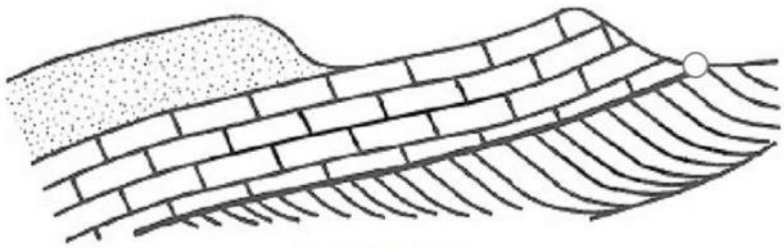
Newsletter of

The Farnham Geological Society

Volume 24, Number 3, August 2021

Farnham Geological Society

Farnhamia farnhamensis



Founded 1970

A local group within the GA

Volume 24, No. 3 **Newsletter** August 2021

Issue No. 113

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Editorial

Welcome to the latest FGS Newsletter. I do hope you are all fit and well and that most of you will have had both vaccinations.

At the time of writing England has relaxed all Covid restrictions, although many institutions and businesses are continuing to ask customers to wear masks indoors and maintain a social distance. Although the continuing rise of Covid cases is a worry, the vaccination programme seems to be on target and very effective against the virus.

With the easing of restrictions in mind, our Field Trip Secretary, John Williams, has arranged a Building Stone Walk on 26 August in Central London. For further details and how to book see under "*Field Trip Programme 2021*" below.

Our next lecture meeting is on 10 September when Liz Aston, Mike Millar and myself will present "*Tales from the Offshore: Random stories of working in the oil industry*". It will again be via Zoom.

Please note that we will continue to hold our monthly lectures via Zoom and will only return to The Maltings when it is safe to do so. Obviously, the Committee will keep you informed as to when a return might be possible, but it does seem likely that we will continue with Zoom-only lectures for this year.

I hope you enjoy this edition of your Newsletter. I have tried to bring you interesting geoscience stories that have appeared since the May issue, together with our "regular" features. Please feel free to contact me with any comments or articles for inclusion. Note my email address is caulfm@hotmail.com.

Front Cover

Fluorite (CaF_2) from the Diana Maria Mine, Frosterley, Weardale, County Durham, England. The mineral exhibits "daylight fluorescence". It looks green (*top left*) under white light (for example in a display cabinet), but the Ultraviolet in daylight brings out the blue/purple tints (*on the right*). The blue/purple intensity changes, depending upon how much UV is present and is a stronger colour on a sunny day. The bottom left image is the sample under UV light only (365nm). *(Image: Peter Crow, FGS Member)*

Farnham Geological Society

Committee 2021

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

Meeting Programme 2021

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

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

No meeting Fri, 13 August

Tales from the Offshore: Random stories of working in the oil industry
Liz Aston, Mike Millar & Mick Caulfield
FGS Fri, 10 September

Colours in the NHM
Robin Hansen Fri, 8 October
Curator, Minerals, NHM

Exploring Life at Deep-sea Hydrothermal Vents: Patterns in Space and Time
Dr. Jon Copley Fri, 12 November
Associate Professor in Ocean Exploration & Public Engagement, NOC, Southampton

Lost Worlds of the Solar System
Professor Hilary Downes Fri, 10 December
Birkbeck College, University of London

Field Trip Programme 2021

Updated 7 July 2021

We will be restarting Field Trips slowly with a **Building Stone Walk** on **26 August 2021** around **South Kensington** led by **Leonie Biggenden**, one of the Education Team at the Natural History Museum.

We will meet at the corner of Exhibition Road and Cromwell Road outside the southwest corner of the Victoria and Albert Museum at 2pm. The walk will take about 2 hours and end at The Albert Monument opposite the Royal Albert Hall.

If you would like to take part **please let John Williams know** by email **clawdip@yahoo.com** or phone **077406 20694** by 15 August.

Geologists' Association
Lecture Programme 2021

Updated 19 July 2021

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

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

Please note the Zoom lecture time: 6.00 pm start.

