speed of 25 knots (46 km/h). *(Credit: European Union, Copernicus Sentinel-2 imagery)*

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Impact structure hidden under Arctic ice dates to the Paleocene

Greenland's Hiawatha impact structure, more than 30 kilometers in diameter, is much older than previously thought, new results suggest.

By Katherine Kornei, Science Writer, EOS 13 April 2022

In northwestern Greenland, there's a secret hidden deep beneath glacial ice: a circular depression hundreds of meters deep and tens of kilometers wide. It's believed to have been formed by **an asteroid impact**, and researchers now have analyzed bits of rock sloughed off from the structure to determine its age: about 58 Ma. That's a surprise—earlier work suggested that the impact might have occurred as recently as a few tens of thousands of years ago, during the Pleistocene, and therefore might have been responsible for the cold period known as the Younger Dryas.

What Lies Beneath

From the surface, Hiawatha Glacier looks like any other expanse of glacial ice. But in 2016, researchers flying in a converted DC-3 plane used ice-penetrating radar to peek beneath the icy mass. They discovered a bowl-shaped depression in the underlying bedrock more than 30 kilometers in diameter with an uplifted central region, geometry characteristic of an asteroid impact. On the basis of estimates of how quickly the structure was eroding, in 2018 a team suggested that the impact occurred relatively recently, during the Pleistocene.

But now researchers, including some members of the 2018 team, have pinned down the precise age of the Hiawatha impact structure. It is much, much older than previously believed—58 Ma or so years, which places its formation solidly in the Paleocene. To arrive at that age estimate, the scientists analyzed grains of sand and pebble-sized rocks collected just a few kilometers from the impact structure's northern rim. This material, transported out from under the ice by flowing water, was shed from the impact structure, the team presumed.

Dating Sand and Rocks

Michael Storey, a geochronologist at the **Natural History Museum of Denmark** in Copenhagen and a member of the research team, led the analysis of the sand grains. Storey and his colleagues selected 50 grains, each a few millimeters in diameter, that all showed evidence of having been melted. The researchers then used argon-argon age dating, a technique that involves measuring the relative concentrations of two isotopes of argon, 39Ar and radiogenic 40Ar, to estimate the grains' ages. Storey and his team found that the grains ranged in age, but none was younger than about 50 Ma. "The 40Ar/39Ar ages hit a brick wall in the late Paleocene," said Storey.

Gavin Kenny, a geochemist at the **Swedish Museum of Natural History** in Stockholm and also a team member, next led an independent analysis of two rocks from the impact structure to estimate their ages. The centimeter-scale specimens, which show signs of having experienced conditions representative of an impact, are a critical find, said Kenny. That's because given their size, it's more likely they're derived from whatever cataclysm created the impact structure. Sand grains, said Kenny, "could have been scattered from somewhere else."

Kenny and his collaborators homed in on zircon crystals, which form deep underground

and incorporate tiny bits of uranium into their crystalline structure as they grow. Because uranium radioactively decays to lead over time at a known rate, the age of a zircon crystal can be inferred by measuring its relative abundances of uranium and lead. However, an asteroid impact results in extremely high temperatures and pressures, conditions that can cause zircon to recrystallize and kick out the lead within it. By measuring the ages of recrystallized zircon, it's therefore possible to infer when an impact occurred.

The researchers analyzed 28 zircon crystals that were likely to have been recrystallized. They recovered ages as old as roughly 1.9 Ga—probably tracing the rocks that existed at the time of the impact, the team surmised—but also a cluster of ages in the Paleocene, around 58 Ma ago. Given that clustering, and the fact that none of the 40Ar/39Ar–derived ages of the sand grains was younger than the Paleocene, the team concluded that the event that formed the Hiawatha impact structure occurred 58 Ma ago. There's accordingly no link whatsoever between this event and the Younger Dryas, a period of cooler-than-normal temperatures roughly 13,000 years ago that's been tied to the rise of agriculture, said Storey.

A Greenland of Rain Forest, Not Ice

Fifty-eight Ma ago, northwestern Greenland would have looked nothing like it does today. For starters, there wouldn't have been any ice, said Storey. "What the asteroid hit was a temperate rain forest." Rather than polar bears, the landscape would have been home to hippopotamus-like creatures, alligators, and crocodiles, he said. "It was a really different world."

And the destruction wrought by the impact might have been significant on a continental scale, but the effects probably weren't felt globally, said Storey. "It's not Chicxulub. It probably didn't have a significant effect on the global climate, but it may have had interesting effects on a continental scale." These results were published in March in ***Science Advances***.

In the future, it'd be valuable to extract material directly from this impact site, said Aaron Cavosie, a planetary scientist at the Space Science and Technology Centre at Curtin University in Perth, Australia, who was not involved in the research. That means drilling through hundreds of meters of ice into bedrock, which is no small feat, he acknowledged. But doing so would provide rock samples that unambiguously trace the impact event. "That'll provide ground-truth evidence," said Cavosie.

Reference:

Kornei, K. (2022), Impact structure hidden under Arctic ice dates to the Paleocene, *Eos*, 103, https://doi.org/10.1029/2022EO220181. Published on 13 April 2022.

https://eos.org/articles/impact-structure-hidden-under-arctic-ice-dates-to-the-paleocene?utm_source=EosBuzz&mkt_tok=OTg3LUlHVC01NzIAAAGD77Ooi2bxXy_wRbG9oaSKblxudnWRpZ4uMNS6aBDcm9EKDpT80gGI2lvEq25JPswKylwwgUitHlw-dZuRe_-wdIvmmVnyj3iZDxFhZGk

'Vigorous' magnetic field oddity spotted over South Atlantic

By Stephanie Pappas, Space.com
28 May 2020

A long-standing weak spot in Earth's magnetic field is getting weirder, and it may be splitting into two distinct zones of weakness.

