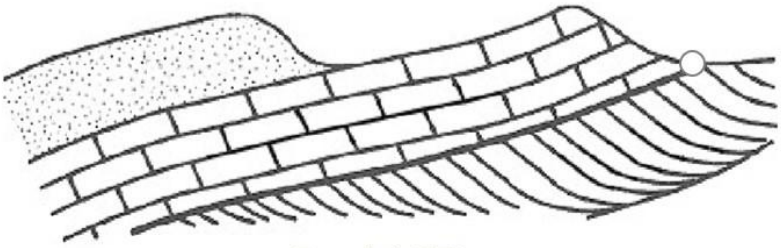
Newsletter of
The Farnham Geological Society

Volume 25, Number 1, February 2022

Cover illustration by Audrey Price, December 1984

Farnham Geological Society

Farnhamia farnhamensis



Founded 1970

A local group within the GA

Volume 25, No. 1 **Newsletter** February 2022
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Contents

Editorial

Welcome to the first edition of the FGS Newsletter for 2022. I hope you all had a lovely Christmas, and I would like to wish each and every one of you a very happy New Year and hope that this year will be a better and brighter year than 2021.

As you will have seen the FGS Committee is recommending that our first "face-to-face" meeting will be a social occasion on Friday, 11th March in the afternoon at the **Aldershot Cricket Club**, Guildford Road, Aldershot, GU12 4BP, followed by face-to-face lectures back at The Maltings starting on Friday, 1st April. Note the intention is to make the lectures at The Maltings both "live" and also available to view in real time via Zoom. This should allow those members who are unable or do not wish to travel to Farnham to continue to participate in the monthly meetings.

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

This month's Newsletter brings you some interesting articles, including reports from our monthly lectures for all those who didn't get a chance to view them live. And don't forget to zoom-in for Prof. Mike Benton's "New Visions of a Lost World" which looks set to be an excellent presentation.

We also have news from John Williams, our Field Trip Secretary who has arranged a joint **Field Trip** with the Reading Geological Society to **South Pembrokeshire**. This looks like an excellent 4-day trip to a beautiful part of the country. If you are interested in attending you will need to provide a deposit by 15th February *(see pages 43 and 44 for further details).*

John is also arranging a day trip to look behind the scenes at the **Natural History Museum** to be led by Leonie Biggendon in March. Please look out for further details via email.

RIP

It is with regret that we have reported the following members who sadly died in 2021. May they Rest In Peace: **John Stanley**, **Dr. John Gahan**, **Robert Gott**, **Mary Clarke** and **Paul Olver**. Our condolences go to all their family and friends.

Front Cover

This month's Front Cover delves back into the archives to December 1984 when Audrey Price provided the Newsletter cover.

Farnham Geological Society

Committee 2022

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

Meeting Programme 2022

Meetings in February & May will be conducted remotely via Zoom.

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

Please note The Maltings meeting time: 7.30 pm for 8.00 pm start.

New Visions of a Lost World
Prof. Mike Benton Fri, 11 February
Bristol University **ZOOM ONLY**

Social Afternoon, 2.00 to 5.00pm
Aldershot Cricket Club Fri, 11 March

Why are the Andes so High?
Dr. Laura Evenstar Fri, 1 April
Brighton University **MALTINGS**

Plant Fossils of the Crossley Coal Field
Dr. Lil Stevens Fri, 13 May
NHM **ZOOM ONLY**

Glaciations of the British Isles
Dr. Jim Rose Fri, 17 June
RHUL **MALTINGS**

The Burgess Shale
Janet Catchpole Fri, 8 July
FGS **MALTINGS**

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

Field Trip Programme 2022

Our Field Trip Secretary, John Williams, is putting together our programme for 2022.

The first of these trips will be a visit to the Natural History Museum led by Leonie Biggenden in March (*date tba*).

A joint Field Trip with the Reading Geological Society to **South Pembrokeshire**, led by Sid Howells, will take place from 16 May to 19 May. *See pages 43 & 44 for further details*.

Geologists' Association Lecture Programme 2022

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

Halstead Lecture
The power of outreach in the geosciences
Amy Edgington Fri, 4 March

The Pebbles of the Ice Age Coast
Mike Horne Fri, 1 April

AGM and Presidential Address; Defining catchments in karst environments.
Dr. Vanessa Banks Fri, 6 May

From Laurussia with love
Dr. Nick Riley Fri, 3 June

Old crust, new ideas': Constraining lunar crustal formation using trace-elements
Dr. John Purnet-Fisher Fri, 1 July

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

13 degrees of warming: Understanding the Eocene Earth
Dr. Tom Dunkley Jones Mon, 7 February
University of Birmingham

Presidential Address; Engineering geo-hazard challenges for construction upon the Hythe Formation in Kent
Dr. Clive Edmonds Mon, 7 March
President RGS

The Voyage of The Beagle
Prof. Peter Worsley Mon, 4 April
University of Reading

Mole Valley Geological Society Lecture Programme 2022

http://mvgs.org.uk

Bumps in the Bay: enigmatic, circular, seafloor structures off the Jurassic Coast
Prof. Dan Bosence Thu, 10 February
Royal Holloway, University of London

A History of Plants in 50 Fossils
Dr Paul Kenrick Thu, 10 March
Natural History Museum

Did the Earth Move for You? Measuring tiny ground movements from space.
Dr. Philippa Mason *Thu, 14 April*
Imperial College, London

Next Lecture

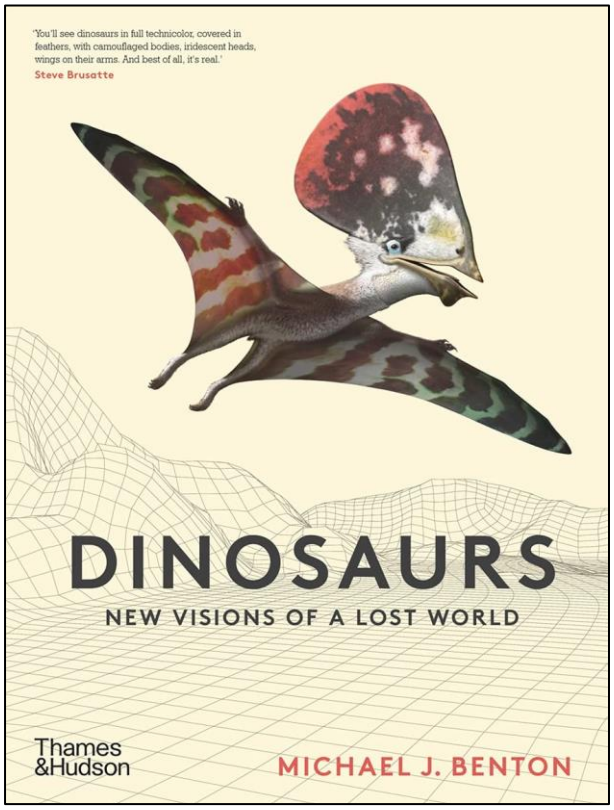
Friday, 11 February 2022

Zoom: 6.50 pm for 7.00 pm start

New Visions of a Lost World

Prof. Michael Benton
Professor of Vertebrate Palaeontology, School of Earth Sciences, University of Bristol

In this exciting event, join world-leading palaeontologist Professor Michael J. Benton as he discusses his book **Dinosaurs: New Visions of a Lost World**, a new visual guide showing how rapid advances in technology and amazing new fossil finds have changed the way we see dinosaurs forever.



© Thames & Hudson

Michael Benton was elected Fellow of the Royal Society in 2014 for his fundamental contributions to understanding the history of life, particularly biodiversity fluctuations through time.

He is fascinated by the transformation of palaeobiology from a speculative subject to testable science and led one of these discoveries – how to determine the colour of dinosaurs, rated as one of the top scientific discoveries of the 2010s.

He works with fossils and rocks to interpret ancient environments, especially around the end-Permian mass extinction, the greatest loss of life on Earth, some 250 Ma ago.

He also works with fossils to build evolutionary trees and use them to date major events and rates and patterns of evolution, so helping us understand why some groups of animals are more successful than others.

He is currently working on the Triassic, the time during which life recovered from the end-Permian mass extinction and when modern ecosystems arose; this was a time of "arms races" between major groups, and dinosaurs won.

Michael Benton has written some 400 scientific papers and more than 50 books on a broad range of palaeontological topics. He has supervised more than 70 PhD students, and was founder of the Bristol MSc in Palaeobiology, which has welcomed 400 students since its foundation, in 1996.

Lecture Summary

Friday, 12 November 2021

On Friday, 12 November 2021 51+ attendees from the FGS, together with Reading Geological Society members, welcomed Jon Copley to present our external lecture via Zoom.

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

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

Over fifty attendees enjoyed this fascinating presentation on deep-sea hydrothermal vent environments. The close links between the biology, geology, chemistry, evolution and palaeontology of these relatively newly discovered environments became apparent and is clearly fundamental to developing our understanding of them.

Dr Copley's presentation included:

- An up-to-date summary of the variety of life found in the different locations of these geological structures from the Arctic to the Tropics and the Antarctic, which is by no means uniform at all hydrothermal vents.
- Evolutionary history of life at the vents and the different patterns of life observed with reasons for these, at fast and slow spreading ridges.

Background Geology

Deep-sea hydrothermal vents are hot springs or geysers under the sea at sea floor-spreading and neo volcanic centres. Scientists only became aware of deep-sea hydrothermal vents in the 1970's and research only really began about 25 years ago. They include black smokers and other similar structures found above a heat source located around 2 km under the sea floor at conservative or divergent plate boundaries at Mid-Ocean ridges (Fig. 1) *(All images kindly supplied by Dr Jon Copley).*

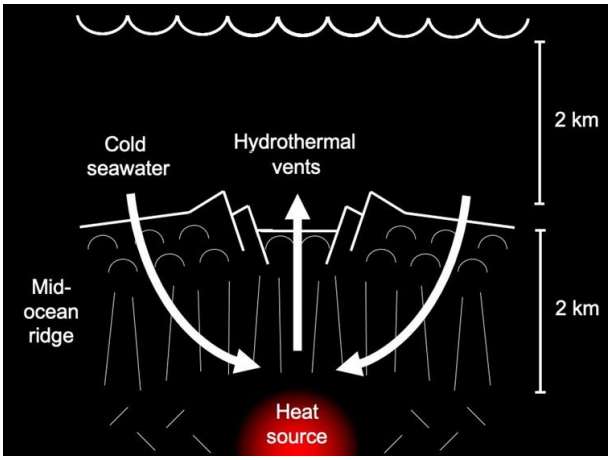


Figure 1: Diagram to show the formation of hydrothermal vents at Mid-Ocean Ridges.

Cold sea water enters the permeable gabbros and sinks down towards the heat source. Here pressures are high, and the temperature is about 1200°C. Under these conditions the upwelling, hot water mixes with cold water, some minerals come out of solution, precipitating, and depositing as a crust; others get leached out of the solution altering its chemistry. This altered, hot chemical solution rises, enriched in chemicals, is important for life. When this hot solution hits the cold sea water metallic sulphides and oxides precipitate out forming the 'black smoke', which is sparkly and more purple than black due to pyrites.

Evolutionary History of Life at Vents

More than 500 animal species have now been described at deep-sea hydrothermal vents. These habitats are rare and vulnerable occupying only about 50 km^2 worldwide. The idea that today's deep-sea hydrothermal vents represent fossil relics of ancient life has now shown to be incorrect.

Today's hydrothermal vents are very different from the ancient ones as conditions are very different; they are not a parallel system since the beginning of life on Earth. Life at hydrothermal vents today consists of organisms of Cenozoic age, i.e., 65 Ma or younger, so not a refuge for ancient taxa that have become extinct elsewhere.

There is a fossil record of life at hydrothermal vents going back to the Silurian, but this is rather fragmentary due to the Wilson Cycle of subduction, etc. Some ophiolites contain fossils of hydrothermal vent life which are different from life found at these sites today.

Due to the ephemeral nature of deep-sea hydrothermal vents the adult stages of life found here must have dispersible young stages which allow them to spread and colonise new vents as old ones block up and cease. Many of these vent life forms have mobile larval stages which can feed on marine snow or photosynthetic organisms until they can happen upon a new vent. This is where the distance between vents is crucial.

Anything which affects photosynthesis will affect the hydrothermal vent community even though the adults are chemotrophs. Other factors affecting ocean life are anoxic and dysoxic events, greenhouse conditions (i.e.,

10-15°C warmer) which reduces oxygen solubility and increases metabolic demand.

Rates of Sea Floor Spreading

Different rates of sea floor spreading occur in different locations and this affects the species diversity found at the different hydrothermal vents. At fast-spreading Ocean ridges such as the East Pacific Rise there is more volcanic activity so hydrothermal vents are more numerous along these ridges and are relatively close together, i.e., a few kms apart and the vents are more ephemeral as they soon become covered by newly erupted material. At slower-spreading rate sites, such as the Mid Atlantic Ridge, the hydrothermal vents are hundreds of kms apart and endure for thousands of years. This affects life at the vents because the animals must be able to move to new hydrothermal vents. If the sites are very far apart the larvae may drift and die before alighting on a new suitable vent.

East Pacific Rise – a fast-spreading ridge

Organisms found at this type of site include Alvinellid polychaete or 'Pompeii worms' such as *Alvinella pompejana* (Fig. 2). Much of the life survives in temperatures around 25°C.

Figure 2: "Pompeii worm" or Alvinella pompejana at the East Pacific Rise.

Around the base of chimneys, tube worms of about 78 cm in length are found (Fig. 3). These contain a bag of chemosynthetic bacteria which they digest, getting oxygen from the ocean water. Mussel beds colonise the periphery of the vents. So, there is a zonation of life just as there is on the seashore.

Mid-Atlantic Ridge – a slow-spreading ridge

Here there is a totally different community; no tube worms or Alvinellid polychaetes; instead, there are shrimps, anemones and mussels. Mussels are common to both slow and fast spreading ridges as they have feeding larval stages which can thus live longer giving them time to drift to another vent.

Figure 3: Siboglinid tubeworms found at the East Pacific Rise.

Ultra-slow spreading ridges, such as the Mid-Cayman Trough and SW Indian Ridge

These show more variation in geochemistry being ultramafic settings where the vent fluid is dominated by hydrogen. This in turn determines the microbe community and thus the animals which depend upon them. The ultra-slow spreading rate gives rise to a slower turnover of species.

"There are no specific examples to report; ultraslow ridges are still under-explored, so it is too soon to generalise about types of species found on them." Dr Jon Copley *(pers. Comm.)*

High Latitude vents e.g., Arctic Ocean Hydrothermal vents

At these sites there is a filter on life; what thrives in these deep oceans is life with non-feeding larvae i.e., yolked larvae or brooded larvae which are limited to about 38 days survival on their food stores. (*Thorsons's Rule* applies, i.e., there feeding larvae are not found in species at such high latitudes.)

So, if the vents are too far apart the larvae will die before reaching another suitable vent. At 2.4 km depth there are stalked barnacles, anemones, gastropods, Metilid amphipods, lecithotrophic polychaetes, Hoff Crabs along with about 30 species new to science.

Partnerships exist between microbes and animals that sustain them both. The animal and its associated microbes are known as a holobiont. (Humans and their associated microbes are examples of holobionts.) These relationships help to elucidate the pattern of life at hydrothermal vents at the biological and chemical levels. These vary over the world at different sites, and more is being discovered every day.