"Pills and Politics"; a new look at George Bellas Greenough and his Geological Map of 1820...
Prof. Hugh Torrens
Keele University Fri, 1 October

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

Reading Geological Society
Lecture Programme 2021

Updated 19 July 2021

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

Time: 7:45pm for 8:00pm *(subject to change)*

Venue: Zoom talks

Evolution of flowering plants, especially in relation to Darwin's "abominable mystery"
Prof. Richard Buggs Mon, 6 September
University of London

Cambrian Explosion
Dr. Luke Parry Mon, 4 October
University of Oxford

Ireland's geology and landscape
Dr. Michael J Simms Mon, 1 November
Senior Curator of Natural Sciences, National Museums, NI

Mole Valley Geological Society

http://mvgs.org.uk/index.htm

Geology of the Gower
Dr. Mark G. Eller Thu, 2 September
MVGS

West Sussex Geological Society

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

Scotland's lost meteorite
Ken Amor Fri, 17 September
University of Oxford

The Boxgrove Wider Area Project; mapping early Pleistocene deposits across the coastal plain of West Sussex
Dr. Matt Pope Fri, 15 October
University College, London

Lapis Lazuli
Dr. Chris Duffin Fri, 19 November
Natural History Museum

Harrow & Hillingdon Geological Society

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

Deccan-induced environmental changes
Matthew Staitis Wed, 8 September
University of Edinburgh

Developments in Understanding the flow mechanisms in the Chalk and the groundwater-surface water interactions
Dr. Ilias Karapanos Wed, 13 October
Affinity Water

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

It Happened in September

1 September 1923

The Tokyo-Yokohama earthquake, also called Great Kanto earthquake, struck the Tokyo-Yokohama metropolitan area near noon with a magnitude of 7.9. The death toll from the tremor was estimated to have exceeded 140,000. More than half of the brick buildings and one-tenth of the reinforced concrete structures in the region collapsed. Many hundreds of thousands of houses were either shaken down or burned in the ensuing fire. The shock generated a tsunami that reached a height of 12 metres at Atami on Sagami Gulf, where it destroyed 155 houses and killed 60 people.

Damage caused by the Tokyo-Yokohama earthquake, 1923. (Image: Encyclopædia Britannica, Inc.)

2 September 1666

The Great Fire of London began in a bakery in Pudding Lane near the Tower of London. Over the next three days more than 13,000 houses were destroyed, although only six lives were believed lost.

3 September 1939

Britain and France declare war on Germany.

6 September 1620

The Mayflower sets sail from Plymouth, Devon, carrying the Pilgrim Fathers to America.

11 September 2001

The worst terrorist attack in U.S. history occurred as four large passenger jets were hijacked then crashed, killing nearly 3,000 persons. This included 2 planes that were piloted into the twin towers of the World Trade Centre in New York City. The impact and subsequent fire caused both towers to collapse, killing 2,752 persons including hundreds of rescue workers and people employed in the towers.

13 September 1902

Harry Jackson becomes the first person in Britain to be convicted on fingerprint evidence.

19 September 1985

The Mexico City earthquake struck in the early morning of 19 September at 07:17 CST with a moment magnitude of 8.0 and a maximal Mercalli intensity of IX (Violent). The event caused serious damage to the Greater Mexico City area and the deaths of at least 5,000 people. The sequence of events included a foreshock of magnitude 5.2 that occurred the prior May, the main shock on 19 September, and two large aftershocks.

19 September 2017

The 2017 Puebla earthquake struck at 13:14 CDT with an estimated magnitude of Mw7.1 and strong shaking for about 20 seconds. Its epicentre was about 55 km south of the city of Puebla, Mexico. 370 people were killed by the earthquake and related building collapses, including 228 in Mexico City and more than 6,000 were injured.

27 September 2014

A volcanic eruption of Mount Ontake in Japan took place on 27 September 2014, killing 63 people. Mount Ontake is a volcano located on the Japanese island of Honshu around 100 km northeast of Nagoya and around 200 km west of Tokyo.