The **South Atlantic Anomaly** is a section of Earth's magnetic field between Africa and South America. For decades at least, this region of the magnetic field has gotten weaker and weaker, part of a global trend. According to the European Space Agency (ESA), the global magnetic field has lost 9% of its strength over the past 200 years. The South Atlantic Anomaly seems to be a particular point of change. Now, satellites investigating the anomaly have detected an intensified weakening southwest of Africa, suggesting that the anomaly could split into two separate low points.

This change wouldn't signal any imminent danger, but it might help reveal what's going on in the Earth's core to drive the changes,

according to the ESA. The agency's satellites are gathering data on the electromagnetic field to answer this question.

Fluctuating field

The magnetic field is why compasses and GPS work, and it protects the planet from charged solar particles that can damage electrical equipment. For that reason, its fluctuations are important. But they are also poorly understood. The Earth's magnetic field arises from the churn of the planet's liquid iron core, which acts like an enormous magnet (thus, the North and South poles). But the magnetic field isn't as neat and tidy as the one created by a typical bar magnet. It has areas of strength and weakness, and sometimes the field even flip-flops, with north and south switching places.

The current weakening of the Earth's magnetic field could portend another one of these flip-flops, or it could simply be a temporary fluctuation. If the field does reverse, the **South Atlantic Anomaly** is likely to be the origin of the change, research has found.

The ESA's Swarm constellation of satellites, launched in 2013, is probing the anomaly for small changes that could explain what's going on in the core. Since the group of satellites went into orbit, the South Atlantic Anomaly has developed a second centre of minimum magnetic intensity, according to the ESA. This second weak spot indicates a complex process in the Earth's core; a simple dipolar, north-south magnetic field can't explain the pattern, the agency reported in a press release.

Mystery below

"The new, eastern minimum of the South Atlantic Anomaly has appeared over the last decade and in recent years is developing vigorously," Jürgen Matzka, a geomagnetism researcher at the GFZ German Research Centre for Geosciences, said in a statement. "We are very lucky to have the Swarm satellites in orbit to investigate the development of the South Atlantic Anomaly. The challenge now is to understand the processes in Earth's core driving these changes."

The field is weak enough to sometimes affect satellites that pass over the region, according to the ESA. Unprotected from space radiation, the International Space Station and other satellites in low-Earth orbit sometimes experience "single event upsets" in which communications are disrupted or computers go on the fritz. Astronauts sometimes see sudden white flashes from a burst of radiation in front of their eyes.

"This is a well-known area where all different types of satellites — not just a space station with people, but normal communication satellites and others — have problems," former astronaut Terry Virts told the BBC in 2018. "You want to kind of get through there as fast as you can on the way to the moon, or wherever you're going."

Reference:

https://www.space.com/weakening-magnetic-field-satellites.html

Arctic heat wave

30 May 2022

The image below, acquired by one of the **Copernicus Sentinel-2 satellites** on 29 May 2022, shows the significant discharge of sediment into the Arctic Ocean due to melting snow and glaciers around Longyearbyen in the Svalbard archipelago in Norway.

Credit: European Union, Copernicus Sentinel-2 imagery

The massive melting is caused by an ongoing heatwave in the Arctic. According to the Norwegian Meteorological Institute, on 28 May, at Akseløya, an island 60 km southeast of Longyearbyen, the temperature rose to

10.5°C, the highest value for the month of May in 46 years of observations. Additionally, according to the University of Liège's climatology laboratory, on the day of this image acquisition, the surface melting at the Svalbard archipelago reached a record high value for the end of May.

Data acquired by the Copernicus Sentinel satellites are used to detect changes in the earth's surface with great detail, even at northern latitudes, and monitor the melting of glaciers.

Reference:

https://www.copernicus.eu/en/media/image-day-gallery/arctic-heat-wave

From The Archives

September 1993
Newsletter Vol. 3, No. 11

As suggested by Colin Brash.

REPLY TO ANON

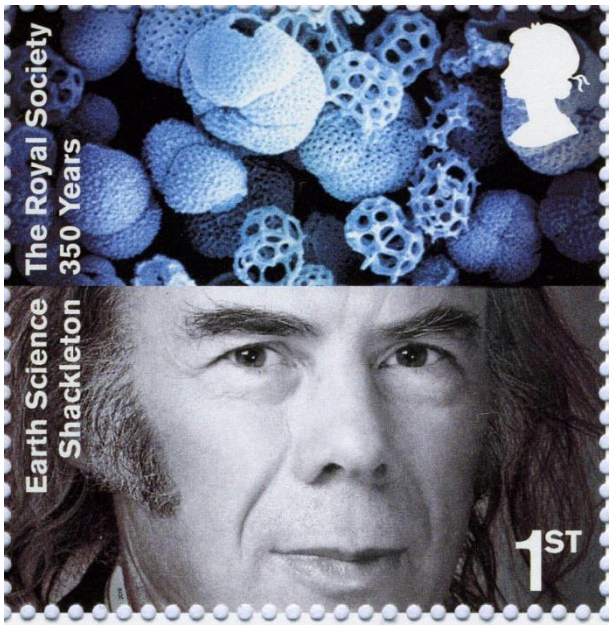
I've read the poem many times
To find the author of the rhymes
Should I refer
To "his" or "her"?
For **Tony** talked on copper mining
Puffs of air, then metal shining,
So did he toil
By midnight oil?
Jill and **Colin** paid attention,
Crystals clear, they'd like to mention
They might unite
This work to write.
Janet showed her slides on travels
She's keen on lavas, sands, and gravels
And surmised
How dinosaurs died.
Peter plays on words for fun,
And he was there in ninety-one
Has he made quotes from last year's notes?
This student dreams of gemstones bright
And learnt that emeralds fade in light
But doesn't pass
Remarks in class!
So, in the end, it seems to me
The hand that penned was **Mary-B**?