A functional zonation in vent holobionts has been observed (Fig. 4); closest to the vent fluid source are epsilon ε - proteobacteria dominated holobionts including Hoff crabs, and Alvinellid polychaetes or "Pompeii worms", such as *Alvinella pompejana.*

Further from the vent are γ - proteobacteria dominated holobionts.

On the periphery are other trophic modes e.g., suspension feeders and predators such as anemones.

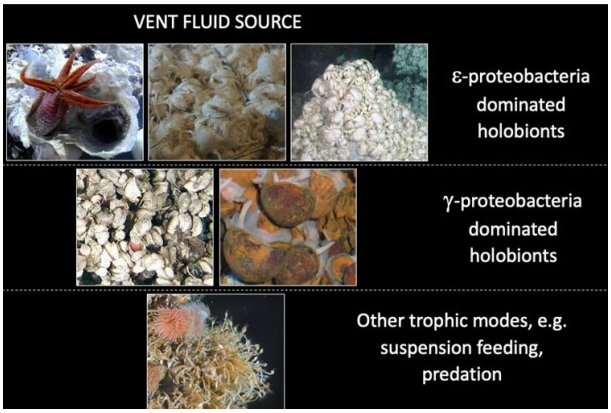


Figure 4: "Universal" functional zonation in vent holobionts?

An interesting question which was only touched upon is: how did/does life start at these deep-sea hydrothermal vents? One theory is 'Wooden Steps' (Fig. 5), i.e., life forms seeded from organic substrates such as driftwood or dead animals. These cells forming symbiotic associations with bacterial cells evolving into new life forms. However, a variety of mechanisms may be involved.

What a fascinating update on the scientific inter relationships at these varied and relatively rare, deep-sea hydrothermal vent sites. Thankfully they are, so far, of no economic interest to mining companies who are far more

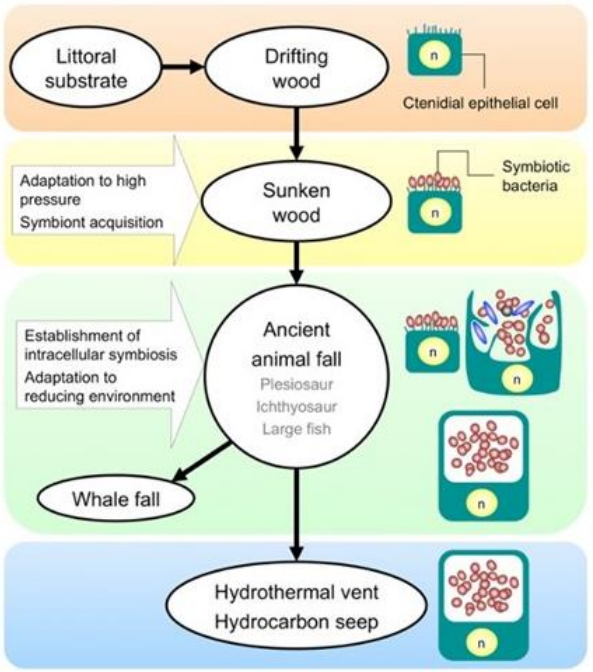


Figure 5: "Wooden steps" to deep-sea vents (Fujiwara et al., 2010)

interested in the more numerous and less biologically diverse manganese nodules.

Thank you to Dr Jon Copley for this most interesting presentation and for supplying all of the images.

This excellent summary of the Zoom presentation is provided by FGS Member Helen Phythian.

Reference:

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

Lecture Summary

Friday, 8 October 2021

On Friday, 8 October 2021 35+ attendees from the FGS, together with Reading Geological Society members, welcomed Robin Hansen to present our external lecture via Zoom.

Colours of the NHM Mineral and Gem Collection

By Robin Hansen
Curator, Minerals and Gemstones, The Natural History Museum, London

The collection of the Natural History Museum began in 1753 with the collection of Sir Hans Sloane. A physician with an interest in natural history, he amassed a collection of 71,000 items including many books which were bequeathed to the Nation. This collection formed the basis of the British Museum which today is split between the British Museum, the Natural History Museum, and the British Library. Specimens that we can trace back to Sloane include a magnificent 31.5 ct sapphire set into a button made of rock crystal, gold, rubies and emeralds, and an aquamarine crystal faceted in Moghul style. Today the Mineral and Gem collection holds around 185,000 specimens representing the breadth of the mineral kingdom.

BM.6000a Aquamarine crystal faceted in Moghul style, with a groove on the top for a gold wire to hold the crystal in place as an ornament, Sir Hans Sloane Collection. (© The Trustees of the Natural History Museum, London)

Minerals and gemstones have many important properties, and colour is one of the most distinctive. Minerals have been used for their colour as pigments for millennia, and colour is what determines their beauty and value. It is a property that is also used to identify minerals and gemstones; however, colour is very subjective, and can be altered such as through the treatment of gemstones. It is therefore important to understand the cause of colour in minerals and gemstones, for both identification and to detect treatments.

Visible light, the light that our eyes can detect, is a type of energy which can be thought of as a wave. When white light (which contains all the different colour wavelengths of light) falls on a mineral, the light energy interacts with the mineral, and some wavelengths are absorbed. The eye detects the remaining transmitted or reflected wavelengths of visible light, and 'sees' the colour of the object as the combination of these wavelengths.

There are many different causes of colour in minerals, for instance certain elements known as chromophores absorb specific wavelengths, and imperfections in the crystal structure (known as colour centres) can also absorb certain energies.

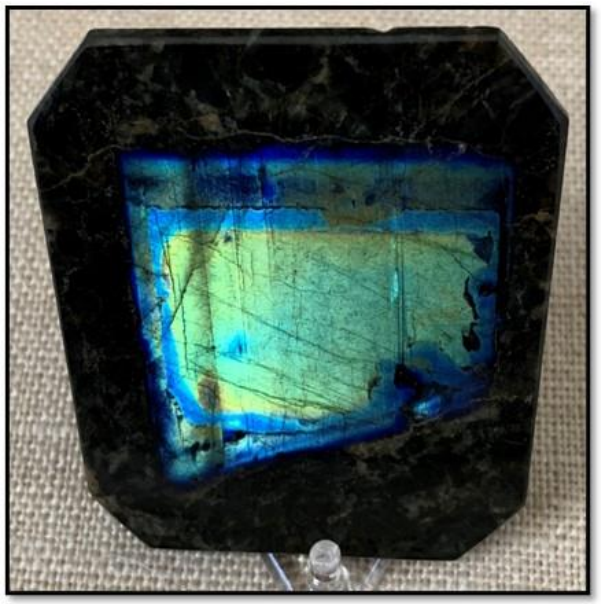
Minerals can be classed into three groups based on the cause of colour:

1. **Idiochromatic** (self-coloured) when the colour is caused by an essential element in the chemical composition. This colour is constant and predictable. Minerals such as Azurite, Malachite and Cuprite are idiochromatic as it is the essential copper in their composition which causes a blue, green or red colour respectively.

A beautiful, banded malachite Cu2(CO3)(OH)2 coloured green by the essential copper in its composition. (© The Trustees of the Natural History Museum, London)

2. **Allochromatic** (other coloured) is when an impurity is the cause of colour. This colour is not constant and is unpredictable. These minerals when pure are colourless, like quartz variety rock crystal, but impurities such as iron or aluminium, as well as defects in the crystal structure, cause the colours of yellow citrine, purple amethyst and smoky quartz.

Gemstones of Quartz varieties rock crystal (top left), citrine (bottom left), smoky quartz (top right) and amethyst (bottom right). The different colours are caused by impurities and defects in the crystal structure. (© The Trustees of the Natural History Museum, London)



Polished slice of Labradorite from Russia, showing iridescence known as labradorescence, caused by minute layering within the crystal from which light is reflected, refracted and diffracted. (© The Trustees of the Natural History Museum, London)

3. **Pseudochromatic** (false coloured) when the colour is due to a physical or optical property, and the colour often appears to move within the gem. This often involves the processes of refraction (the bending of light), and dispersion or diffraction (the spreading of light into the rainbow spectrum). This category includes the iridescence seen in labradorite and the rainbow flashes in opal's play of colour.

A cube of iolite, the violet gem variety of cordierite, cut as a cube orientated in the same direction as the crystallographic orientation of the crystal. (© The Trustees of the Natural History Museum, London)

When the cube is rotated and viewed from each direction the three different pleochroic colours are easily seen – blue, violet and straw yellow. This is caused by light interacting differently in each direction, with different wavelengths absorbed, therefore appearing a different colour (© The Trustees of the Natural History Museum, London)

The crystal structure of a mineral is classed into one of seven different systems of symmetry, from cubic (the most symmetrical) to triclinic (the least symmetrical). In cubic minerals, the symmetry is the same in each of the three directions of a cube. As light passes through the crystal in each of these directions, the interaction is the same, so it has no directional optical properties. In the other six

systems of symmetry, the symmetry is not the same in each direction, so these minerals possess directional optical properties. This means as light passes through the crystal structure in each direction, it does not interact the same, and different wavelengths may be absorbed. This means the crystal can appear with different colours from different directions. This optical phenomenon is known as **pleochroism** and occurs to varying degrees in transparent coloured minerals.

When light passes through a mineral in all systems of symmetry except cubic, the light is split into two 'rays' which vibrate perpendicular to each other. As they are travelling differently through the crystal structure, each ray will show a different pleochroic colour. We only see the object as one colour as the eye combines the two colours, but the colour of each ray can be seen using a dichroscope (two polarising filters side by side, set perpendicular to each other).

Aquamarine crystal from Vietnam. The dichroscope reveals the light blue and dark blue pleochroic colours of each 'ray', which combine to create the medium blue colour of this crystal. (© The Trustees of the Natural History Museum, London)

Rubies and **sapphires** are both varieties of the mineral corundum (Al_2O_3). Pure corundum is colourless, so it is allochromatic, and impurities of chromium (>1%) create the red of ruby, and blue sapphire is caused by iron and titanium impurities (0.01%). **Beryl** ($Be_3Al_2SiO_6$) includes the varieties of emerald and aquamarine. Chromium, the cause of ruby's red, is also the cause of emerald's green. The reason these two gems are different colours is because of the different geometries of the crystal structure with chromium in a different orientation. The chromium will interact differently with light, absorbing slightly different wavelengths to produce a different colour. Aquamarine is blue due to iron impurities.

Red cordierite from Madagascar. This gem shows the strong pleochroism of cordierite. Here one ray is red and the other greenish-brown. (© The Trustees of the Natural History Museum, London)

Chrysoberyl ($BeAl_2O_4$) is normally yellow to green caused by iron impurities. It has a special variety called alexandrite which displays a colour change phenomenon. This is different to pleochroism and occurs when viewing the gem in different lighting conditions.

BM.46311 Chrysoberyl variety Alexandrite. A 43.18 ct gemstone from Sri Lanka, acquired in 1873. On the left under daylight lighting, it appears green, and on the right under incandescent lighting it appears red. (© The Trustees of the Natural History Museum, London)

Like ruby and emerald, alexandrite contains impurities of chromium. The chromium absorbs light in the yellow part of the visible spectrum, and the wavelengths in both the red and green

are transmitted. When viewed in daylight (which is rich in blue and green wavelengths) the gem appears green. This is also helped by the fact that the eye is more sensitive to green light. When viewed in incandescent or candlelight (which is richer in red wavelengths and contains less greens and blues) more red and less green light is transmitted, and this is enough to tip the balance, and the brain interprets the colour as red.

Topaz is a gem that is commonly treated to improve or change the colour. Blue topaz is rare in nature, and most blue topaz gemstones have undergone irradiation followed by heat treatment to create a blue colour in a previously colourless gemstone. Imperial topaz is the pinkish-orange variety of topaz. It is coloured by a combination of chromium which imparts the pinkish colour, and a structural defect which creates the orange colour. By heating these golden crystals, it 'heals' the structural defect, removing the orange colour and leaving only a pure pink.

This imperial topaz crystal has been heated on the tip causing the colour to change to pink by removing the orange hues. (© The Trustees of the Natural History Museum, London)

Colour not only gives gems and minerals their beauty but is a fascinating subject to understand what causes the great variety that we see within the mineral kingdom.

Many thanks to Robin Hansen for this excellent summary.

Interesting Places & Topics 1

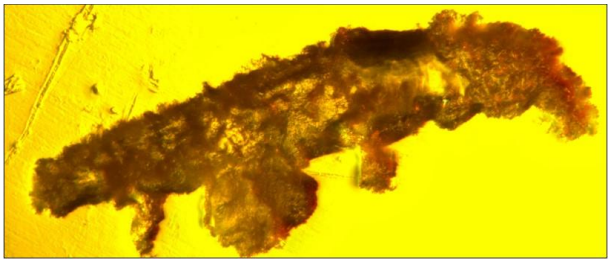
Northern Lights reflected in the water at Kirkjufell in Iceland
(Credit: Farero)

The Grave of Sir Henry Morton Stanley, the American journalist and explorer who found Dr David Livingstone and uttered one of the most famous "one liners" in history, is situated in the graveyard at **St Michael and All Angels church, Pirbright**. The large monolith is Dartmoor granite and bears the inscription 'BULA MATARI' (the breaker of rocks), which refers to his introduction of the sledgehammer to the Congo.
(© Copyright Len Williams)(Ref: https://www.geograph.org.uk/photo/3512738)

La Palma lava

Drone footage shows the scale of devastation following the eruption of the Cumbre Vieja volcano on the Spanish island of La Palma. Vast amounts of lava began oozing out of the volcano in mid-September 2021, burying everything in its path as it flowed all the way to the island's west coast. The lava eventually spilled over the cliffs and into the Atlantic Ocean, creating a 'low island' more than half a kilometre wide, according to Spain's National Research Council.

(Credit: Esri Inc and The Cabildo de La Palma)



Water-bear fossil

This tiny tardigrade has been preserved in a chunk of Dominican amber for 16 Ma. Researchers were studying the fragment for months before spotting the half-millimetre-long creature in a corner. The discovery is "truly a once-in-a-generation event", said Phil Barden, an entomologist at the New Jersey Institute of Technology in Newark. It is only the third fossilized tardigrade to be found, and the first from the Cenozoic. Tardigrades, also called water bears or moss piglets, are known for their ability to survive extreme heat, radiation and even the vacuum of outer space. The fossil specimen — a genus and species new to science — has been formally named *Paradoryphoribius chronocaribbeus.*

(Credit: Ninon Robin, Harvard/NJIT)

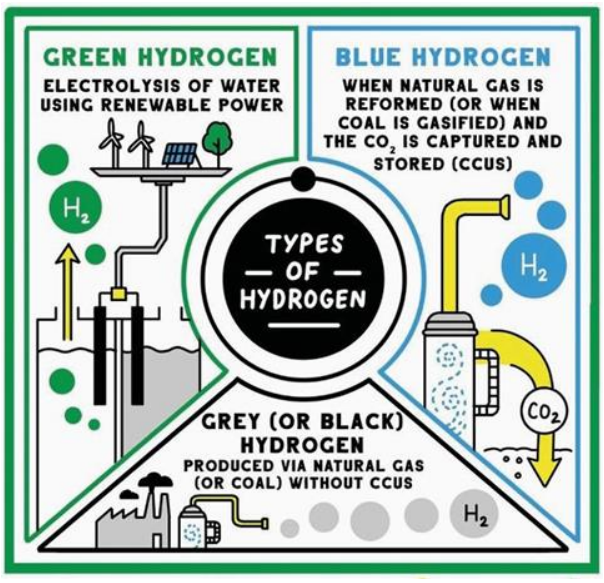
(Ref: https://www.nature.com/immersive/d41586-021-02880-1/index.html?utm_source=Nature+Briefing&utm_campaign=d16d818218-briefing-dy-20211104&utm_medium=email&utm_term=0_c9dfd39373-d16d818218-46721658)

Florida as seen from The Space Station

7 November 2021

Thomas Pesquet, Astronaut ISS: "A unique aspect of space travel is that you can see your destination before you leave! We flew over Florida recently and probably in a few days we will splashdown there. I don't want to liken us to the Apollo astronauts, but it must have been a strange feeling to look up at the Moon in 1969 and think that you would be there in a few days' time!"