A huge cloud of rolling ash and dust poured down the side of Mount Ontake in central Japan (Image: YouTube)

28 September 1745

'God Save the King' is sung for the first time at London's Drury Lane Theatre.

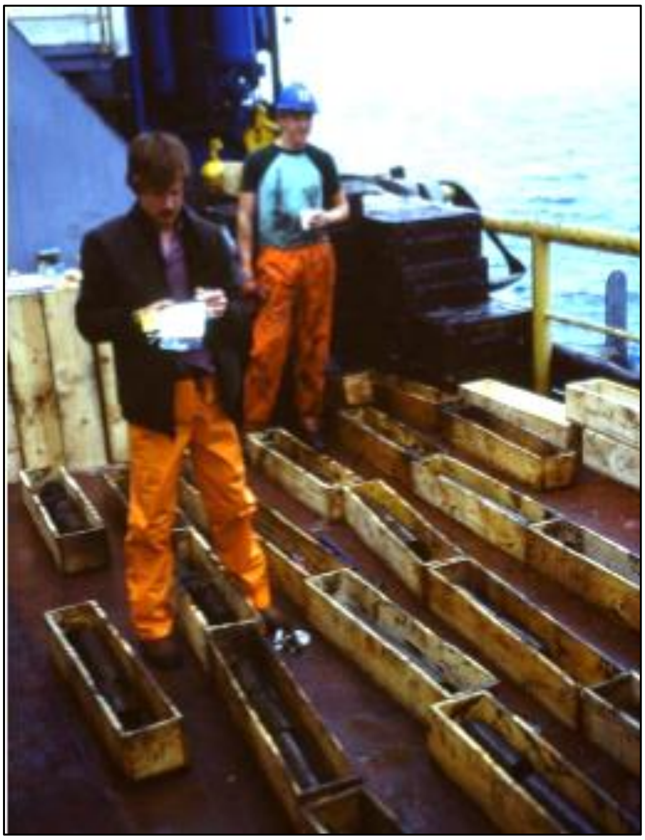
Next Lecture

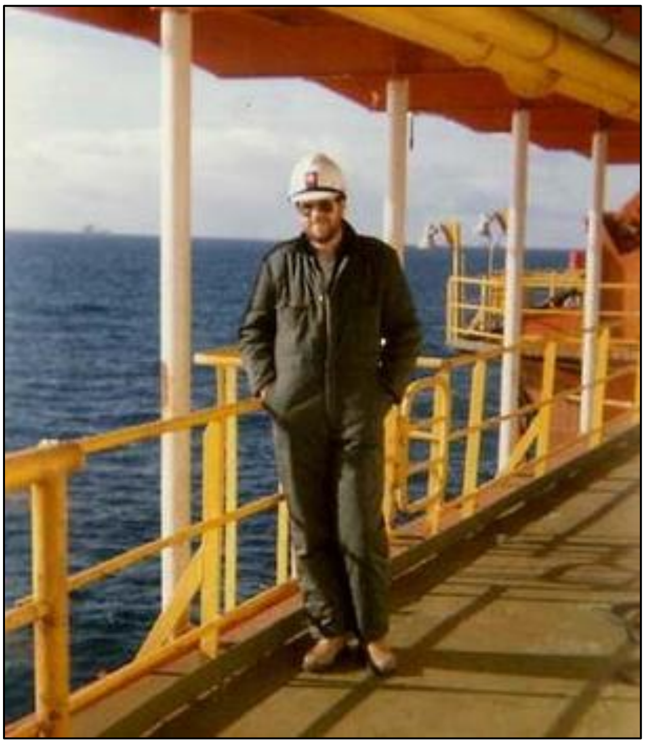
Friday, 10 September 2021

Zoom: 6.50 pm for 7.00 pm start

Tales from the Offshore: Random stories of working in the oil industry

Liz Aston, Mike Millar & Mick Caulfield
FGS





Lecture Summaries

9 July 2011

On Friday, 11 June 2021 our Chair Liz Aston and 34+ attendees from the FGS, together with GA and Reading Geological Society members welcomed FGS members Christina Fisher & Ben Dixon of the Natural History Museum to present our external lecture via Zoom.