*Those mentioned: **Tony** Brown (?), **Jill** & **Colin** Brash, **Janet** Catchpole (?), **Peter** Cotton & **Maryb**eth Hovendon.*

History of Geology

28 April 2021

Geologist Jessica Watkins made history on Wednesday, 27 April 2021 by becoming the first black woman launched into space for an extended mission on the International Space Station.



June 23, 1937

Birthday of **English geologist** and paleoclimatologist Nicholas Shackleton. Pioneer in the use of mass spectrometry to determine climate change as recorded in isotopes of calcareous microfossils.

Book Review

‘Dinosaurs are not us’: book reveals how mammals came to rule the world

Steve Brusatte writes of the evolutionary twists, catastrophes and luck that led to the warm-blooded animals of today

Nicola Davis, Guardian Science correspondent
11 Jun 2022

Prof Steve Brusatte, author of ***The Rise and Reign of the Mammals****, with a Tetraclaeonodon fossil and other mammal skulls. (Photograph: Murdo MacLeod/The Guardian)*

With a head like a horse, a body resembling a giant bear and possessing huge, clawed knuckles upon which it walked like a gorilla, Anisodon looks like a figure from Greek mythology.

But it is not a beast of the underworld or a monster of nightmares. Instead it is one of a bizarre group of animals called *Chalicotheres* that roamed Earth from 46 Ma ago, with the last of the creatures surviving long enough to have been encountered by human ancestors. What’s more, Anisodon was a mammal. Just like us.

King Kong may have easily bested a T rex in the 1933 film, but since then our interest in dinosaurs has conquered any fascination with mammals. While the reptiles have been propelled into the public eye by films such as Jurassic Park, early mammals have been the

(Photograph: Faenkova Elena/Shutterstock)

underdog – with mammoths and sabre-toothed tigers among the few garnering fame.

Yet the mammal family tree is bristling with jaw-dropping creatures, from Anisodon to the biggest creature that has ever lived – the blue whale.

“I don’t think we appreciate this enough,” says Steve Brusatte, a palaeontologist at the University of Edinburgh and author of **The Rise and Reign of the Mammals**, which sets out to bridge the fascination gap. “Just imagine if whales were extinct, and all we had were their bones. I mean, they would surely be as famous, as fascinating, as dinosaurs.”

As a science consultant for the forthcoming film **Jurassic World Dominion**, Brusatte has nothing against dinosaurs, and the shelves of his office are teeming with sketches, plastic models and even origami creations of the beasts.

The effusive American even began as a T rex expert before branching out into studying mammal fossils. But there’s a simple reason why he’s so passionate about the latter. As he says in his new book: “Dinosaurs are awesome, but they are not us.”

The Rise and Reign of the Mammals is nothing short of a thriller, revealing the luck, evolutionary twists and near-apocalyptical catastrophes that have led to the mammals of today, us included.

Fascinating revelations come thick and fast, from the discovery that ancient rodents and monkeys crossed the vast distance from Africa to South America on rafts, to the fact whales have belly buttons and elephants recognise themselves in the mirror.

Along the way, Brusatte brings readers face to face with our distant ancestors, including the last common ancestor of mammals and reptiles: a small, scaly, swamp-dwelling creature that lived about 325 Ma years ago.

At some point, two populations of these lizard-like creatures became separated from each other. And the rest is history.

As natural selection got to work, one population accrued adaptations that would eventually give rise to mammals. Chief among them was a single opening behind the eyes – allowing for bigger, stronger jaw muscles – and teeth specialised for different purposes.

Dimetrodon. (Photograph: Todd Marshall)

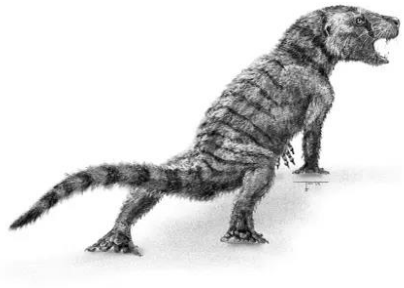
"A lot of our biological superpowers come from our teeth," says Brusatte. "Something like a T rex, or a lizard, just basically has all the same type of teeth, they can just chomp up and down. Mammals, we have all these different varieties of teeth, we basically have a Swiss army knife in our jaws and the teeth do many things."

The early ancestors of mammals are a far cry from our fluffy pets. About 290 Ma ago the huge, sail-backed *Dimetrodon*, dubbed "something of a Frankenstein creature," by Brusatte, was stalking the landscape with its sprawling limbs and sharp teeth, and about 255 Ma ago an intrepid time traveller could have met *Inostrancevia*, a group of monstrous sabre-toothed beasts. "These things were nasty flesh-eaters," says Brusatte.

Soon, hair began sprouting, brains grew in size, and higher metabolisms developed. "When you look in the fossil record, you see there was this long story [over] tens of millions of years, when mammals were essentially assembled by evolution, piece by piece," says Brusatte.

Then, about 252 Ma ago, volcanoes erupted in what is now Siberia. The upshot was runaway global warming and the death of about 90% of the planet's species – an event called the end-Permian extinction, or **"The Great Dying"**.

Most of the forerunners of mammals bit the dust. But, against the odds, some survived, including a hairy, cat-sized creature called *Thrinaxodon* that could not only burrow but rapidly grow and reproduce. It was the ultimate "disaster species".



Thrinaxodon. (Photograph: Todd Marshall)

"It seems like that just by the dumb luck of evolution most [mammal ancestors] died, but a small number of them turned out to be particularly suited to a world of chaos," says Brusatte.