(Credit: ESA)



Types of Hydrogen

The different sources of black, grey, blue and green hydrogen. *(Graphic source: BP)*

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 - 1

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

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

Part 1

1. **Sardinia** (Hercynian Basement) & **Corsica** (Hercynian Basement with Alpine Nappes)
2. **Beguia, Sesua Val Granede** & **Adamello-Brenta** (NW / Alpine domain)
    a. The Piemonte Area: The Alps-Apennines Junction – Po Valley

Part 2 *(see May 2022 Newsletter)*

3. **Tuscany** & the **N Central Apennines**
4. **Central Apennines**: The Majella National Geopark
    a. The Apulia Adria Problem

Part 3 *(see August 2022 Newsletter)*

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**

1. **SARDINIA …** *"8,000 yrs. of Mining"*

Parco Geominerario della Sardegna Geopark entails the entire island of Sardinia. Located in the centre of the W Med, Sardinia is located only 12 km from Corsica, 120 km from Tuscany, and 185 km from the coast of N Africa. It has no high mountain ranges but predominately mesas between 300 - 1,000 m high. Among the mountain ranges stands out the Gennargentu in the centre of the Island, with its peak Punta La Marmora (1,834 m).

The Geopark preserves a geological history dating back >500 Ma and shows a variety of geological events between Palaeozoic and Quaternary. This territory comprises sequences of sedimentary, metamorphic and magmatic rocks and an amazing variety of types of ore deposits which have been exploited over thousands of years.

The lithostratigraphic sequences are among the most complete ones of the European and Circum-Mediterranean area and document a geological history older than 500 Ma. The stratigraphic successions of Sardinia show geological events from when Sardinia joined the S edge of the European plate (Hercynian Orogeny). Since then, it has separated from it (in Oligocene-Miocene) as a result of the opening of the W Med (rifting phase and subsequent counterclockwise rotation of the Sardinian-Corsican microplate).

The geological history of Sardinia is part of the geological history of W Europe and is totally different from that of the Italian peninsula. Sardinia (Fig. 1) has a basement which was formed during the Hercynian Orogeny. The 'basement' comprises a Precambrian to Lower Carboniferous metamorphic complex of schists to gneisses with intrusive complexes of Upper Carboniferous to Lower Permian age. The metamorphism developed under intermediate to low pressure conditions and the post-metamorphic plutonism appears to be more compatible with intracontinental orogenic processes than with an active continental margin. There is locally a cover of Mesozoic rocks.

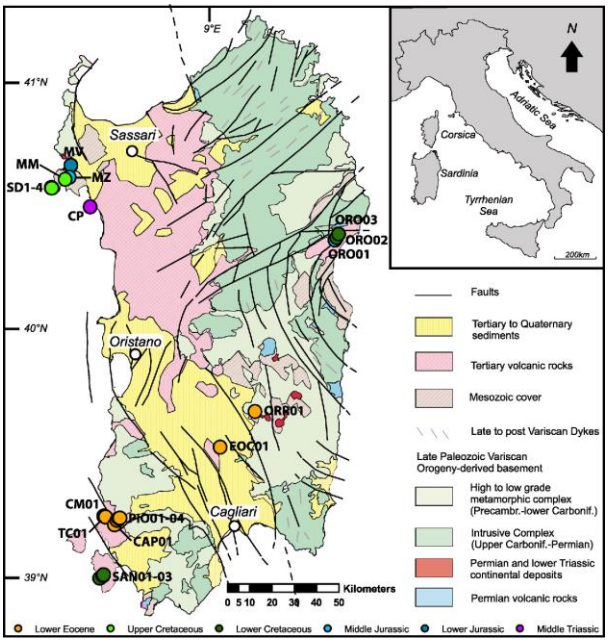


Figure 1: Simplified geological map of Sardinia showing the main lithologies, structures and sampling sites, based on Cherchi et al. (2010), including modifications from Kirscher et al. (2011). Sampling locations are coloured according to age. (Ref. 1)

Rifting occurred during the Oligocene to Miocene periods of extension and the graben are now filled with marine sediments and volcanic rocks – initially calc-alkaline and later (Plio-Pleistocene) basalts (Fig. 1). Two Cenozoic magmatic cycles occurred in Sardinia separated by a gap of 5 Ma: Oligo-Miocene subduction-related magmatism associated with Sardinia's migration from the European continental margin to its current location, and Plio-Pleistocene intraplate magmatism associated with the opening of the S Tyrrhenian basin.

Uplift and cessation of deposition occurred in the Miocene when the island was rotated in an anticlockwise fashion to (approximately) its current position.

The Precambrian to Palaeozoic orogenies, together with rifting and volcanic episodes have provided the accumulation of ore deposits of different types and origins. They have been known for millennia and from an abundance of archaeological mining evidence the geopark has reconstructed its mining history. This industrial archaeology includes mine works and settlements, traditions, customs, human events related to the mining activity.

The territory of the Geopark is divided into 8 areas based on mining characteristics and history, telling the story of almost 8,000 years of mining. Each Area is original with different geological deposits, mineralogical characteristics, mining activity and techniques. Mining has created the landscape and the villages, extraction pits, kilometres of galleries, industrial systems, an old railway station, important records and the memories of generations of miners make this Park a large cultural centre.

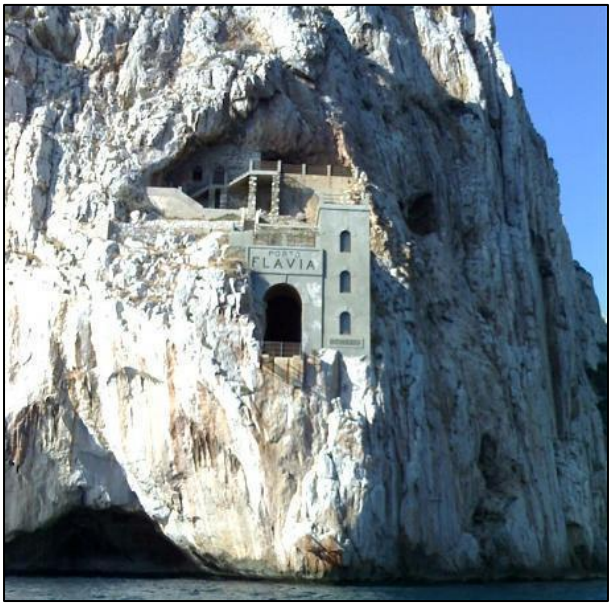


Figure 2: Porto Flavio loading terminal. (Credit: http://wikimapia.org/2056393/it/Porto-Flavia#/photo/716205)

Figure 3: Henry Gallery (Credit: https://discoversouthwestsardinia.com/en/cultural-heritage/buggerru-en/galleria-henry/)

Examples of mining engineering include Porto Flavia (Fig. 2), Henry Gallery (Fig. 3) and

numerous tunnels of the Italian Centre of Coal Culture and Saint Barbara's Cave.

A network of trails allows one to go on foot, by bike or on horseback. It has a spectacular coast and inland relief, with underground hollows and archaeological areas.

1. **CORSICA …** *"Two Mountain Ranges in the Sea"*

A line that runs roughly from Lîle Rousse on the N coast, through Corte in the interior, to Favone on the SE coast, divides Corsica into two distinct geologic terranes.

Most of the rock to W of the line is granite, the roots of the Hercynian orogeny, 345-225 Ma ago. This is the same 'basement' as found in Sardinia and were both part of Pangaea.

Everything E of the line is "Alpine Corsica" - mountains thrust and folded during the Alpine orogeny, 250-60 Ma ago. These rocks are mainly schist to gneiss, but also gabbro, limestone, and other marine sedimentary rocks.

Figure 4: Typical rounded weathered granite slopes, Western Mts, Hercynian basement, Corsica.

These two periods of mountain-building generated the rugged terrain of Corsica. The tallest peak, Monte Cinto, rises to 2,706 m, one of 20 mountains >2,000 m and mainly on W side of the island. During the Jurassic, a large marine basin extended from W to E from the Atlantic Ocean (Newfoundland) to the Vocontian trough (Nice) and was bordered by the Corsica-Sardinia block.

Figure 5: Frost attacked peaks of granite, Hercynian basement, western side of Corsica.

Figure 6: Rhyolite flows – part of the Permian volcanic suite. Part of the Hercynian basement, Corsica.

Figure 7: Permian Volcanics – ash band and coarse tuffs and volcaniclastics. Part of the Permo-Trias sequences of the Sardinia-Corsica Hercynian.

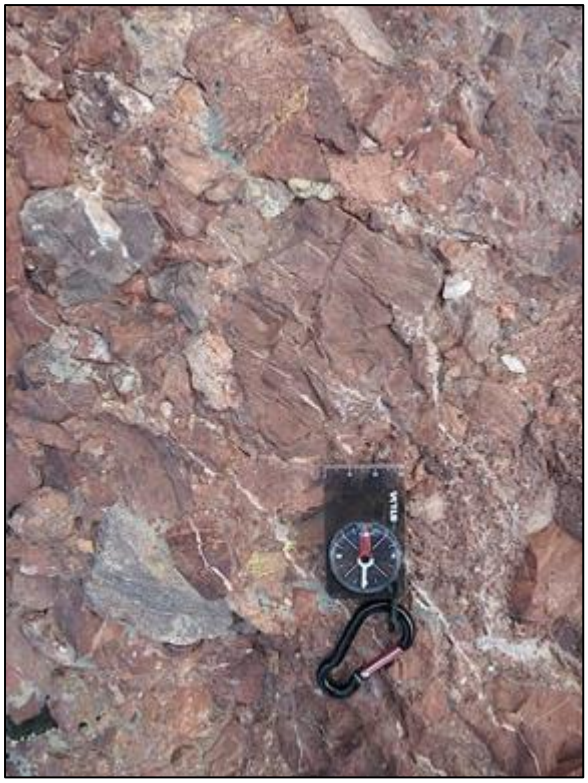


Figure 8: Permo-Trias pebbles form conglomerates, part of a continental series of red beds.

Figure 9: Mylonite zone – associated with a major fault plane, often transcurrent; the original rocks have been sheared so intensely they are unrecognisable.

During the Cretaceous, the Iberian plate moved SE along reactivated Caledonian faults (N Pyrenean F Zone, NPFZ) and brought up peridotites from upper mantle depths of 50–70 km. Initially, Iberia's drift was "free", with a large 'tongue' of the Ocean extending from the Atlantic to the Central Pyrenees where a huge carbonate flysch (~7 km thick) was deposited from both the N (European) and S (Iberian) margins of this basin. Sardinia and Corsica lay to the NE of this basin.

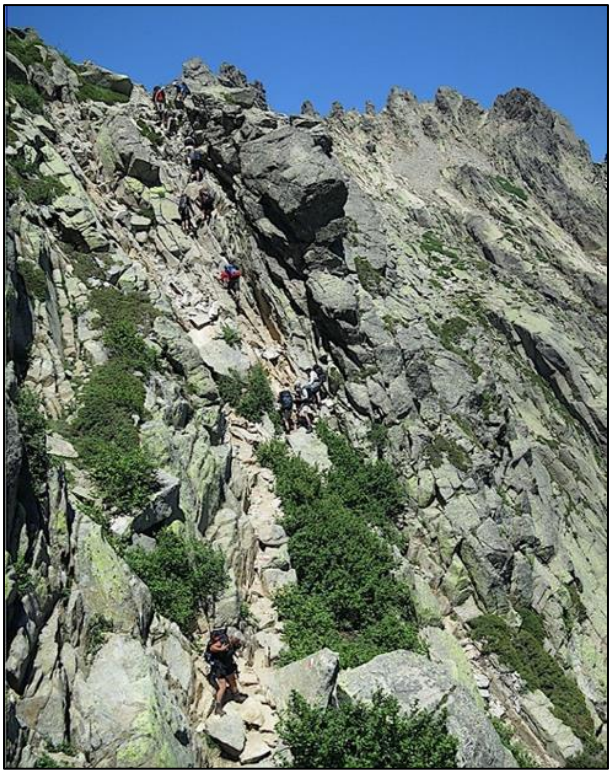


Figure 10: Vertically dipping sediments of an Alpine Nappe on Corsica. Note the scale, wall of rock >30 m – there are 4 sets of climbers from base to top!!

The African plate moved N compressing the small N Algerian and Betic blocks. To E, the Ligurian Ocean (N of Corsica today) and the Alboran plate (E of Gibraltar today) slid SW along transform faults. The Alboran plate comprises oceanic material with the continental fragments of the Rif (N of Morocco), N Algeria and the basement of Minorca (Balearic Is, Spain).

In the Upper Cretaceous, the African plate subducted below the N part of the Corsica-Sardinia block and the Ligurian Ocean, initiating the Alpine orogeny.

A deep NW–SE Fault separates Sardinia from the Balearic Islands and the Betic margin, bordered by Alboran Plate oceanic crust. Compression continued from Upper Cretaceous to Eocene in the N (along the Pyrenees) and in the S (in Algeria). The Rif-Betic margin moved NW from Morocco along transform faults onto the Iberian Peninsula.

In the N, the Pyrenees were compressed, slabs of continental basement were reactivated along Iberia's N border and the NPF was

affected by large vertical movements, Iberia was rising 4000 m.

During the Miocene, the W Med was spreading with anticlockwise rotation of the Corsica-Sardinia block and Pyrenean deformation continued N to Digne, W Alps.

The NPFZ may continue E, along the Gulf of Lion shelf and N of Corsica; it may also merge with Minorcan Fault.

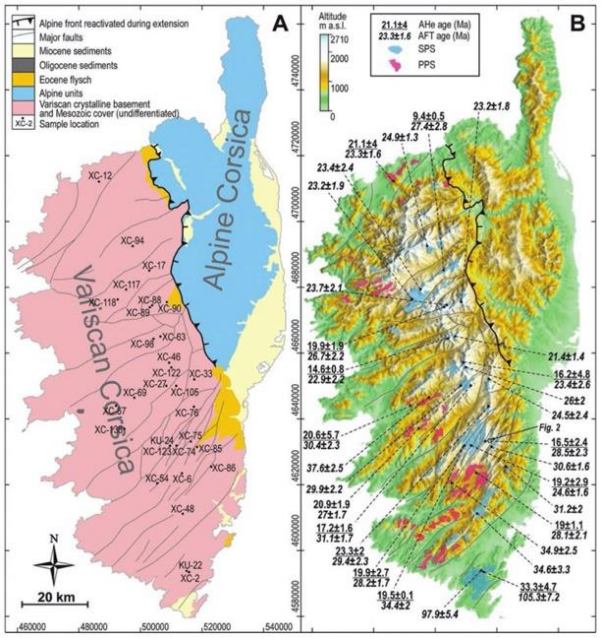


Figure 11: Geology (A) and geomorphology (B) maps of Corsica.