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

Christina Fisher & Ben Dixon
Identification & Advisory Officers, NHM

11 June 2021

On Friday, 11 June 2021 our Chair Liz Aston and 34+ attendees from the FGS, together with GA and Reading Geological Society members welcomed Dr. James Witt to present our external lecture via Zoom.

Ammonite extinction and the Cretaceous-Paleogene (K-Pg) boundary in the Gulf Coastal Plain, USA

Dr. James D Witt
University of New Mexico, Albuquerque, USA

Biography

James graduated with a MEarthSci, from the University of Manchester and completed a PhD at the University of Leeds. Since then, 2016, he has held various postdoctoral positions at the American Museum of Natural History, New York. His current affiliation is as a Research Affiliate, at the Department of Earth and Planetary Sciences, University of New Mexico.

Abstract

The Cretaceous–Paleogene (K–Pg) mass extinction event 66 Ma ago is linked to a catastrophic asteroid impact at Chicxulub in the Gulf of Mexico, but debate remains as to the timing and precise mechanisms which led to global extinction. Fossiliferous shallow marine sediments in the Gulf and Atlantic Coastal Plains of the United

States contain an exceptional record of palaeoenvironmental change across the K–Pg boundary, including sedimentary deposits related directly to the Chicxulub impact ~1500 km to the south. In this talk Dr. Witt presented new data from K–Pg sites in this region which are providing new details on this dramatic transition in Earth history and its effects on marine ecosystems – in particular the final extinction of the ammonoid cephalopods (ammonites) which are among the most high-profile victims of this crisis.

14 May 2021

On Friday, 14 May 2021 our Chair Liz Aston and 32+ attendees from the FGS, together with GA and Reading Geological Society members welcomed Dr. Greg Edgecombe to present our external lecture via Zoom.

Exceptionally preserved Cambrian arthropods and their role in understanding arthropod evolution

Dr. Greg Edgecombe
Merit Researcher, NHM

Biography

Dr. Greg Edgecombe has been a Researcher at the Natural History Museum in London since 2007. His research focus is about 50% fossil arthropods (often from the Cambrian) and 50% living ones (especially centipedes). Before joining the NHM he worked as a Research Scientist at the Australian Museum in Sydney for 14 years. He received his PhD from Columbia University in New York City in 1991, working at the American Museum of Natural History on the systematics of trilobites. He was elected a Fellow of the Royal Society in 2018.

Summary

With more than 1.2 million named living species, arthropods represent some 85% of described animal diversity; more than a million species of insects make up the majority of this staggering diversity. The evolutionary relationships of living arthropods are now largely understood through analyses of DNA sequence data drawing on samples of thousands of genes (Ref. 3). These have provided novel insights, such as the finding that crustaceans are an evolutionary grade (rather than a natural group), some crustacean lineages being the closest relatives of the hexapods (which include insects).

Figure 1: Microtomographic scan of the Cambrian trilobitomorph Naraoia spinosa from the Chengjiang biota (Cambrian Series 2, Stage 3), Yunnan, China. Specimen in ventral view to show the appendages.

Arthropod megadiversity is not, however, confined to the geological recent. Wholly extinct groups such as trilobites are composed of ca 20,000 species, and arthropods are the most abundant and diverse component of exceptionally preserved Cambrian biotas dating back as far as 518 Ma. These windows into the non-biomineralised members of Cambrian ecosystems are known as Burgess Shale-type biotas ("BSTs"), after the eponymous Middle Cambrian Burgess Shale in British Columbia, Canada. In such assemblages, shelly fossils such as trilobites, brachiopods and silicious sponges are preserved with worms and a broad diversity of arthropods of which the chitinous exoskeleton was non-biomineralised. Without rapid burial in poorly oxygenated sediment these "soft-bodied" organisms would normally be lost to decay. Some of the most intensely studied BSTs over the past 20 years are those from China, Greenland, Australia, and new outcrops of the Burgess Shale itself. Arthropods (and other animal phyla) in these biotas preserve certain internal organ systems (often the gut and muscle, and sometimes traces of the nervous system) as well as external structures such as the appendages in fine detail, providing palaeontologists with characters for inferring evolutionary relationships and understanding the biology of these Cambrian organisms. Under the right conditions of preservation, we can scan these fossils using a CT scanner not unlike those used in hospitals and digitally dissect each of the appendages to see their morphological details in three dimensions (Fig. 1).