These survivors garnered new adaptations: their lower jaw changed from having a collection of bones to just one, and a new type of joint emerged – long thought the hallmark of true mammals. The vestigial bones were repurposed, becoming tiny bones in the middle ear commonly known as the hammer and anvil – a radical development that super-charged hearing. At some point they started feeding milk to their young, and became truly warm-blooded.

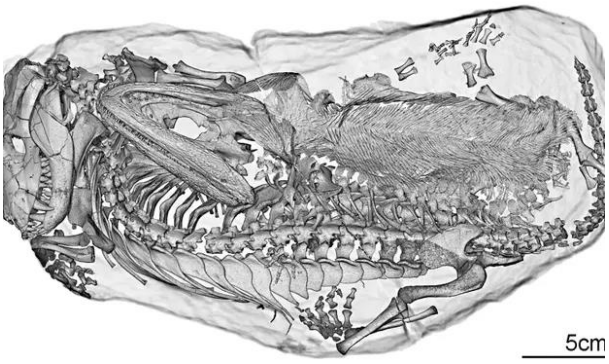
But another type of creature was also on the rise: dinosaurs. And as these beasts went big – a *diplodocus* was roughly the length of a basketball court – mammals went small. Brusatte is keen to stress that the pressure went both ways. “You never saw a triceratops the size of a mouse. And that’s because the mammals were keeping the dinosaurs big,” he says.

Their diminutive form was to be mammals’ trump card when, about 66 Ma ago, a six-mile-wide space rock collided with Earth. The dinosaurs, with the exception of the ancestors of birds, died out. So too did a vast array of mammals, perhaps as many as 90%.

But some lived. “Those that did survive happen to be the ones that were smaller, the ones that could burrow or hide more easily, and the ones that had very generalist diets that could eat lots of things,” says Brusatte.

Mammals soon grew larger. And while some laid eggs, like platypuses today, others gave birth to live young – either nurturing them via a complex placenta in the womb, or in a pouch.

Down the corridor at Edinburgh University, Dr Sarah Shelley, a palaeontologist who illustrated Brusatte’s book, unveils the jaw of a creature that lived a few hundred thousand years after the space rock struck.



Upper-side 3D rendering of content inside a burrow: Thrinaxodon and Broomistega. (Photograph: Creative Commons Attribution LicenseTodd Marshall)

Periptychus was about the size of a border collie, but chunkier, with a big head, massive cheek muscles, a small brain and teeth like lemon juicers. And it was hairy, and had five digits and fingernails. “Its hands look freakishly human,” Shelley adds. “They’re not yet hooves, but they’re more than claws.”

But Brusatte is not only enthusiastic about showcasing bizarre mammals of the past. He wants greater appreciation of what is here now. To illustrate his point, he notes that besides birds and pterodactyls, only one creature has evolved the ability to fly by flapping its wings: bats.

“Imagine if they were not around any more and all we had were fossils. I mean, we would marvel at something like a bat,” he says.

Humans, too, offer much to marvel at: as Brusatte points out, we are sentient apes that have changed the world. But we are only a chapter in a far bigger story.

“I want people to come to appreciate our evolutionary history – where we come from, why we look the way we do, why we behave the way we do, why we have hair and feed our babies milk and we have the teeth we do and we have big brains and keen senses, and all of these things,” says Brusatte. “This all comes from evolution.”

Reference:

https://www.theguardian.com/science/2022/jun/11/dinosaurs-are-not-us-book-reveals-how-mammals-came-to-rule-the-world

TV Review

Brian Cox: Seven Days on Mars – out of this world!

The staggering science and jaw-dropping feats of humanity at mission control for Mars make the particle physicist more excited than ever. Will they find signs of life?

Lucy Mangan, The Guardian
17 June 2022

‘They’re talking, now,” says Brian Cox (particle physics professor), gesturing to the banks of screens filled with numbers, images, graphs and data, “to the solar system.” Cox is in the **Jet Propulsion Laboratory in Pasadena,**

California – otherwise known as mission control for Mars 2020. Everything we can see is dedicated to ensuring the safe passage of the **Perseverance Rover** across the surface of Mars as it searches for, among other things, signs that we are not alone in the universe.

In ***Brian Cox: Seven Days on Mars*** *(BBC Two),* the professor spends a week with the engineers and scientists dedicated to the multibillion-dollar task of developing the rover, sending it safely on its six-month journey through space and landing it on the hazardous rocky surface. They must then compile its daily set of instructions – thousand of lines of code – and upload them via the *Deep Space Network* so it can take rock samples, beam back data and make its way to the **ancient dried river delta within Jezero Crater**, whose hydrated history is thought to make it the most likely site on which to find evidence of past Martian life.

It's the kind of programme that, long before it gets to the presence or otherwise of little green men/chemical traces of cyanobacteria in three-billion-year-old stromatolites, has you periodically open-mouthed at the staggering feats of humanity on display.

Here's the team fixing the rover, which is currently stuck sampling a rock, from a room 200 million miles away. Here's chief engineer of robotics operations Vandi Verma donning 3D goggles to help her plot a route for Perseverance through some particularly tricky terrain before they can let the autodrive function take over again. Here's Al Chen, the man responsible for designing the rover's precision landing system, whose first full test was – the landing itself. "In front of everyone else in the world," he says. "I definitely didn't want to know what my blood pressure was doing."

We watch footage of the day itself, people hunched over screens, hands touched to headphones to see if Chen's system for taking the Perseverance from 20,000 km/h to walking pace to touchdown in a place determined by the rover to be safe would work. "We have confirmation," says one of the team, straightening up, "that the lander vision system has provided a valid solution." Were sweeter words ever spoken? The room erupts in cheers.

There was so much to see and say about the incredible technology, emergent data and essentially new knowledge pouring out all around him that it dispelled some of the whimsicality that is generally attendant on Cox's programmes. Whether you think this is a good or a bad thing, of course, will depend on your tolerance for it. Mine is low, so I enjoyed **Seven Days in Mars** more than some of his previous outings. Being able to trust his material, and it being so abundant, made for a much more substantial offering.