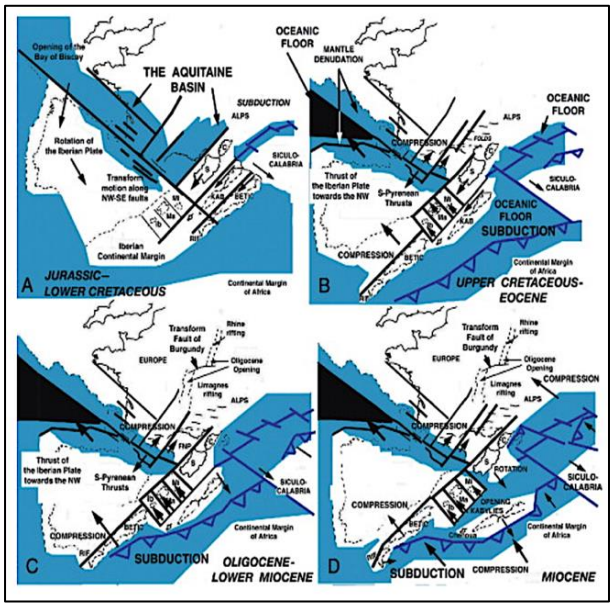


Figure 12: Evolution of the Pyrenees and the W Mediterranean -

(A) Jurassic – Lwr Cretaceous: Iberia moving SE, Siculo-Calabria (Boot of Italy) begins to separate from the massifs of Corsica-Sardinia and Kabylies (N Algeria).

(B) Upr Cretaceous - Eocene: Africa blocks drift off Iberia causing collision between Iberia and S Europe. Large normal faults inverted and developed into High Thrusts toward S Pyrenean basin. The Siculo-Calabrian block is moving SE.

(C) Oligocene–Lwr Miocene: the Bay of Biscay retreats W, and the Kabylies area moves SE, colliding with Africa. Siculo-Calabria collides with Africa.

(D) Rotation of the Corsica-Sardinia block occurs; the space between Kabylies and Balearic archipelago opens. Siculo-Calabria is crushed. (Ref. 2 & 3)

SW Sardinia comprises Palaeozoic and Variscan nappes, but Variscan nappes are absent in the closest continental land, the Minorcan Palaeozoic. This was clearly a very complicated area of micro-continents which were caught up in the final closure of the Variscan Orogen, which in turn forms part of the Hercynian mega-suture along which Laurussia and Gondwana were welded together.

This closure involved the step-wise accretion of a number of Gondwana-derived and other terranes onto the S margin of Laurussia and ultimately the collision of Africa with Europe.

2. **BEIGUA GEOPARK** *'Discovering Earth Heritage, enjoying nature and local traditions'*

The **Beigua Geopark** is located in Liguria, NW Italy, near France covering an area of about 400 km^2. It includes the Beigua Regional Nature Park. The Beigua massif dominates the coast with summits widely over 1000 m with Beigua mountain reaching 1287 m.

The Geopark helps understand the evolution of the Alpine and Apennine chains. The area includes an ophiolite (part of the Jurassic Ocean, 200-145 Ma old) with garnet bearing rocks. Such outcrops are relatively rare in the Alps. In the E area, near Sassello and Stella

Santa Giustina, Oligocene outcrops include a tropical fauna & flora with leaves, shells (mainly gastropods and bivalves) and corals. There are periglacial forms, raised beaches along the coast and impressive canyons in the Oligocene conglomerates of Val Gargassa, Rossiglione. The vegetation is unique with ~1,130 plant species. Trails have panels etc. linking the geology, biology and culture. There are also cave engravings and ancient human monuments.

2. **SESIA VAL GRANDE GEOPARK** *'Where rocks turn into culture'.*

The **Sesia Val Grande Geopark** is located on NE Piemonte Region, NW Italy. It includes the Val Grande National Park: Alta Valsesia & Monte Fenera, and the Reserves of S. Monte of Varallo, Sanctuary of Ghiffa and Domodossola - all are UNESCO World Heritage sites.

The Sesia-Val Grande Geopark is the highest and steepest one in Europe. Within 60 km the land ranges from 4,554 m at Gnifetti Peak to 190 m at Lake Maggiore.

The area comprises continental crust with rocks from the deep, middle and upper crust exposed by the Alpine orogeny. Along the Alps is the plate boundary between the Adriatic plate and the European plate - the Insubric line. Continental collision continues today - the central Alps are rising causing vertical slip along the fault. In places the Central Alps have risen by 'x' km with a drift of >50 km.

In this area, the Super volcano of the Sesia erupted approximately 280 Ma ago forming a huge caldera, the remains of this and its magmatic plumbing system are clearly visible today.

2. **ADAMELLO-BRENTA GEOPARK**
'Different geological worlds'

The **Adamello-Brenta Geopark** is located in the Rhaetian Alps, the Italian sector of S-central Alps, in W Trentino between Giudicarie, Non and Sole valleys. It has two big mountainous massifs (Adamello and Brenta) of very different geology and geomorphology.

Here the tectonic boundaries between the Austrian and S Alps and the crossover of 3 structural segments of the Periadriatic Lineament (major fault includes Insubric Line) occur. The geology spans a long, complex history - Lower Palaeozoic (~500-400 Ma); the main features are:

a. Pre-alpine orogeny - a long phase of lithosphere extension forming the Adriatic passive margin.

b. Alpine orogeny, started in Cretaceous (~140-65 Ma ago) and is still going on (neo-tectonic, seismicity).

c. Pleistocene glaciation - that has intensely reshaped the area.

d. Karstic phenomena, in Dolomites, both at the surface and at depth (sink holes, caves, etc.).

Figure 13: The Adamello Massif (Credit: Denis Faustinelli, https://commons.wikimedia.org/)

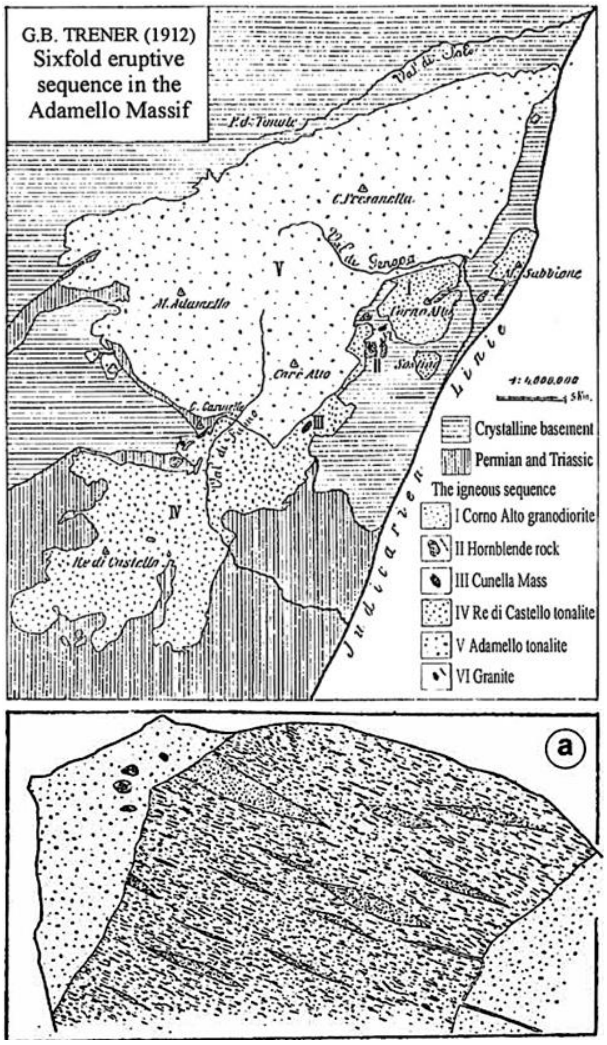
The Ademello Massif

Adamello at 3,539 m is the second highest peak of the Adamello-Presanella Alps. "*The central mass of Adamello ... is a huge block, … for … many miles the ground never falls below 3,990 m … a vast central snow-field ... Carè Alto and Adamello, are merely slight elevations of the rim of this uplifted plain. … (but) from without they are … noble mountains falling in great precipices towards the wild glacier-*

closed glens ..." This mountain is a huge pluton comprising many different acidic to intermediate igneous bodies similar to granodiorites/diorites.

The Adamello massif is the largest of numerous Tertiary intrusions in the Alps along the Insubric Line. The massif cuts through Permo-Triassic country rocks (the dolomites) which in turn lie unconformably on phyllites of the pre-Alpine basement.

The massif includes 6 main intrusions (Fig. 14): firstly granite-granodiorite on the E border, then mafic intermediate diorites 'hornblende rocks'; last came acidic 'veins' of fine-grained aplite and coarse-grained pegmatite.



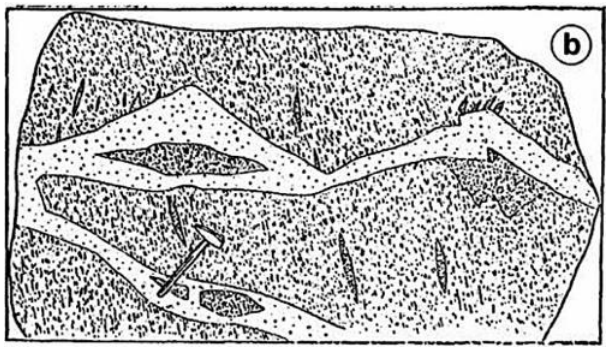


Figure 14:
Top - Cross-cutting relationships of younger massive Adamello tonalite (V) and older foliated Mt Re di Castello tonalite (IV).
a) Foliation seen by parallel orientation of disc shaped inclusions.
b) Veins of massive Adamello cross-cut foliated Mt Re di Castello tonalite.

The Brenta Dolomites

The reason they describe this geopark as different geological worlds is because the area comprises: a) a classic granite massif (Adamello) and b) a classic 'Dolomite' mountain (Brenta) looking like a castle with towers, spires and sheer walls.

The Brenta massif is a heavily eroded sequence of dolomites, which were deposited as limestones on shallow platforms subdivided by troughs with dark limestones and marls (also now dolomites) from an almost anoxic environment or grey nodular cherty limestones.

These limestones accumulated along shallow shores of the Triassic Oceans surrounding Pangaea. Subsidence and deposition rates were high (>100 m / Ma), both on the carbonate platform and in the anoxic troughs. The main lithofacies were carbonate mudstones and wackestones (*see "Classification of Limestones" August 2022 Newsletter*), together with packstones and carbonate breccias; almost 75% of the total thickness comprises slumps, submarine debris flows pouring down into the troughs from the shallow platform highs.

The Brenta Dolomites (Fig. 15) cover an area ~40 x 12 km, from the Val di Sole to the Valle di Non, Lake Molveno and the Paganella

mountain chain. They are divided into 3 subgroups:

- N Brenta Dolomites, wild habitat with bears.
- Central Brenta Dolomites, with peaks, accessible from Molveno & Madonna di Campiglio.
- S Brenta Dolomites with impressive landscapes.

Figure 15: The Brenta Dolomites

The Brenta Dolomites include 8 peaks >3,000 m high, with several other peaks >2,800 m high.

Dolomitization is widespread - it is a diagenetic process whereby the $CaCO_3$ accepts Mg in place of some Ca to form $CaMg(CO_3)^2$.

The Piemonte Area - The Alps-Apennines Junction and the Po Valley

The junction of the Alps and Apennine Mountain chains is complicated. The two areas have little in common, they locally share bits and pieces of Alpine ophiolite sequences, but that is all.

The Apennine accretionary prism developed during the N subduction (since Oligocene) of the Alpine Tethys sea-floor under Spain.

The N margin of this Alpine Tethys area was cut by the Pyrenean rift system, which allowed a direct connection between the Pyrenees-Biscay Sea and Alpine Tethys Sea.

In the Piemonte region of NW Italy (the Alps–Apennines interference zone) there are several important domains which have influenced the structural geology:

- The palaeo-European continental margin (Iberia).
- The distal part of the palaeo-European continental margin (France).
- The Liguria–Piemonte oceanic domain and Valais domain (N of Corsica).
- The palaeo-Adriatic continental margin (Adriatic).
- The synorogenic Cenozoic basins (Po Valley, etc.).
- The Alpine synorogenic magmatic bodies (Adamello Massif, etc.).

The Po Valley

This is a major geographical feature of N Italy. It runs ~650 km W-E, from the W Alps to the Adriatic Sea and from the Alps in N to the Apennines in S; a total area of 46,000 km^2. The altitude increases from ~4 m below sea level at the Adriatic delta to ~2,100 m in S Piedmontese. The Apennines and Alps are both sources of its tributaries.

Figure 16: The Po Valley in N Italy. (Credit: Google Map)

It is an in-filled system of ancient rifts, part of the 'European' foreland basin of N Italy or it may be a syncline, continuous with the deeps of the Adriatic Sea. Fig. 16 shows the continuity of depression from Ligurian Sea Floor to Adriatic Sea Floor.

Since the Late Miocene (7-5 Ma) the system has been filling with sediment mainly from the older Apennines but also from the Alps. The shoreline of the Adriatic depends on a balance between the sedimentation rate and isostatic changes.

A gas condensate field (Malossa) was discovered in 1973 and produces at 6,000 m from Upper Triassic and Lower Jurassic dolomites, the reservoir is capped by Lower Cretaceous marls.

Until about 1950 the Po delta built out into the Adriatic, then, human factors and sedimentation rates caused the delta to degrade, the coastline to subside and Venice to submerge.

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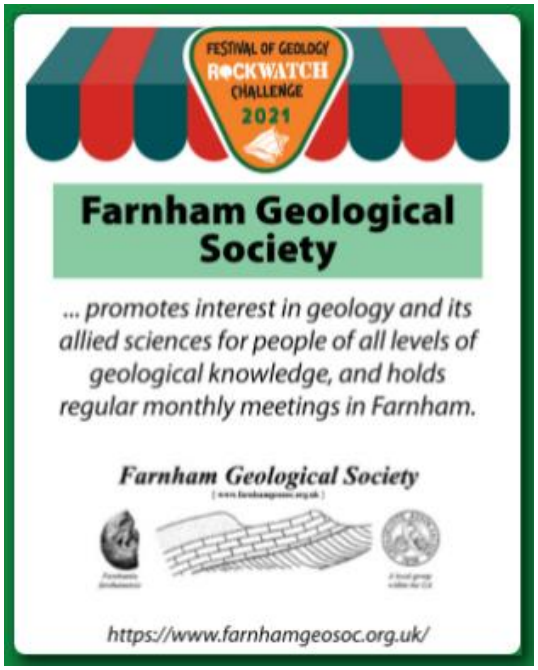


164 Ma old plant fossil is the oldest example of a flowering bud

By Harry Baker, Live Science
19 January 2022

The discovery changes what we know about the evolution of flowering plants, researchers say

Researchers have uncovered the earliest example of a flower bud in a 164 Ma old plant fossil in China. The discovery firmly pushes back the emergence of flowering plants into the Jurassic period, between 145 and 201 Ma ago.