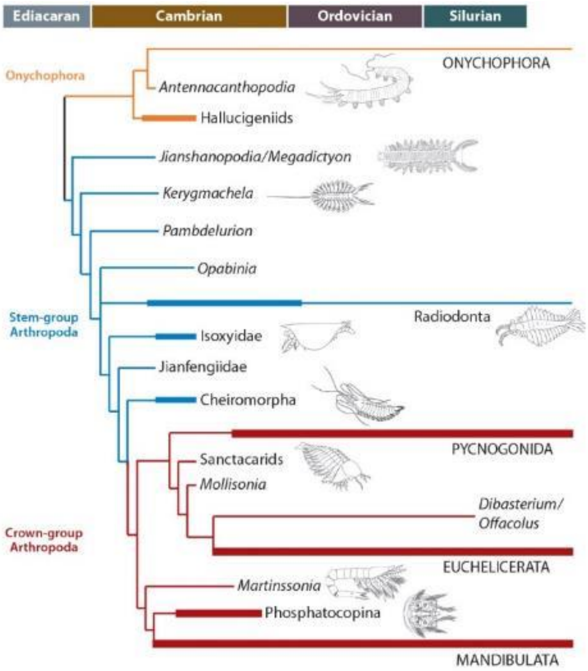


Figure 2: Phylogenetic tree showing interrelationships in the arthropod stem- and crown-groups, with reconstructions of Cambrian fossil representatives (from Ref. 2).

Molecular phylogenetics revealed that arthropods are not most closely related to segmented worms as was thought for most of the past two centuries. Instead, arthropods are part of a grouping of eight animal phyla that share the periodic moulting of their cuticle in order to grow. This process is called ecdysis and the group was accordingly named Ecdysozoa in 1997. Other ecdysozoans include the very diverse roundworms (nematodes), parasitic horsehair worms (nematomorphs) and two other phyla that share paired segmental appendages with arthropods: the Tardigrada (water bears) and Onychophora (velvet worms). Cambrian fossils from BSTs known as lobopodians are "worms with legs" that are now thought to include the closest relatives of each of the tardigrades, onychophorans and arthropods. These fossils that branch off before the most recent common ancestor of living diversity of a group (the descendants of which are called a crown group) are called a stem group. A picture of the sequence of steps by which arthropod evolved their diagnostic characters has largely been elucidated by study of stem-group arthropod fossils (Fig. 2).

The earliest branches of the arthropod stem group are known from large-bodied (even centimetres wide) Cambrian lobopodians. Their bodies are annulated, with transverse wrinkles but no chitinous skeletal plates like in later arthropods. They have a series of similar-looking trunk legs, which are also annulated like those of living onychophorans. They have one pair of specialised appendages, the anteriormost pair, which is enlarged and bears a battery of long spines along its inner margin. This frontal appendage pair was modified for prey capture. The guts of these earliest worm-like arthropods also show a specialisation for digestion of a novel kind of food via predation or scavenging: the midgut has a series of paired, kidney-shaped digestive glands with a network of internal canals.

Figure 3: Compound eye of the Cambrian radiodont Anomalocaris briggsi from the Emu Bay Shale (Cambrian Series 2, Stage 4), South Australia, showing hexagonal dense-packing arrangement of ommatidial lenses.