Not that his genuine and obvious joy in his surroundings and the findings round every corner weren't a pleasure. Even those of us who don't want saccharine aren't looking for jaded. And it was particularly good to have him challenge those who in – ahem – their cynicism might have been wondering what the point of looking for life on Mars is. It's to see, he explained, if it started there or here. To determine how easily and/or how differently life can evolve. To recalculate the likelihood of our uniqueness or otherwise. And to show what we are capable of when we work together to increase the sum of human knowledge.

At least the best of us will leave a little more than another layer of stromatolites when they go.

Reference:

https://www.theguardian.com/tv-and-radio/2022/jun/17/brian-cox-seven-days-on-mars-review-nasa-pereverance-bbc

Prehistoric Planet – you'll genuinely think you're watching real dinosaurs

This nature show about millions of years ago looks so good it's like a wildlife documentary – especially as David Attenborough narrates. What a wonderful spectacle.

Lucy Mangan, The Guardian
23 May 2022

What is the opposite of an existential crisis? Because I think I'm having one. Watching **Prehistoric Planet** *(Apple TV+)* has induced in me an existential – joy/delight? – that I don't quite know what to do with.

To explain. Because it is new, made of money and eager to pump its schedules full of prestigious productions to attract the kind of viewers and subscription rates that keep its coffers full and reputation buffed – thus creating a virtuous, quality-programming circle for thee, me and whichever shareholders/billionaires need to be kept in space-rocket funds – *Apple TV+* has recreated dinosaurs.

For real? T. rex and baby in Prehistoric Planet. (Photograph: Apple TV+)

I mean, not quite in the Jurassic Park sense (though I suspect it's only a matter of time) but in a manner much safer and more accessible to a wider public. **Prehistoric Planet** is stuffed to bursting with CGI renderings of the reptiles that roamed the Earth 66 Ma ago.

And not just your ordinary dinosaurs. Tyrannosaurus rex is there, of course, but beyond that there is the mosasaur, pterosaur, hadrosaur, tethyshadros, edmontosaurus, dromaeosaurid, antarctopelta, pachyrhinosaurus, nanuqsaurus and so many others that you may need to beg the loan of a 10-year-old dino-fan if you want to have a hope of correctly spelling the names of all the species and genuses. I couldn't find one and so have doubtless made a billion mistakes in the above list.

The internet, plus the 47-year-old brain, is no match for the knowledge-sponge that is the pre-adolescent hobbyist, and I can only apologise.

There is no uncanny valley here. The beasts – large or small, parents or juveniles, flightless or soaring – created by Moving Picture Company, the special-effects experts behind the likes of *The Lion King*, *Spider-Man: No Way Home* and *Blade Runner 2049*, have made them look … real. I can say no more than that. You look at the screen and you see dinosaurs. You watch episode one and find yourself thinking: "Hang on. I've just seen dinosaurs. Near as dammit, they've just filmed a wildlife documentary in the Cretaceous period and I've watched it." They walk, run and hunt (in a pack, if you're a tenacious but tiny dromaeosaurid aiming for a massive hadrosaur instead of your customary insect intake), chirp (if you're a baby olorotitan just out of the egg your mother laid in volcanic sand to keep you warm), and sometimes simply mooch about, heedless of any extinction events one day coming their way.

It is a heady, if slightly disorientating, experience. For British viewers, the sense of discombobulation is increased by the fact that, despite being on an aggressively new and modern channel that feels like the antithesis of the BBC, it is presented by David Attenborough. Is this allowed, you wonder? Are there not bylaws about this? Can he, too, just roam the world at will? His presence is explained by the fact that the five-part series (covering forests, sea coasts, freshwater habitats and frozen landscapes) is produced by the BBC Studios Natural History Unit, but it still takes you a moment to adjust.

His presence assures us of the veracity of the programme's claim to have used the most up to date research available about all the dinosaurs before us. Species that have been proved to be feathered – the ancestors of modern birds – are feathered. Nest-building methods are detailed, and we're given innumerable other specifics about feeding behaviours, how young are reared, and winter-survival techniques that – presumably – have

been inferred from the fossil record and currently form the best of our knowledge.

The spectacle is wonderful, and the information valuable. But perhaps by the end there will be an appetite for something more about how that fossil record tells experts what it does. How do you look at a single skull – all that is left, as far as we are aware, of some species – and come to know anything about its owner and its ilk? Where does fact end and educated guessing begin? Does educated guessing ever blur into imagination? How do you know the colour of a dinosaur? I could take as many hours of explanation required from well-chosen workers in the myriad sub-fields of expertise to tell me all about this. The 10-year-old in me has awakened, and with it the atavistic childhood prime directive: trust, yet verify. How do you think we humans survived this long?

Reference:

https://www.theguardian.com/tv-and-radio/2022/may/23/apple-tv-prehistoric-planet-review-youll-genuinely-think-youre-watching-real-dinosaurs

Dinosaurs: The Final Day with David Attenborough (BBC) – a thrilling slice of time-travelling detective work

The awe-inspiring broadcaster vividly brings dinosaurs' last terrifying minutes to life in this slick, gripping and elegiac feature-length documentary

Chitra Ramaswamy, The Guardian
15 Apr 2022

The last day of the dinosaurs probably began as a morning like any other. On a sandbank bounded by a river and warm wet forests in what's now the dusty North Dakota prairies, triceratops and tyrannosaurs laid eggs, roamed, did their late Cretaceous thing. *Thescelosaurs* and turtles swam in the river. *Pterosaurs* flew overhead and furry mammalian creatures burrowed underground. On one of the most important days in Planet Earth's history, as only David Attenborough can so portentously pronounce it, life went on in abundance. Until an asteroid bigger than Mount Everest hit what is now Mexico's Yucatan peninsula with an explosion whose force was greater than that of a billion Hiroshima bombs. In less than two hours, the world as we never knew it was for ever changed.