The fossilised Florigerminis jurassica plant with a defined stem, bulbous fruit and fossilised flower bud (marked by the white arrow). (Image credit: NIGPAS)

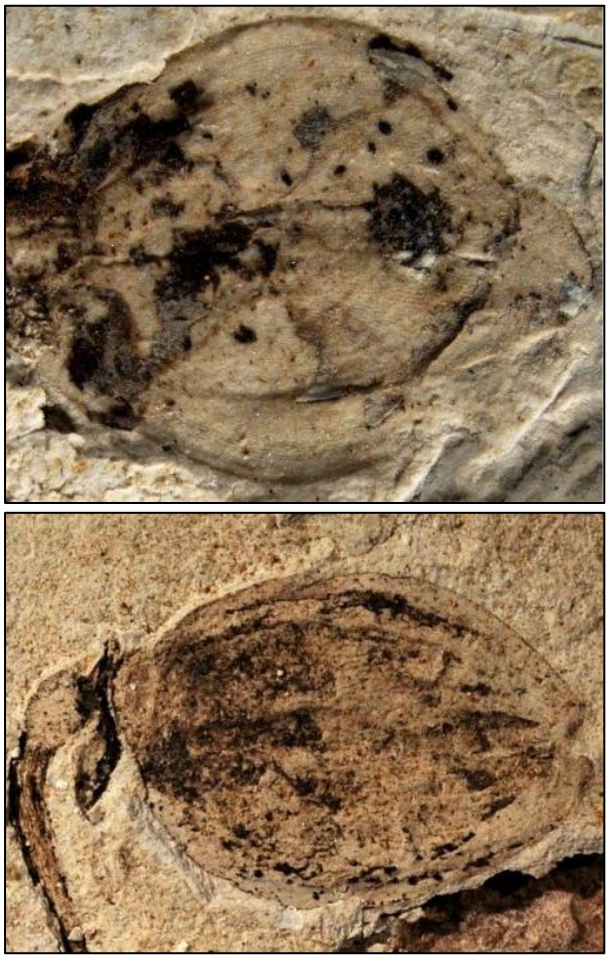
The fossil, which was uncovered in the Inner Mongolia region of China, is 4.2 cm long and 2.0 cm wide. It contains a stem, a leafy branch, a bulbous fruit and a tiny flower bud around 3 square millimetres in size. The researchers have named the new species *Florigerminis jurassica.*

There are two main types of plants: flowering plants, known as **angiosperms**, and non-flowering plants, known as **gymnosperms**. The flower bud and fruit in the fossil are both clear indicators that *F. jurassica* was an angiosperm and not a gymnosperm, which was the dominant plant type during the Jurassic period. Until now, fossil evidence has shown that angiosperms did not arise until the Cretaceous period, between 66 and 145 Ma ago, but the new fossil is the most convincing evidence yet that this was not the case.

"Many palaeobotanists are surprised (by the fossil), as it is quite different from what is stated in books," senior author Xin Wang, a researcher at Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS), told *Live Science* in an email. "But I am not so surprised," he added.

The new fossil is not the oldest example of a fossilized flower to ever be discovered. In 2018, in a study published in *eLife*, researchers described 174 Ma old flowers from a plant in the genus *Nanjinganthus*, also found in China, *Live Science* previously reported.

However, some researchers have questioned whether *Nanjinganthus* can truly be considered an angiosperm because the flowers were not



Close-up images of the fossilized flower bud (top) & fruit (bottom). (Image credit: NIGPAS)

complex enough to distinguish them from leafy structures seen in gymnosperms, *ScienceAlert* reported. Flowers are also extremely delicate and hard to fossilise, which can make it hard to tell them apart from other plant material, Wang said.

But the flower bud and fruit in the new fossil prove without a doubt that *F. jurassica* was definitely an angiosperm, he said. The fossil, therefore, "underscores the presence of angiosperms in the Jurassic and demands a rethinking of angiosperm evolution," the researchers wrote in a statement.

Wang believes that several other known plant genera from the Jurassic period, including *Nanjinganthus, Juraherba, Yuhania, Jurafructus, Xingxueanthus* & *Schmeissneria,* could also potentially be angiosperms, but he says there is no way to tell for sure without fossil evidence. Until now, scientists had just assumed those genera were gymnosperms because they arose in the Jurassic.

However, if angiosperms were present during the Jurassic, they would have been very uncommon compared to gymnosperms and geographically isolated, which makes finding similarly well-preserved examples of other flower buds very unlikely, he said.

Alternatively, it is also possible that *F. jurassica* may be one of the very first evolutionary links between older angiosperm-like plants, such as *Nanjinganthus,* and more recent true angiosperms found in the Cretaceous period, Wang said.

The study was published online January 6 in the journal of the ***Geological Society of London.***

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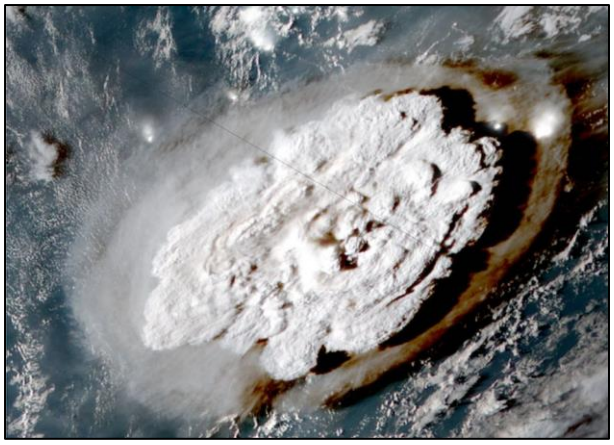
Ga	**(giga-annum)**	**billion years**
Ma	**(mega-annum)**	**million years**
ka	**(kilo-annum)**	**thousand years**

Tsunami warning in Tonga after giant eruption

BBC
15 January 2022



Tonga's underwater volcano Hunga Tonga-Hunga Ha'apai violently erupted, triggering a widespread tsunami threat. (Image source: NOAA)

A tsunami warning has been issued in several countries, including Tonga and New Zealand, after a giant underwater volcano eruption.

Social media footage from Tonga showed waves washing through a church and several homes. Witnesses said ash is falling over the capital, Nuku'alofa.

Residents of the Pacific island have been urged to move to higher ground.

It is the latest in a series of eruptions of the Hunga Tonga-Hunga Ha'apai volcano.

The US has also issued a tsunami advisory for American Samoa, citing a threat of "sea level fluctuations and strong ocean currents that could be a hazard along beaches".

The eight-minute eruption was so violent it could be heard as "loud thunder sounds" in Fiji, more than 800 km away, officials in the capital Suva said.

The plumes of gas, smoke and ash pouring from the volcano reached 20 km into the sky, said Tonga Geological Services.

In New Zealand, which is more than 2,300 km away, officials have warned of storm surges from the eruption.

The National Emergency Management Agency said parts of the country could see "strong and unusual currents and unpredictable surges at the shore".

Local forecaster *Weather Watch* tweeted: "The energy release is simply astonishing", adding: "Reports of people hearing the sonic booms across New Zealand."

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6. "The Tonga Pumice Raft" by Dr. Isobel Yeo: Lecture Summary FGS Newsletter, May 2021

Tonga eruption seen from space.

Eruption at Hunga Ha'apai - Hunga Ha'apai, witnessed by TGS observer team, a 5 km wide plume rises over 18 km above sea level, Jan. 14, 2022 at 5:14pm. (Photo: Taaniela Kula/TGS)

Huge 'sea dragon' named one of UK's greatest fossil finds

Ichthyosaur about 10 metres long and dating back 180 Ma discovered at Rutland Water

Hannah Devlin,
The Guardian Science correspondent
10 January 2022

A gigantic prehistoric "sea dragon" discovered in the Midlands has been described as one of the greatest finds in the history of British palaeontology.

The ichthyosaur, which is between 182.0 to 181.5 Ma old (Lower Jurassic) with a skeleton measuring about 10 m in length and a skull weighing about a tonne, is the largest and most complete fossil of its kind ever found in the UK.

The ichthyosaur skeleton is the largest and most complete fossil of its kind ever found in the UK. (Photograph: Anglian Water/PA)

Joe Davis of the Leicestershire and Rutland Wildlife Trust discovered it during the routine draining of a lagoon island at the Rutland Water reservoir in February 2021.

The first ichthyosaurs, which are called *sea dragons* because they tend to have very large teeth and eyes, were discovered by the fossil hunter and palaeontologist **Mary Anning** in the early 19th century *(see also pages 26 & 27).*

Dean Lomax, a palaeontologist who has studied the species, said: "Despite the many ichthyosaur fossils found in Britain, it is remarkable to think that the Rutland ichthyosaur is the largest skeleton ever found in the UK. It is a truly unprecedented discovery and one of the greatest finds in British palaeontological history."

Ichthyosaurs, which were marine reptiles, first appeared about 250 Ma ago and went extinct 90 Ma ago (Lower Triassic to Upper Cretaceous). They varied in size from 1 m to more than 25 m in length and resembled dolphins in their general body shape.

The remains were dug out by a team of experts from around the UK in August and September.

Two incomplete and much smaller ichthyosaurs were found during the construction of Rutland Water in the 1970s, but the latest discovery is the first complete skeleton.

Mark Evans of the British Antarctic Survey, who has been studying the Jurassic fossil reptiles of Rutland and Leicestershire for more than 20 years, said that even from the first

The fossil was discovered during the routine draining of a lagoon island at Rutland Water in February 2021.
(Photograph: Anglian Water/PA)

An artist's impression of an ichthyosaur. (Photograph: Bob Nicholls/Anglian Water/PA)

glimpse of the partially exposed fossil it was clear that it was the largest ichthyosaur discovered in the region.

"However, it was only after our exploratory dig that we realised that it was practically complete to the tip of the tail," he said. "It's a highly significant discovery both nationally and internationally but also of huge importance to the people of Rutland and the surrounding area."

Nigel Larkin, a specialist palaeontological conservator, said: "It's not often you are responsible for safely lifting a very important but very fragile fossil weighing that much. It is a responsibility, but I love a challenge. It was a very complex operation to uncover, record, and collect this important specimen safely."

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Research shines new light on role of karst in Chalk aquifer

24 December 2021
By Nia Kajastie

A British Geological Survey (BGS) led study has revealed new insights into the role of karst in the Chalk Group aquifer, which provides

public water supplies to millions of people, agriculture and industry.

The study has compiled evidence showing that karst and rapid groundwater flow are much more widespread in the Chalk than previously thought.

The BGS believes the research will be of particular interest for regulators and water companies, both globally and in the UK, when planning future approaches to groundwater source protection and catchment management. Existing research shows that globally, around 20 to 25% of people rely on karst groundwater for supply.

"Karst" is a geomorphological term that is applied to a type of landscape where erosion caused by dissolution, in other words the dissolving of bedrock, has resulted in fissures, sinkholes, sinking streams, ridges, caves, springs and other characteristic features. It is typically associated with soluble rock types such as limestone, marble and gypsum.

The Chalk is an unusual karst aquifer with limited cave development, but extensive networks of smaller solutional conduits and fissures that enable rapid groundwater flow.

BGS Senior Hydrogeologist and lead author of the study Louise Maurice explained: "This research is the culmination of many years of work and is a step forward in our understanding of the Chalk aquifer. Our research presents evidence of the extent of karst in the Chalk throughout England, including almost 100 tracer connections demonstrating rapid groundwater flow.

"We found high densities of stream sinks, and karstic conduits, springs, dolines and dissolution pipes are common.

"We demonstrate that rapid groundwater flow and karst occur much more frequently than previously thought, which provides an important step forwards in our conceptual understanding of the Chalk and of global karst aquifers more generally.

"Our work examines the implications of karst in the Chalk for groundwater protection and demonstrates how the evidence for karst should be central to future strategies for groundwater protection and management."

The BGS explained that an improved understanding of Chalk karst will expand understanding of similar karst aquifers with limited cave development that are globally widespread and provide vital public water resources to millions of people.

Such insights into the unique nature of Chalk karst may also help to advance understanding of classical karst aquifers, where major caves are often the main focus of research and fissures or smaller conduits are less understood.

The full study titled **"Karst hydrogeology of the Chalk and implications for groundwater protection"** was published in the ***Geological Society of London Special Publication SP517, The Chalk Aquifers of Europe.*** The work is funded by the Natural Environment Research Council knowledge exchange fellowship scheme.

Other work in the Geological Society of London special publication also highlights the importance of karst in the Chalk, including a further BGS led study – "The genesis and evolution of karstic conduit systems in the Chalk".

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Mary Anning: Lyme Regis statue of fossil-hunting pioneer approved

BBC
1 January 2022

A charity's plan for a statue of fossil hunter Mary Anning, which will stand close to the cliffs where she made her discoveries, has been approved.

Mary Anning and a model of her statue. The statue will stand on a spot overlooking Black Ven, where Anning made many of her discoveries. (Image Source: SPL/MAR)

Dorset Council passed Mary Anning Rocks' plan for the Lyme Regis statue.

Born in 1799, Anning made numerous groundbreaking discoveries on the Dorset coast, which are still displayed in museums around the world.

The campaign for the statue began in 2018, led by schoolgirl Evie Swire, and raised about £100,000.

She set about fundraising with her mother after realising the resort had no statue marking Anning's achievements.

The Local Democracy Reporting Service said the charity hopes to unveil the statue on **21 May**, which would be the 223rd anniversary of the fossil hunter's birth.

The planning application stated that despite coming from a poor background and having no formal training, Anning's finds changed the way scientists thought about how life evolved.

"Her achievements have largely gone unacknowledged with her name having been eradicated from the historic archives due to her being an uneducated, working-class woman and an outsider to the polite and scientific community," it said.

The proposed life-size bronze statue by Denise Dutton will be placed in a spot overlooking Black Ven, where she unearthed many of her finds.

Anning, whose life inspired the Kate Winslet and Saoirse Ronan-led film ***Ammonite*** and Tracy Chevalier's novel ***Remarkable***

Evie Swire started the campaign for a statue of Mary Anning in Lyme Regis.
(Image Source: Mary Anning Rocks)

Creatures, was never fully credited for her discoveries due to her gender and social status.

She was born to a poor, working-class family, but made a name for herself unearthing never-before-seen specimens from the cliffs near her home, including a 5.2 m ichthyosaur when she was 12 years old.

Twelve years later, she found the first complete fossil of a plesiosaur, a marine reptile that seemed so bizarre to the scientists of the day that they initially thought it was a fake.

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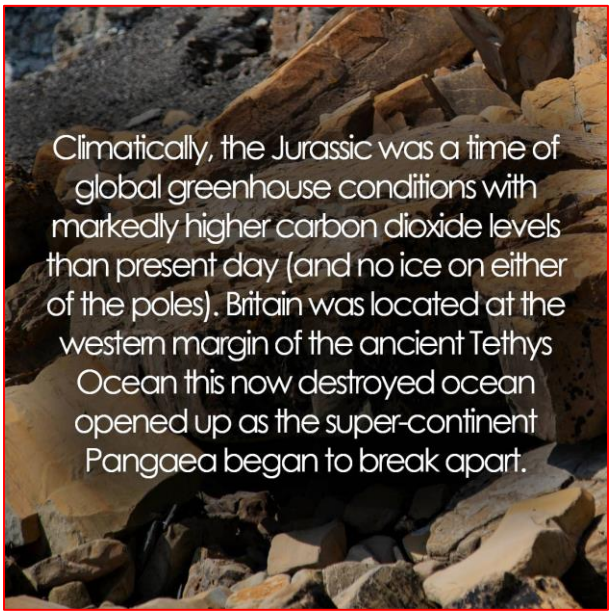

(Credit: The Etches Collection)

Largest-ever millipede fossil found on Northumberland beach

By Jonah Fisher,
BBC Online Environment Correspondent
21 December 2021

The fossil was found on a Northumberland beach. (Image Source: Neil Davies)

Scientists say they have discovered the largest-ever fossil of a giant millipede on a beach in Northumberland, totally by chance.