Sense of drama … David Attenborough looking at fossilised triceratops skin. (Photograph: Jon Sayer/BBC Studios)

We don't know exactly when the asteroid hit. But within 40 minutes, the consequences 2,000 miles away at Tanis – the name given to the Dakotan sandbank by the palaeontologists who have been digging there for a decade – were profound. ***Dinosaurs: The Final Day with David Attenborough*** *(BBC One)* recreates those last terrifying minutes as wildfires, earthquakes, tsunamis and seismic waves ravaged the globe and all life at Tanis was swiftly entombed in sediment. For context, this was 60 Ma years before we pitched (or rather stood) up. And we're seeing in real time how that's panning out.

That's just the last half-hour of ***Dinosaurs: The Final Day***. And it's disturbingly prescient for something that happened 66 Ma years ago. I found myself sloshing back and forth, much like the Norwegian fjords mysteriously did in 2011 after an earthquake hit Japan, while watching this slick, gripping and elegiac feature-length documentary. Lurching from abject despair at our contemporary role in this history to profound awe at our ability to unearth its deep mysteries. The signature Attenborough cocktail of feelings, then. One of my scribbled notes simply reads: "We are the asteroid."

Dinosaurs: The Final Day deftly uses state-of-the-art FX and a virtual production studio,

which I no more understand than the Sauronesque eye of the Oxfordshire synchrotron, where lead palaeontologist Robert DePalma takes his astonishing finds to be scanned. The point is to transport us back to the late Cretaceous so we can see for ourselves how the dinosaurs' last days might have been. And how Attenborough would have looked (like a fish very much in water, naturally) having his chinos sniffed by our cute furry ancestors. Edge-of-your-seat stuff for some, but for me virtual FX in nature/science documentaries tend to induce the disappointment of fake flowers: never as stirring as the real thing.

A hint of Indiana Jones … palaeontologist Robert DePalma at Tanis in North Dakota. (Photograph: Ali Pares /BBC Studios)

More exciting is the dig at Hell Creek Formation. Here, DePalma and his team are excavating a mass dinosaur graveyard entombed in a layer of crumbly rock. Happily, DePalma has Indiana Jones levels of magnetism, and can unearth a good line with as much class as he wields his trowel (and fedora). "It's like trying to defuse a nuclear weapon while you're in a rainstorm," he drawls, brushing the mass death layer. While "performing surgery on a Cretaceous fish", he discovers tiny balls of molten rock in the fish's gill bars. They are ejector spherules propelled into the atmosphere by the asteroid, which "last saw the light of day when they were flying through the air 66 million years ago". In a knot of amber, he finds spherules containing a perfectly preserved particle "of the bullet that killed the dinosaurs". The asteroid itself.

Wow.

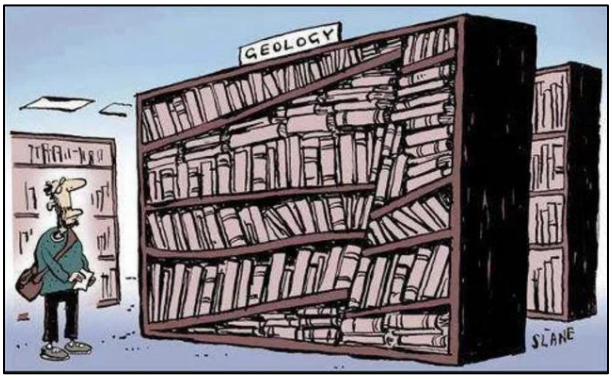
In another thrilling moment of this detective story set in deep time, the team uncover what has never before been found: the body of a dinosaur killed by the effects of the asteroid's impact. "I think we got ourselves a dinosaur!" DePalma cries as they dig a square of sediment that, to me, looks like any other square of sediment. Hours later, the fossilised leg of a *thescelosaurus*, skin and tissue included, emerges, looking "like a Thanksgiving turkey". The leg's location, entangled in the "log jam" of Tanis's mass death layer, which is where they found the meteorite-flecked amber and spherules, is proof enough. The dinosaur died as a result of the asteroid collision.

After that Earth-shattering day, sulphur ejected by the asteroid blocked all sunlight. The planet was plunged into semi-darkness for a decade. Temperatures dropped dramatically. On land, the plants died and in the seas the plankton vanished. Three quarters of all species were wiped out. "Then," says Attenborough, "came something wonderful." Plant life returned, and with it, some of the smallest and most resourceful creatures, including our little furry ancestors who had survived the nuclear winter in their burrows. And Attenborough hasn't given up, either. "We are unique in our ability to learn from the distant past," he concludes. "Now we must use that ability wisely … to protect the millions of species for whom, alongside us, this planet is home."

Reference:

https://www.theguardian.com/tv-and-radio/2022/apr/15/dinosaurs-the-final-day-with-david-attenborough-review-a-thrilling-slice-of-time-travelling-detective-work

Cartoon Corner



(Credit: Chris Slane)

NASA's James Webb Space Telescope Images

Photo 1: Carina Nebula *(Credit: NASA/ESA/CSA/STSCI)*

Photo 1: "Cosmic Cliffs" in the Carina Nebula

What looks much like craggy mountains on a moonlit evening is actually the edge of a nearby, young, star-forming region NGC 3324 in the Carina Nebula. Captured in infrared light by the Near-Infrared Camera (NIRCam) on NASA's **James Webb Space Telescope**, this image reveals previously obscured areas of star birth.

Called the **Cosmic Cliffs**, the region is actually the edge of a gigantic, gaseous cavity within NGC 3324, roughly 7,600 light-years away. The cavernous area has been carved from the nebula by the intense ultraviolet radiation and stellar winds from extremely massive, hot, young stars located in the centre of the bubble, above the area shown in this image. The high-energy radiation from these stars is sculpting the nebula's wall by slowly eroding it away.

Photo 2: Stephan's Quintet

An enormous mosaic of Stephan's Quintet is the largest image to date from NASA's **James Webb Space Telescope**, covering about one-fifth of the Moon's diameter. It contains over 150 million pixels and is constructed from almost 1,000 separate image files. The visual grouping of five galaxies was captured by Webb's Near-Infrared Camera (NIRCam) and Mid-Infrared Instrument (MIRI).

With its powerful, infrared vision and extremely high spatial resolution, Webb shows never-before-seen details in this galaxy group. Sparkling clusters of millions of young stars and starburst regions of fresh star birth grace the image. Sweeping tails of gas, dust and stars are being pulled from several of the galaxies due to gravitational interactions. Most dramatically, Webb's MIRI instrument captures huge shock waves as one of the galaxies, NGC 7318B, smashes through the cluster. These regions surrounding the central pair of galaxies are shown in the colours red and gold.

Together, the five galaxies of Stephan's Quintet are also known as the Hickson Compact Group 92 (HCG 92). Although called a "quintet," only four of the galaxies are truly close together and caught up in a cosmic dance. The fifth and leftmost galaxy, called NGC 7320, is well in the foreground compared with the other four.

Photo 3: Southern Ring Nebula

The side-by-side comparison shows observations of the Southern Ring Nebula in near-infrared light, at left, and mid-infrared light, at right, from NASA's **Webb Telescope**.

This scene was created by a white dwarf star – the remains of a star like our Sun after it shed its outer layers and stopped burning fuel though nuclear fusion. Those outer layers now form the ejected shells all along this view.

In the Near-Infrared Camera (NIRCam) image, the white dwarf appears to the lower left of the bright, central star, partially hidden by a diffraction spike. The same star appears – but

Photo 2: Stephan's Quintet *(Credit: NASA/ESA/CSA/STSCI)*

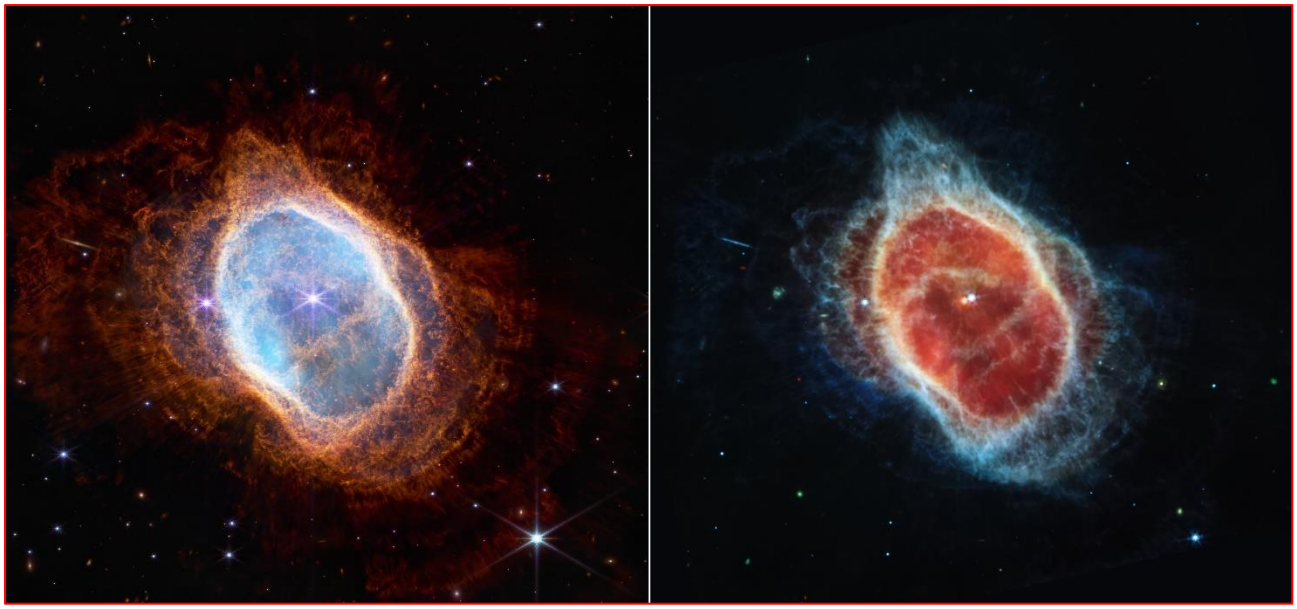


Photo 3: Southern Ring Nebula *(Credit: NASA/ESA/CSA/STSCI)*

brighter, larger, and redder – in the Mid-Infrared Instrument (MIRI) image. This white dwarf star is cloaked in thick layers of dust, which make it appear larger.

The brighter star in both images hasn't yet shed its layers. It closely orbits the dimmer white dwarf, helping to distribute what it's ejected.

Photo 4: Galaxy cluster SMACS 0723.

Thousands of galaxies flood this near-infrared image of galaxy cluster SMACS 0723. High-resolution imaging from NASA's **James Webb Space Telescope** combined with a natural effect known as gravitational lensing made this finely detailed image possible.

First, focus on the galaxies responsible for the lensing: the bright white elliptical galaxy at the centre of the image and smaller white galaxies throughout the image. Bound together by gravity in a galaxy cluster, they are bending the light from galaxies that appear in the vast distances behind them. The combined mass of the galaxies and dark matter act as a cosmic telescope, creating magnified, contorted, and sometimes mirrored images of individual galaxies.