The millipede, known as *Arthropleura*, is thought to have been more than 2.5 m long. It would have weighed about 50 kg.

The fossil segment was first spotted in 2018 when a large block of sandstone fell on to a beach at Howick Bay.

It will be displayed in Cambridge's Sedgwick Museum next year.

"It was a complete fluke of a discovery," said Dr. Neil Davies, from Cambridge's Department of Earth Sciences, who has been analysing the 75 cm-long fossil.

"The way the boulder had fallen, it had cracked open and perfectly exposed the fossil, which one of our former PhD students happened to spot when walking by," Dr. Davies said.

When the giant millipede lived, 326 Ma ago, the north-east of England had a much more tropical climate than today.

This specimen was found in what researchers believe was an old river channel. It may well not actually be the fossil of a dead creature, but an exoskeleton that was shed as the massive millipede grew.

Millipede. (Image Source: Neil Davies)

"Finding these giant millipede fossils is rare, because once they died, their bodies tend to disarticulate, so it's likely that the fossil is a moulted carapace that the animal shed as it grew," said Dr. Davies. "We have not yet found a fossilised head, so it's difficult to know everything about them."

One thing that can be said with certainty is, that in common with almost all millipedes, it did not have 1,000 legs - the researchers believe it had at least 32, but it may have been up to 64.

This fossil is just the third *Arthropleura* to be discovered and is far older and larger than the two previous specimens which were both found in Germany.

The researchers believe that to get to such a large size, *Arthropleura* must have had a high-nutrient diet. That could have meant it supplementing a diet of nuts and seeds with small creatures and amphibians.

The fossil is due to go on public display in Cambridge in the new year.

A paper analysing the discovery has been published in the *Journal of the Geological Society.*

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A Deadly Day on Mount Semeru

Adam Voiland, NASA Earth Observatory
7 December 2021

Mount Semeru, the tallest and most active volcano on the Indonesian island of Java, has routinely thrown up small, mostly harmless plumes of ash and gas for years. The circumstances changed on December 4, 2021.

Following a partial collapse of the summit lava dome early in December, sensors began to detect elevated seismic activity, according to the Volcanological Survey of Indonesia (PVMBG). After more of Semeru's lava dome gave way, billowing fronts of superheated ash, tephra, soil, and other debris raced down several channels on the mountain's southeastern flank.

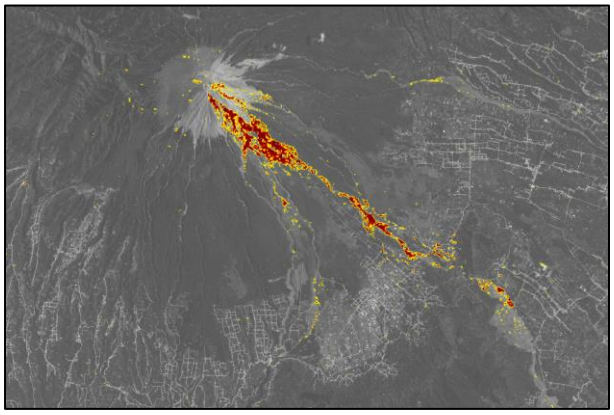

Figure 1: Flows of superheated ash and tephra mixed with rain to create destructive rivers of debris on the volcano. (Credit: NASA)

Pyroclastic flows are among the most dangerous hazards posed by volcanoes. Sometimes accelerating to speeds of hundreds of kilometres per hour, these masses of volcanic material and landscape debris can be impossible to outrun. They destroy most living things in their path. Though explosive eruptions at the summit were likely small, the pyroclastic flows at Mount Semeru on December 4 were still hot enough that they likely helped propel a billowing **"Phoenix cloud"** that rose as high as 15 km into the air.

Since heavy rains preceded and accompanied the eruption, the pyroclastic flows mixed with large amounts of rainwater and morphed into muddy lahars that rushed down the mountain into populated areas. **Lahars** are mixtures of water and volcanic debris that behave like rivers of concrete, flattening or burying much of what they encounter.

The damage proxy map (Fig. 1) shows areas on the surface that were likely damaged by pyroclastic flows and lahars in December 2021. Dark red pixels represent the most severe damage, while orange and yellow areas are moderately or partially damaged. Each coloured pixel represents an area of 30 m by 30 m (about the size of a croquet field). Researchers from **The Earth Observatory of Singapore - Remote Sensing Lab** (EOS-RS) made the maps by comparing a post-eruption image from December 7, 2021, with a set of pre-eruption images from August 9, 2021, through November 21, 2021.

The slurry of debris that swept down Semeru proved catastrophic to villagers living around the mountain's base in the Lumajang Regency, particularly Curah Kobokan. According to The Jakarta Post, at least 39 people have died. Large numbers of homes were destroyed or damaged, and many animals are among the eruption's victims.

The maps were derived from synthetic aperture radar (SAR) images acquired by the Copernicus Sentinel-1 satellites, operated by the European Space Agency (ESA). The researchers used the Advanced Rapid Imaging and Analysis (ARIA) system originally developed at NASA's Jet Propulsion Laboratory, California Institute of Technology, and modified at EOS-RS. The ARIA team is supported by NASA's Earth Science Disasters Program.

NASA Earth Observatory image by Lauren Dauphin, using modified Copernicus Sentinel data (2021) processed by ESA and analysed by Earth Observatory of Singapore (EOS) in collaboration with NASA-JPL and Caltech, Landsat data from the U.S. Geological Survey., and data from OpenStreetMap.

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UK forked out more than £18bn on oil and gas imports in first six months of 2021, according to trading figures

By Hamish Penman
20 November 2021

The UK shelled out more than £18 billion on oil and gas imports in the first few months of the year, according to the government's latest trading figures.

The vast bulk came from Norway, with Russia, Qatar and the US also supplying significant volumes of hydrocarbons.

Oil and Gas UK (OGUK) said the figures demonstrate the UK's already high reliance on other countries for energy, with half of its gas coming from overseas. And the trade body warned that, unless new domestic oil and gas projects are approved, consumers could be "even more exposed" to global energy shortages.

According to Westminster's trade figures, in the first six months of the year the UK paid Norway £5.2bn for gas, plus £6.1bn for crude oil.

Russia received £524 million for gas and £3.2bn for oil, while £675m went to Qatar for liquefied natural gas (LNG) and £2.8bn to the US for crude oil.

Domestic supply

Gas prices soared again recently with delays to the Nord Stream 2 pipeline from Russia to Europe fuelling concerns of a shortage.

In October UK natural gas futures topped the 300 pence a therm threshold for the first time ever.

Domestic energy supply has been in the headlines for much of this year, with debate about the planned Cambo field west of Shetland raging on.

Siccar Point Energy and Shell, which have 70% and 30% stake in the project respectively, believe it could produce 170m barrels of oil over many years.

Many are wanting Cambo to be blocked though, believing it to be out of step with efforts to tackle climate change. First Minister Nicola Sturgeon recently added her name to the list of those wanting it scrapped.

Industry figures have defended the plans, underlining the importance of domestic supply and North Sea companies' efforts to cut operational emissions, meaning production from Cambo would likely incur fewer emissions than other projects globally.

UK oil and gas production to 'plummet' without new fields

OGUK claims that if the project doesn't go ahead, UK production "would plummet", with gas output dropping up to 75% by 2030. At present, oil and gas provides 73% of the UK's total energy, rising to 78% in Scotland.

Deirdre Michie, chief executive of OGUK, said: "The UK's offshore oil and gas industry is committed to helping the UK government meet its ambitious net zero goals. We accept all the science around climate change and the need to cut emissions, but this transition must be managed.

"If we cut our own supplies of gas and oil faster than we can reduce demand then we will have to import more of what we need. Our import bills will go up without any reduction in emissions. That means we need to develop new oil and gas reserves simply to maintain domestic production

"These new projects will help protect consumers, supply the UK with lower carbon energy, reduce our need for imports and support the 200,000 people working in the industry as it transitions to a greener low-carbon future."

The argument that Cambo will be integral in maintaining domestic supply has been called into question though, with a leading environmental lawyer claiming the majority of oil will be sent overseas.

In a series of tweets, Tessa Khan, part of the *Stop Cambo* campaign, said “of the 170 million barrels of oil produced from Cambo, 150 million will be exported”. She claimed there’s a “12.9% chance” that oil from the new project will find its way to a UK refinery and end up being used domestically.

As oil has to be processed to be used, much of it is exported to refineries in Europe, each of which tends to specialise in a different type of crude.

After it has been treated, the fuel or product is then imported into the UK in order to breach the gap between demand and domestic refinery production.

Reference:

https://www.energyvoice.com/oilandgas/365922/uk-forked-out-more-than-18bn-on-oil-and-gas-imports-in-year-to-june/

Life on Mars search could be misled by False Fossils, study says

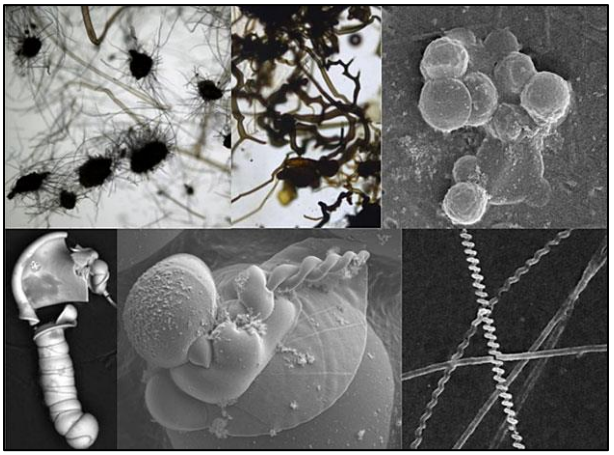
University of Edinburgh / Astrobiology
18 November 2021 12:35

Mars explorers searching for signs of ancient life could be fooled by fossil-like specimens created by chemical processes, research suggests.

Rocks on Mars may contain numerous types of non-biological deposits that look similar to the kinds of fossils likely to be found if the planet ever supported life, a study says.

Telling these false fossils apart from what could be evidence of ancient life on the surface of Mars - which was temporarily habitable four billion years ago - is key to the success of current and future missions, researchers say.

Astrobiologists from the Universities of Edinburgh and Oxford reviewed evidence of all known processes that could have created lifelike deposits in rocks on Mars.



Composite image showing some of the types of fossil-like specimens created by chemical reactions that could be found on Mars. (CREDIT Sean McMahon, Julie Cosmidis and Joti Rouillard)

They identified dozens of processes - with many more likely still undiscovered - that can produce structures that mimic those of microscopic, simple lifeforms that may once have existed on Mars.

Among the lifelike specimens these processes can create are deposits that look like bacterial cells and carbon-based molecules that closely resemble the building blocks of all known life.

Because signs of life can be so closely mimicked by non-living processes, the origins of any fossil-like specimens found on Mars are likely to be very ambiguous, the team says.

They call for greater interdisciplinary research to shed more light on how lifelike deposits could form on Mars, and thereby aid the search for evidence of ancient life there and elsewhere in the solar system.

The research is published in the *Journal of the Geological Society.*

Dr. Sean McMahon, Chancellor's Fellow in Astrobiology at the University of Edinburgh's School of Physic and Astronomy, said: "At some stage a Mars rover will almost certainly find something that looks a lot like a fossil, so being able to confidently distinguish these from structures and substances made by chemical reactions is vital. For every type of fossil out there, there is at least one non-biological process that creates very similar things, so

there is a real need to improve our understanding of how these form."

Julie Cosmidis, Associate Professor of Geobiology at the University of Oxford, said: "We have been fooled by life-mimicking processes in the past. On many occasions, objects that looked like fossil microbes were described in ancient rocks on Earth and even in meteorites from Mars, but after deeper examination they turned out to have non-biological origins. This article is a cautionary tale in which we call for further research on life-mimicking processes in the context of Mars, so that we avoid falling into the same traps over and over again."

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First-ever interior Earth mineral discovered in nature

Press Release: UNLV
16 November 2021

UNLV (University of Nevada, Las Vegas) geochemists have discovered a new mineral on the surface of the Earth. There's just one catch: it shouldn't be here.

The mineral -- entrapped in a diamond -- travelled up to the surface from at least 410 miles (660 kms) deep within the Earth's lower mantle, the area between the planet's core and crust. It's the first time that lower mantle minerals have ever been observed in nature because they usually fall apart before they reach the Earth's surface, unable to retain their structure outside of a high-pressure environment. In this case, the diamond's incredible strength preserved the mineral and made the discovery by scientists possible.

UNLV mineralogist Oliver Tschauner and colleagues discovered a new mineral that was carried to the surface of the Earth in a diamond. (Photo credit: Aaron Celestian, Los Angeles County Natural History Museum)

Takeaways

The calcium silicate compound, $CaSiO_3$-**perovskite**, showed up as infinitesimal small dark specks in a diamond unearthed from an African mine in the 1980s.

"For jewellers and buyers, the size, colour, and clarity of a diamond all matter, and inclusions -- those black specks that annoy the jeweller -- for us, they're a gift," said UNLV mineralogist Oliver Tschauner, who led the study which was published 11 November in the journal *Science*. "I think we were very surprised. We didn't expect this."

The diamond arrived on the surface decades ago in Botswana via the Orapa mine, the world's largest diamond mine by area. A gem dealer sold the diamond in 1987 to a mineralogist at the California Institute of Technology in Pasadena, and recently, Tschauner and colleagues, including UNLV geochemist Shichun Huang, got their hands on the diamond and applied a new suite of scientific tools to analyse its interior structure.

What they found is a new crystalline compound that they named **"*davemaoite*"** after Ho-kwang "Dave" Mao, an experimental geophysicist who developed many of the techniques that Tschauner and his colleagues use today.

Davemaoite was approved as a new natural mineral by the Commission of New Minerals,

Nomenclature, and Classification of the International Mineralogical Association.

Tschauner believes davemaoite originated between 410 and 560 miles below the Earth's surface, and its discovery highlights just one of two ways that highly pressurized minerals are found by us in nature: from deep within Earth's interior or inside meteorites.

In 2014, Tschauner's discovery of "bridgmanite," highlighted the latter method.

He's hopeful that discoveries of more minerals - in larger quantities - are on the horizon, which will allow scientists to model the evolution of the Earth's mantle in greater detail.

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Scotland shaken by early hours earthquake

BBC Science
16 November 2021

People in the west of Scotland have been shaken by an earthquake in the early hours of the morning. The earthquake, with a **magnitude of 3.1**, happened just before 02:00 am.

Its epicentre was about 18 km northwest of Lochgilphead in Argyll and Bute, and 142 km northwest of Glasgow, according to the United States Geological Survey.

More than 30 people reported the tremor, from as far away as Edinburgh and Ballycastle in Northern Ireland. The agency said the quake happened 10 km below the Earth's surface.

'Quite frightening'

Rosemary Neagle, who lives on a farm in Kilmartin Glen near Lochgilphead, said the noise of the tremor was so loud that she initially thought something had exploded in one of her sheds.

She told BBC Radio's Good Morning Scotland programme: "It kept on intensifying and the house vibrated. It rumbled on for about 10 seconds afterwards, so it was quite frightening. I have experienced them before here but never to that extent. The house has never shook like that in the past."

Data from the British Geological Survey shows that between 200 and 300 earthquakes are detected in the UK every year, with tremors of between 3.0 and 3.9 magnitude happening on the mainland once every three years on average.