Clear examples of mirroring are found in the prominent orange arcs to the left and right of the brightest cluster galaxy. These are lensed galaxies – each individual galaxy is shown twice in one arc. Webb's image has fully revealed their bright cores, which are filled with stars, along with orange star clusters along their edges.

Not all galaxies in this field are mirrored – some are stretched. Others appear scattered by interactions with other galaxies, leaving trails of stars behind them.

Webb has refined the level of detail we can observe throughout this field. Very diffuse galaxies appear like collections of loosely bound dandelion seeds aloft in a breeze. Individual "pods" of star formation practically bloom within some of the most distant galaxies – the clearest, most detailed views of star clusters in the early universe so far.

One galaxy speckled with star clusters appears near the bottom end of the bright central star's vertical diffraction spike – just to the right of a long orange arc. The long, thin ladybug-like galaxy is flecked with pockets of star formation. Draw a line between its "wings" to roughly match up its star clusters, mirrored top to bottom. Because this galaxy is so magnified and its individual star clusters are so crisp, researchers will be able to study it in exquisite

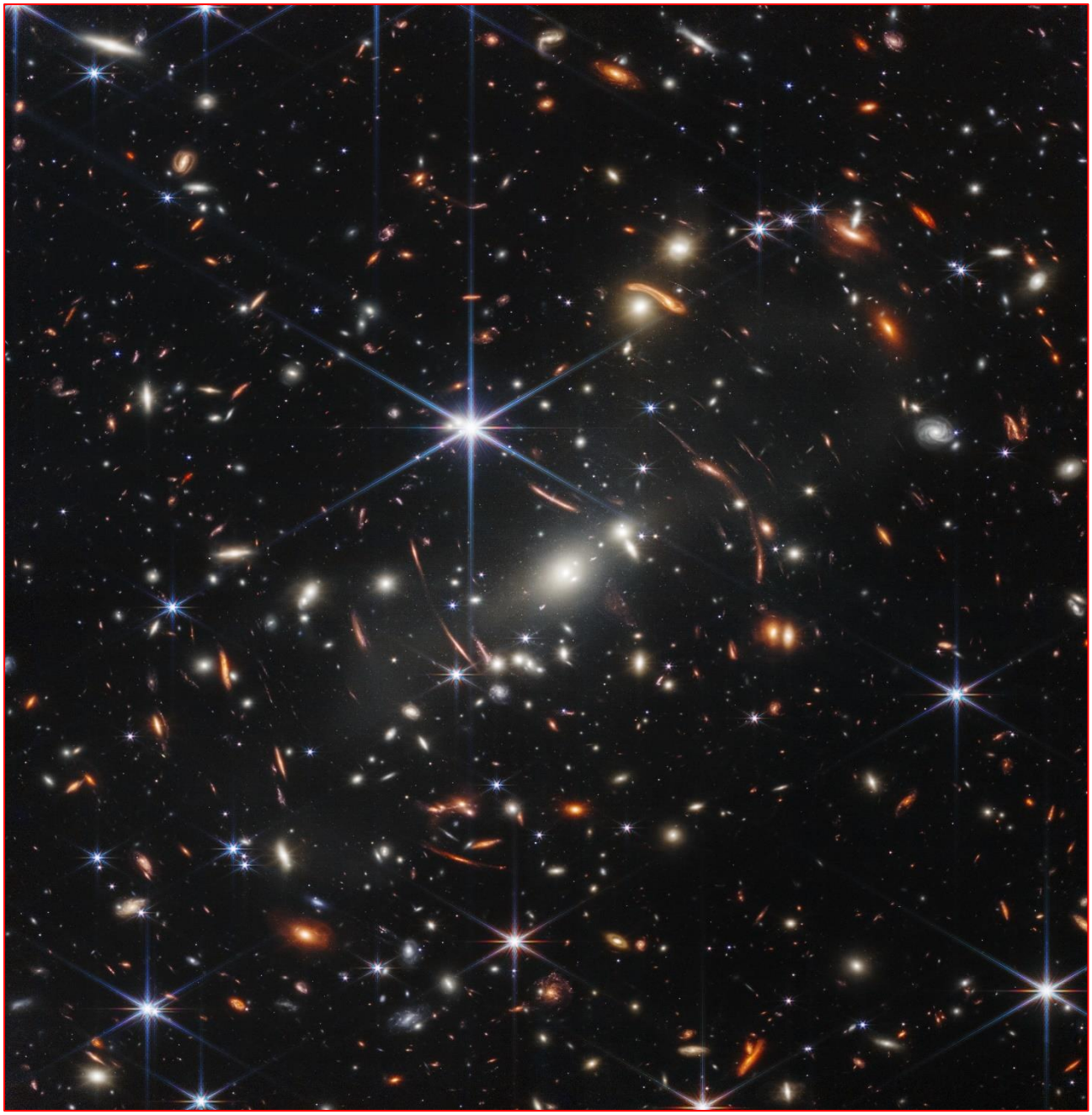


Photo 4: Galaxy cluster SMACS 0723. *(Credit: NASA/ESA/CSA/STSCI)*

detail, which wasn't previously possible for galaxies this distant.

The galaxies in this scene that are farthest away – the tiniest galaxies that are located well behind the cluster – look nothing like the spiral and elliptical galaxies observed in the local universe. They are much clumpier and more irregular. Webb's highly detailed image may help researchers measure the ages and masses of star clusters within these distant galaxies. This might lead to more accurate models of galaxies that existed at cosmic "spring," when galaxies were sprouting tiny "buds" of new growth, actively interacting and merging, and had yet to develop into larger spirals. Ultimately, Webb's upcoming observations will help astronomers better understand how galaxies form and grow in the early universe.

Reference:

https://webbtelescope.org/

Several FGS Committee members wish to retire at the end of 2022.

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