Reference:

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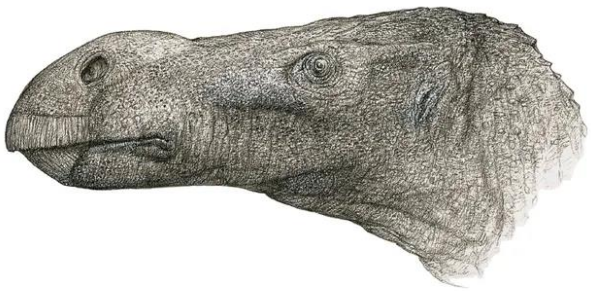
New species of big-nosed dinosaur discovered by retired doctor

Nasal bone distinguishes herbivore *Brighstoneus simmondsi,* whose skull was found on the Isle of Wight

Hannah Devlin,
The Guardian Science correspondent
11 November 2021



The distinctive head of new dinosaur species Brighstoneus simmondsi. (Illustration: John Sibbick/University of Portsmouth)

A new species of dinosaur with an extremely large nose has been identified by a retired GP who spent lockdown rummaging through boxes of ancient bones.

Jeremy Lockwood, who is studying for a PhD at the University of Portsmouth, set himself the task of cataloguing every iguanodon bone

discovered on the Isle of Wight. As he sorted the bones from the collections of the **Natural History Museum** in London and the **Dinosaur Isle Museum** on the Isle of Wight, he discovered a specimen with a unique "bulbous" nasal bone.

"For over 100 years, we'd only seen two types of dinosaur on the Isle of Wight – the plant-eating *Iguanodon bernissartensis* and *Mantellisaurus atherfieldensis*," he said. "I was convinced that subtle differences between bones would reveal a new species, so I set out to measure, photograph and study the anatomy of each bone."

After four years of unpacking and studying boxes of bones, he began reconstructing the skull of a specimen that had been in storage since 1978 and found several striking features that set it apart.

"The number of teeth was a sign," Lockwood said. "*Mantellisaurus* has 23 or 24, but this has 28. It also had a bulbous nose, whereas the other species have very straight noses. Altogether, these and other small differences made it very obviously a new species." He added: "This discovery made it one of the happiest days of lockdown."

The herbivorous dinosaur was about eight metres in length and weighed about 900 kg.

Lockwood, working with Prof David Martill from the University of Portsmouth, and Dr. Susannah Maidment, from the Natural History Museum, has named the new species *Brighstoneus simmondsi,* for a study published in the ***Journal of Systematic Palaeontology.***

Brighstoneus is named after the village of Brighstone on the Isle of Wight, which is close to the excavation site, and the latter part of the name is in honour of Keith Simmonds, an amateur collector, who was involved in finding and excavating the specimen.

The discovery of this new species suggests there were far more iguanodontian dinosaurs in the Early Cretaceous of the UK than previously thought and that a longstanding convention of assigning fossils found on the Isle of Wight to either the Iguanodon or Mantellisaurus species should be reconsidered. "It seems so unlikely to just have two animals being exactly the same for millions of years without change," said Lockwood.

Lockwood, who was involved in the discovery of another new species known as the "hell heron" *(see FGS Newsletter, November 2021)*, said the latest discoveries showed British dinosaurs were not "done and dusted". "I think we could be on to a bit of a renaissance."

Reference:

1. https://www.theguardian.com/science/2021/nov/11/big-nosed-dinosaur-brighstoneus-simmondsi-discovered-retired-doctor-isle-of-wight?CMP=Share_AndroidApp_Other
2. https://www.tandfonline.com/doi/full/10.1080/14772019.2021.1978005

Vast patches of Glassy Rock in Chilean Desert likely created by Ancient Exploding Comet

Press Release: Brown University
4 November 2021

Around 12,000 years ago, something scorched a vast swath of the Atacama Desert in Chile with heat so intense that it turned the sandy soil into widespread slabs of silicate glass.

Now, a research team studying the distribution and composition of those glasses has come to a conclusion about what caused the inferno.

In a study published in the journal *Geology*, researchers show that samples of the desert glass contain tiny fragments with minerals often found in rocks of extra-terrestrial origin. Those minerals closely match the composition of material returned to Earth by NASA's Stardust mission, which sampled the particles from a comet called **Wild 2**.

The team concludes that those mineral assemblages are likely the remains of an extra-terrestrial object - most likely a comet with a composition similar to Wild 2 - that streamed down after the explosion that melted the sandy surface below.

Deposits of dark silicate glass are strewn across a 75 km corridor in the Atacama Desert in northern Chile. New research shows that those glasses were likely formed by the heat of an ancient comet exploding above the surface. (Credit: P.H. Schultz/Brown University)

"This is the first time we have clear evidence of glasses on Earth that were created by the thermal radiation and winds from a fireball exploding just above the surface," said Pete Schultz, a professor emeritus in Brown University's Department of Earth, Environmental and Planetary Sciences. "To have such a dramatic effect on such a large area, this was a truly massive explosion. Lots of us have seen bolide fireballs streaking across the sky, but those are tiny blips compared to this."

The glasses are concentrated in patches across the Atacama Desert east of Pampa del Tamarugal, a plateau in northern Chile nestled between the Andes Mountains to the east and the Chilean Coastal Range to the west. Fields of dark green or black glass occur within a corridor stretching about 75 km. There's no evidence that the glasses could have been created by volcanic activity, Schultz says, so their origin has been a mystery.

Some researchers have posited that the glass resulted from ancient grass fires, as the region wasn't always desert. During the Pleistocene epoch, there were oases with trees and grassy wetlands created by rivers extending from mountains to the east, and it's been suggested that widespread fires may have burned hot enough to melt the sandy soil into large glassy slabs.

But the amount of glass present along with several key physical characteristics make simple fires an impossible formation mechanism, the new research found. The glasses show evidence of having been twisted, folded, rolled and even thrown while still in molten form. That's consistent with a large incoming meteor and airburst explosion, which would have been accompanied by tornado-force winds. The mineralogy of the glass casts further serious doubt on the grassfire idea, Schultz says. Along with researchers from the Fernbank Science Center in Georgia, Chile's Universidad Santo Tomás and the Chilean Geology and Mining Service, Schultz and colleagues performed a detailed chemical analysis of dozens of samples taken from glass deposits across the region.

The analysis found minerals called **zircons** that had thermally decomposed to form **baddeleyite**. That mineral transition typically happens in temperatures in excess of 3,000 degrees Fahrenheit - far hotter than what could be generated by grass fires, Schultz says.

The analysis also turned up assemblages of exotic minerals only found in meteorites and other extra-terrestrial rocks, the researchers say. Specific minerals like **cubanite**, **troilite** and **calcium-aluminium-rich inclusions** matched mineral signatures from comet samples retrieved from NASA's Stardust mission.

"Those minerals are what tell us that this object has all the markings of a comet," said Scott Harris, a planetary geologist at the Fernbank Science Center and study co-author. "To have the same mineralogy we saw in the Stardust samples entrained in these glasses is really powerful evidence that what we're seeing is the result of a cometary airburst."

More work needs to be done to establish the exact ages of the glass, which would determine exactly when the event took place, Schultz says. But the tentative dating puts the impact right around time that large mammals disappeared from the region.

"It's too soon to say if there was a causal connection or not, but what we can say is that this event did happen around the same time as

when we think the megafauna disappeared, which is intriguing," Schultz said. "There's also a chance that this was actually witnessed by early inhabitants, who had just arrived in the region. It would have been quite a show."

Schultz and his team hope that further research may help to constrain the timing and shed light on the size of the impactor. For now, Schultz hopes this study may help researchers identify similar blast sites elsewhere and reveal the potential risk posed by such events.

"There may be lots of these blast scars out there, but until now we haven't had enough evidence to make us believe they were truly related to airburst events," Schultz said. "I think this site provides a template to help refine our impact models and will help to identify similar sites elsewhere."

Other authors of the study were Sebastian Perroud, Nicolas Blanco and Andrew Tomlinson.

Reference:

http://spaceref.com/comets/vast-patches-of-glassy-rock-in-chilean-desert-likely-created-by-ancient-exploding-comet.html

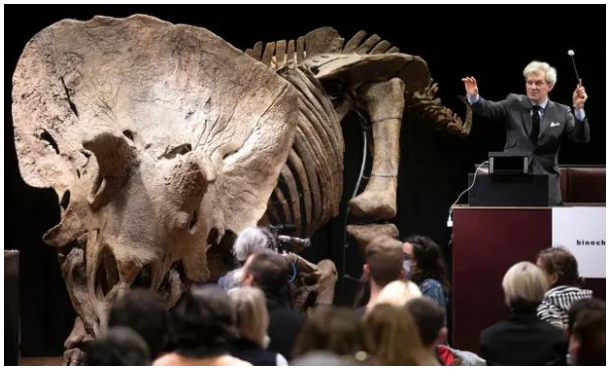
Largest triceratops ever unearthed sold for €6.6m at Paris auction

US collector 'falls in love' with 8-metre-long dinosaur found in South Dakota and reassembled in Italy

Agence France-Presse in Paris
21 October 2021

An 8 m long dinosaur skeleton has sold at auction for €6.6m (about £5.5m), more than four times its expected value, to a private collector in the US said to have fallen in love with the largest triceratops ever unearthed.

The 66 Ma old skeleton, affectionately known as Big John, is 60% complete, and was unearthed in South Dakota, in the US, in 2014 and put together by specialists in Italy.



Collectors bidding for 'Big John' at the Drouot auction house in Paris on 21 October. (Photograph: Ian Langsdon/EPA)

He will return to the US and the private collection of the unnamed buyer, who the Drouot auction house in Paris said had fallen "in love" with the dinosaur after coming to view him. The buyer beat 10 other bidders, with three in particular driving up the price in the final minutes to many times beyond the expected €1.5m.

"I wasn't expecting this," said Iacopo Briano, the palaeontologist overseeing the sale.

Big John lived at the end of the Cretaceous period, the final era of dinosaurs, and died in a floodplain, buried in mud that preserved him. A horn injury near his cranium suggests he got into at least one nasty fight.

The sale was still far off the record of $31.8m (£23m) paid last year for a 67 Ma old Tyrannosaurus rex skeleton in New York.

But the price all but guaranteed museums would be excluded from the purchase. "We can't compete," said Francis Duranthon, director of the Toulouse Museum of Natural History, before the auction. He said even the initial expected price represented 20 to 25 years of his acquisitions budget.

Although Big John is heading for a private collection, the auction house said there was still a chance the buyer may lend the skeleton to a museum or gallery for public viewings.

Scientists were able to analyse the bones before the auction.

The triceratops is among the most distinctive dinosaurs owing to the three horns on its head

– one at the nose and two on the forehead – that give it its Latin name.

Dinosaur sales can be unpredictable: in 2020, several specimens offered in Paris did not find takers after they failed to reach their minimum prices.

Reference:

https://www.theguardian.com/science/2021/oct/21/largest-triceratops-ever-unearthed-sold-for-66m-at-paris-auction

Extinct style of Plate Tectonics explains early Earth's Flat Mountains

The geologic record suggests that despite Earth's hot, thin crust during the Proterozoic, mountains were still able to form thanks to an extinct style of crustal deformation

By Rebecca Dzombak
7 October 2021

Metamorphic rocks, like this 1.3 Ga old sample from Australia, provided Spencer et al. with insights into how ancient mountains formed. (Credit: Christopher Spencer, CC-BY-NC-4.0)

Geochemical and geological records provide key insights into Earth's tectonic history, but in the case of mountains during the Proterozoic eon, records conflict with each other: geochemical evidence says that the crust was thin and hot, which generally indicates that mountains would not have been able to form, but rocks left behind from that time period suggest that mountains were present.

"So how do we reconcile the geological evidence for mountain building with the geochemical evidence for thin crust?" asked Christopher Spencer, a geologist at Queen's University in Ontario, Canada, and lead author of a new study published in *Geophysical Research Letters.*

Using a global database, Spencer *et al.* compared the rock record with the geochemical record from 1.8 Ga to 850 Ma ago, a period that begins about a billion and a half years after the earliest signs of life and ends 150 Ma before complex life evolved. The geochemistry of continental rocks from that time suggests that the continental crust was thin (less than 40 km) and hot—poor conditions for forming mountains.

Despite the hot crust, the mineral composition of rocks from around the world at that time suggests that there was significant crustal flow that resulted in lower mountain ranges. The process for building mountains under these unique conditions is something we've never seen on modern Earth or beyond, the authors suggest. "Mountains during the Proterozoic were different from mountains at any other time in Earth's history" Spencer said.

The authors argue that with thin, hot crust, mountains could still form as relatively weak crust slid past itself in collisions that were more like glancing blows rather than head-on collisions. That behaviour would have been thanks in part to the lower part of the hot crust "flowing" like a highly viscous fluid on geologic timescales, even before modern plate tectonics started. This explanation of an extinct style of plate tectonics knits together the geological and geochemical evidence, describing a relatively flat world that persisted for a billion years.

"Continental motion is possible without global plate tectonics," said Taras Gerya, a geophysicist from the Swiss Federal Institute of Technology (ETH Zurich) who was not involved in the study. According to Gerya, the authors "demonstrate that this period of time was indeed characterized by quite a special tectonic style, which is dissimilar to the present. So, something really changed when

we moved from the Proterozoic to Phanerozoic around 541 Ma ago."

References:

1. https://eos.org/research-spotlights/extinct-style-of-plate-tectonics-explains-early-earths-flat-mountains?utm_campaign=ealert
2. https://doi.org/10.1029/2021GL093312

Gas crisis is a reminder that fossil fuels still matter

Tim Eggar,
Chairman Oil & Gas Authority
23 September 2021

Earlier this month, with the sun blazing, the UK fired up a coal power plant to cover an energy shortfall. The fine, calm weather meant there was not enough wind to keep turbine blades turning.

Gas stocks had been eaten into by a prolonged cold winter, a lack of storage, increased demand from Asia and substantial North Sea maintenance work.

Prices surged, creating the prospect of eye-watering bills for consumers and the collapse of smaller energy suppliers.

Then came the temporary shutdown of fertiliser plants which provide much of the CO2 needed by the food and drinking industry, sparking fears of shortages.

All are harsh reminders of the complexities of moving to a low-carbon economy. The energy transition is just that – **a transition**.

Despite the welcome growth of renewables, the UK is still reliant on oil and gas to keep the lights on, homes heated and the country moving. They currently cover three-quarters of our energy needs and demand for them is expected to persist for decades to come.

To me, it is logical that while demand lasts, we should satisfy as much of it as possible with domestic production. The alternative is to increase our reliance on imports.

The UK can produce gas with a lower carbon footprint than almost all other producing countries.

Shipping in more from overseas would further reduce our energy security at a time when Russia has no apparent interest in combatting climate change, but a great deal of interest in using energy supplies as a weapon.

Responsibility for our decarbonisation would pass to other countries, many of which have less ambitious plans for reducing emissions from oil and gas production.

We might marginally reduce the UK's emissions, but the world's emissions would increase.

Tens of thousands of oil and gas jobs would be jeopardised, too. These positions need to be protected until work on low-carbon projects has ramped up enough to allow workers to make a managed and "just" transition.

Not only that, oil and gas companies would be deprived of revenues required to fund their diversification into green energy.

Realistically, only these companies have the capital, infrastructure and expertise to deliver carbon capture and storage projects, identified by the Climate Change Committee as essential if we are to meet the UK's net-zero target.

Of course, the UK's dependence on fossil fuels must be reduced and we must produce oil and gas in a cleaner way.

In January 2020, I said the climate change debate was over and that the oil and gas industry needed to do much more to retain its licence to operate.

The industry did listen and did act. It did not use Covid-19 as an excuse for inaction, instead securing a landmark **North Sea Transition Deal** with the UK Government.

The first of its kind for a G7 country, it set near-term emissions reduction targets and committed industry to invest billions of pounds in decarbonisation.

For the OGA's part, we revised our statutory strategy to oblige the oil and gas industry to support the country's net-zero ambitions.

Our actions are already having promising results.

In 2021, OGA interventions have helped the industry avoid producing 980,000 tonnes of lifetime CO2e – the same as taking more than 500,000 cars off the road for a year. But external attitudes have hardened further since early 2020.

Ahead of COP26, criticism of the oil and gas industry is everywhere I look. Calls for the rapid wind-down of the industry have been emboldened by recent alarming reports from the IEA and IPCC.

It is clear the sector must work hard to justify new drilling. The climate compatibility checkpoint for new licensing rounds is a welcome sign of that.

North Sea reserves are being produced at a faster rate than they are being replenished – government projections already show that the UK will be a net importer of oil and gas out to 2050. New developments are already factored into our forecasts, so we are counting on them to provide energy, investment and employment. Outlawing them would only widen the supply-demand gap.

At COP26 we need global leaders to agree on ambitious near-term emission reduction targets.

For all our sakes, they must take concrete action which will tackle the world's fundamental problem – persistent and too-high demand for fossil fuels.

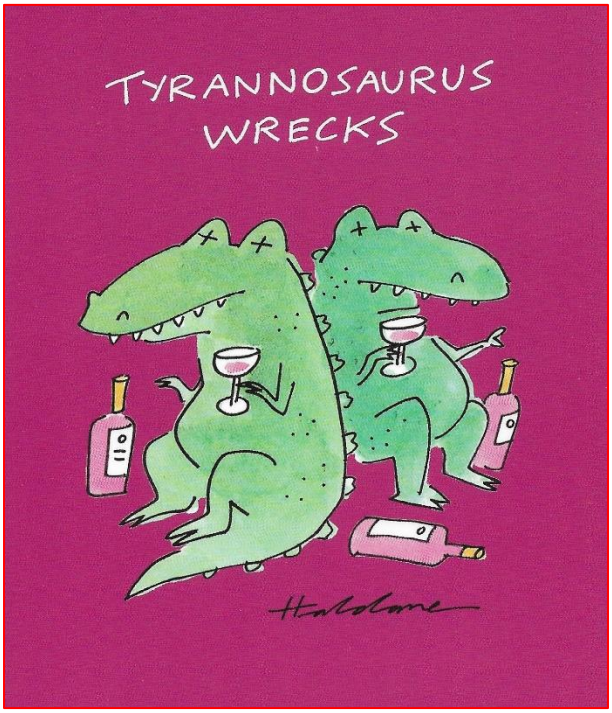
Addressing supply without taking decisive action on demand will lead us down the wrong path, a path to higher oil and gas prices and higher emissions.

Reference:

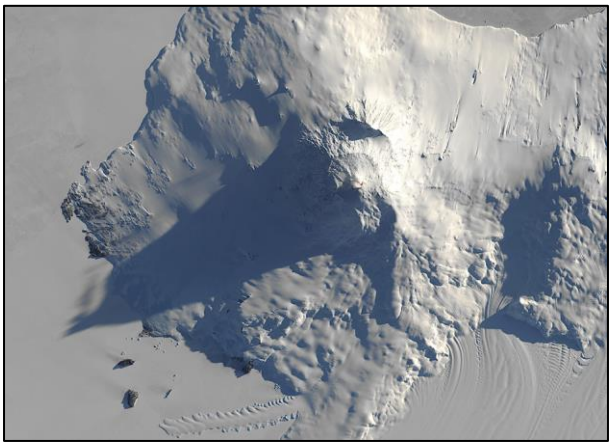
https://www.ogauthority.co.uk/news-publications/news/2021/tim-eggar-times-oped-gas-crisis-is-a-reminder-that-fossil-fuels-still-matter/

https://www.youtube.com/watch?v=rjdHd-IafC0

Interesting Places & Topics 2



(Credit: Haldene … provided by Mike Millar)



Orbital View of Mount Erebus on Ross Island, Antarctica

Source: ESA
11 October 2021

This image, acquired on 29 September 2021 by one of the Copernicus Sentinel-2 satellites, shows Mount Erebus on Ross Island in Antarctica.

Erebus is the southernmost active volcano in the world and is famous for its lake of boiling lava.

Due to the extreme environmental conditions on Ross Island, the volcano is monitored primarily by satellite. According to the Global Volcanism Program, the level of thermal activity during 2020 was lower than in recent years. In this cloudless image, we can see the absence of visible volcanic activity within the crater.

Reference:

http://spaceref.com/onorbit/orbital-view-of-mount-erebus-on-ross-island-antarctica.html

Mt. Vesuvius emerging from low-level clouds

This image, acquired by one of the Copernicus Sentinel-2 satellites on 3 January 2022, shows the summit of the Vesuvius volcano in southern Italy, emerging from a layer of low-level clouds that are lying over the western Mediterranean Sea basin. The clouds have covered marine and coastal areas while leaving inland and mountainous areas uncovered.

This rare phenomenon is associated with the anticyclonic weather pattern which affected Europe. The high pressure was also accompanied by a heatwave that has brought record temperatures in Spain, France, Italy and Germany.

Data from Copernicus satellites provide innovative data to improve the long-term monitoring of climate variables.
(Credit: EU, Copernicus Sentinel-2 imagery … suggested by Peter Crow)

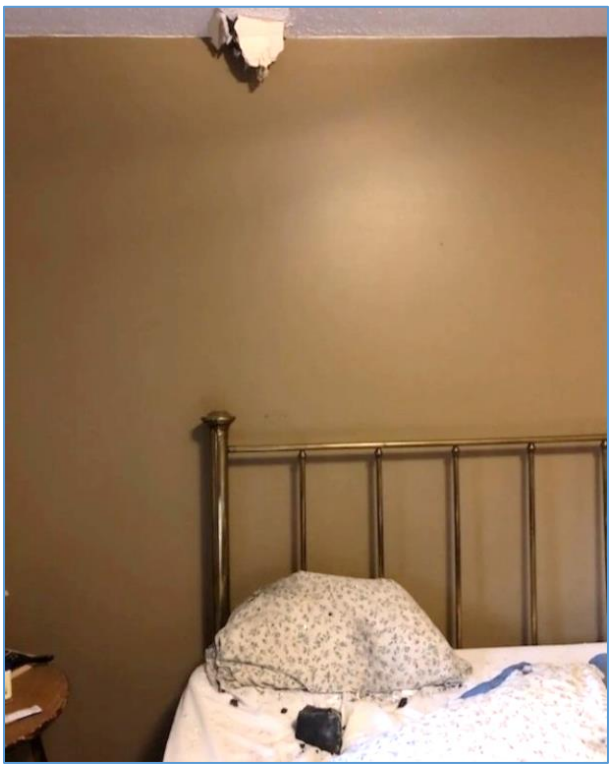
Reference:

https://www.copernicus.eu/en/media/image-day-gallery/mt-vesuvius-emerging-low-level-clouds)

Juno's New View of Ganymede

Source: NASA
30 December 2021

This enhanced image of the Jovian moon Ganymede was obtained by the JunoCam imager aboard NASA's Juno spacecraft during the mission's 7 June 2021, flyby of the icy moon on Juno's 34th pass close to Jupiter.



Meteorite

Colonel Chris Hadfield: "Sometimes you're sleeping and a meteorite crashes through the ceiling onto the pillow next to you."

(Photo by Ruth Hamilton in Golden, British Columbia, 13 October 2021)

Reference:

https://www.cbc.ca/news/canada/british-columbia/meteorite-crashes-into-womans-bedroom-golden-bc-1.6207904?fbclid=IwAR0mPEnBBdCPMD3A6jAcD860vWYIaAYBmYkZPUP68oFUe5G3P3MlUrVWHsk

Earth from Space: Sardinia, Italy

Source: European Space Agency
22 January 2021

Sardinia, the second-largest island in the Mediterranean Sea, is featured in this false-colour image captured by the Copernicus Sentinel-2 mission.

Sardinia (also known as Sardegna) is situated between the Mediterranean Sea to the west and south and the Tyrrhenian Sea to the east. The island sits 200 km west of the Italian Peninsula, 200 km north of Tunisia and around 12 km south of the French island of Corsica, partially visible in the top of the image.

This image, which uses data from 11 October to 14 October 2019, has been processed using the shortwave infrared band and the near infrared band to highlight dense vegetation. Crops and vegetation appear in bright green in the image, while bare soil can be seen in various shades of orange and brown.

Grasslands and croplands with a higher moisture content appear more vibrant in the image. As water is a strong absorber of infrared, inland water bodies are delineated and can be easily spotted in black. Much of the Sardinia's arable land is devoted to cereal cultivation and fruit growing.

TV Recommendations

‘Dinosaurs: The Final Day’: Sir David Attenborough’s latest BBC film to unearth mystery of Prehistoric Creatures’ last days

Max Goldbart
17 January 2022

Sir David Attenborough is to examine the mystery of the dinosaurs’ last days in a BBC1/PBS/France Télévisions feature film that will unearth a dig site hidden in the hills of North Dakota.

The prehistoric graveyard known as Tanis contains fossilised creatures dating back 66 Ma and, in **Dinosaurs: The Final Day, with David Attenborough**, the host will examine some of these findings with experts.

Led by palaeontologist Robert DePalma, a team has for three years been carrying out cutting-edge visualization and scanning

techniques to reveal these fossilized secrets and find out what happened the day an asteroid hit the earth and wiped out the dinosaurs.

The 95-year-old celebrated documentarian recently helmed documentaries on animal song and a mammoth graveyard and **Dinosaurs: The Final Day, with David Attenborough** is his first dinosaur film since 2016's BBC1 feature Attenborough and the Giant Dinosaur.

"Dinosaurs were nature's most extraordinary creatures, dominating the planet for over 150 Ma before they became extinct," he said. "Tanis could be a place where the remains can give us an unprecedented window into the lives of the very last dinosaurs, and a minute-by-minute picture of what happened when the asteroid hit."

https://deadline.com/2022/01/the-fall-of-the-dinosaurs-sir-david-attenboroughs-latest-bbc-film-to-unearth-mystery-of-prehistoric-creatures-last-days-1234913828/amp/?fbclid=IwAR0A06gxLuOD__6yNZsbAeqPNtwZiqd6jdQLS-l70WwKUJH-lZbsn5TxwME

"Pompeii: Secrets of the Dead" review — Bettany Hughes turns Sherlock in magma hell

Carol Midgley, The Times
29 October 2021

I don't know about you, but I'd always naively assumed that the poor souls engulfed in boiling lava and ash when Mount Vesuvius erupted in AD79 died instantly — boosh! — a crumb of comfort in a magma hell. Not so, sadly.

In ***Pompeii: Secrets of the Dead*** Bettany Hughes revealed that, while some would have perished immediately or within two breaths, incinerated at 520°C, others weren't quite so lucky. They had slightly cooler temperatures to contend with and would have taken 15 minutes to die, pummelled by scorching ash. We saw one unfortunate victim's plaster outline, fists aloft in the agonised "heat stress pose". I can't bear to think of those poor horses, one saddled up ready to carry someone to safety, and how frightened they must have been.

What happened at Pompeii and Herculaneum is well-trodden ground, not least by the tourists who flock there every year and buy ornaments of that little dog writhing in agony on a chain, so I didn't expect to learn a great deal that was new. But Hughes set about using forensic evidence to personalise five of the victims — a young boy, a soldier, a slave, a caretaker and a pregnant woman. In doing so the show became a kind of historical Sherlock.

The compacted spine and physical injuries of one man showed that he was a slave; the missing teeth, swords and coinage found on another led to him being identified as a Praetorian guard, stationed in Naples as a naval officer. The young woman, eight months pregnant with a daughter, had metal melted into her skull, which was said to be a decorative hair comb (but couldn't it as easily have been falling metal that embedded in her bonce? How could they know for sure?).

Hughes's enthusiasm was infectious as she walked among the ruins and hopped onto boats with her magnificent neckline (I do hope she was wearing factor 50. That sun looked ruthless). For a story so often told it felt fresh and, for that reason, all the more wretched.

References:

1. https://www.thetimes.co.uk/article/pompeii-secrets-of-the-dead-review-bettany-hughes-channel-5-jf7w7ld9s
2. https://www.channel5.com/show/pompeii-secrets-of-the-dead

Reading Geological Society

Farnham Geological Society

www.readinggeology.org.uk www.farnhamgeolsoc.org.uk

Joint Field Meeting to South Pembrokeshire

led by Sid Howells

Monday 16th May to Thursday 19th May 2022

Joint Field Meeting to South Pembrokeshire

led by Sid Howells

Monday 16th May to Thursday 19th May 2022

Sid Howells is a professional geologist, living and working in South Pembrokeshire with an extensive knowledge of the geology of this area.

We will examine Carboniferous Limestones and Fossils, Devonian Old Red Sandstones including the basal conglomerate, Silurian Sedimentary Rocks and fossils, basalts and tuffs. We will also be looking at coastal morphology and potentially a local quarry.

We will be staying in a small hotel in Pembroke, with the opportunity to explore the town and castle. There are double, twin and single rooms and a licenced restaurant.

Travel will be by car, either independent or shared.

Estimated cost (with local travel only) is:

Shared accommodation £265 Single accommodation £370.

These costs include a £50 contingency, which will be refunded if not used.

Shared return travel from Reading or Farnham is + £35

If you would like to sign up for this trip or you would like any further details or information, the please contact **John Williams:** 0127 626 494 or clawdip@yahoo.com.

A deposit of **£50** to secure your place will be required by **15th February 2022.**

Please make cheques payable to **Farnham Geological Society** and send them to: **John Williams**, FGS Field Trip Secretary, 57 Warren Rise, Camberley, Surrey, GU16 8SJ

FGS Photographic Competition

Farnham Geological Society

Farnham Geological Society
Post-Covid Celebrations
March 11th 2022

FGS PHOTOGRAPHIC COMPETITION

I hope all you enthusiastic photographers will enjoy entering the
FGS Photographic Competition with your favourite geological photos

RULES FOR THE FGS PHOTOGRAPHIC COMPETITION

- The competition is open to all members of the Society.
- Only members of the Society may take part.
- All photographs must be original and have been taken by you personally.
- More than one photograph may be submitted.
- Ideally the photograph should show interesting geological feature(s) or view.
- The photograph can be printed in black & white or colour.
- The photograph should be printed at A4 size, 210 x 297mm
- Write you name on the back of the photograph

Information to provide with the photograph on a separate piece of paper -

- Your name, address, email address
- Re the photo - date, location, title and geological description

Put the photograph and the above information into a suitable envelope

- Seal the envelope and label it 'FGS Photographic Competition'
- Also add your name
- All entries must be submitted by February 28th 2022
- It will not be possible to accept photographs after this date.
- Unfortunately it will not be practical to return the photographs.

Post the completed, sealed envelope to either :

Liz Aston
7 Lamborne Close
Sandhurst, GU47 8JL

Mike Millar
27 Cheylesmore Drive
Frimley, GU16 9BL

Non-participating Members of the Committee will choose the top entries.
Results will be presented at FGS Post-Covid Celebrations on March 11th 2022
The prize for the best photograph will be a desert rose.

Good Luck to You All **Liz Aston, Chair, FGS**