Anomalocaris and its relatives (collectively known as Radiodonta for their ventrally-placed mouth cone composed of a circlet of plates) are a later branching of the arthropod stem group. Unlike the earliest arthropods, which had an annulated frontal appendage, the frontal appendages of radiodonts are arthropodised, that is, composed of a series of sclerotised articles that are separated from each other by weakly sclerotised, membranous regions. This is the first instance of truly arthropodised appendages in the fossil record. Radiodonts also shed light on the origin of another key characters of arthropods, their compound eyes. Recent documentation of radiodont eyes from the Cambrian of Australia (Ref. 4) shows highly organised rows of lenses (Fig. 3), each compound eye being composed of thousands of visual units (ommatidia). In some species these rival dragonflies for their numbers of ommatidia, consistent with such species being visual predators.

Cambrian arthropods known from styles of preservation other than the carbonaceous compressions in BSTs also inform on major evolutionary questions. Secondarily phosphatised microfossils from a preservational style known as Orsten include larval and juvenile stages of Cambrian crustaceans as well as minute forms that lived between sand grains like today's meiofaunal arthropods (Fig. 4). So-called small carbonaceous fossils ("SCFs") can be extracted from mudstone using acid techniques borrowed from palynology and palaeobotany. Cambrian SCFs include the jaws and appendicular filter plates of Cambrian crustaceans. These stunning fossils allow us to date the origin of a few of the living crustacean groups and provide minimal ages to constrain molecular clock studies.

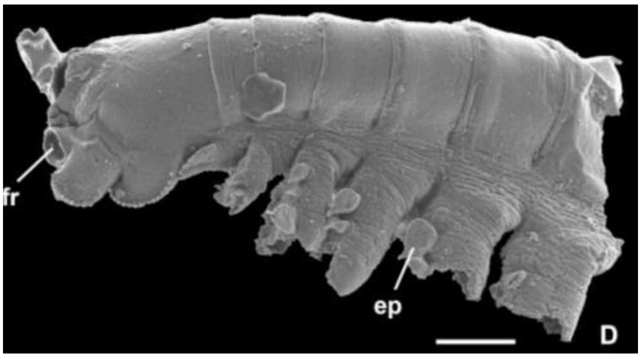


Figure 4: Scanning electron micrograph of posterior segments of the trunk of the 518 Ma Cambrian crustacean Yicaris dianensis, in Orsten-style phosphatic preservation. Ep, epipodite-like projections from the limb bases; fr, furcal rami at posterior end of the body. Scale 0.1 mm. (Image courtesy of Prof Xiguang Zhang)

Understanding the evolutionary origins of complex phenotypic novelties benefits from an integrative approach that draws on anatomy, molecular genetics, phylogeny, and fossil evidence. The origin of the unique mouthpart of insects, crustaceans and myriapods (centipedes and millipedes) exemplifies this approach (Ref. 1). Expression of segmentation genes confirmed evidence from neuronanatomy that the jaws (mandibles) of all these arthropods are found on the same segment of the head, and molecular phylogenetics confirmed evidence from classical comparative anatomy that the arthropods with mandibles on this segment are a natural group with a single evolutionary origin (named Mandibulata). Unique gene expression signatures of mandibles compared to the homologous appendage in chelicerates (e.g., spiders), which is a walking leg, provide additional evidence for a single origin of mandibles. Gene knockdown studies show which proteins play a role in differentiating the mandible as a jaw in the course of its development, rather than (ancestrally) having a form more similar to the next appendage behind it, a maxilla. Finally, Cambrian fossils in Orsten preservation provide a series of stem-group mandibulates (see *Martinssonia* and *Phosphatocopina* in Fig. 2), allowing the sequence by which an appendage that initially resembled a biramous trunk limb because specialised for manipulating and, ultimately, chewing food.

Fossils thus contribute to holistic evolutionary scenarios that draw on many different fields of biology, but they uniquely provide temporal signal for dating evolutionary events and they provide us with glimpses of vanished phenotypes that flesh out the Tree of Life.

Summary by Dr. Greg Edgecombe.

References

1. Edgecombe, G.D. 2017. Inferring arthropod phylogeny: fossils and their interaction with other data sources. Integrative and Comparative Biology, 57:467-476.
2. Edgecombe, G.D. 2020. Arthropod origins: integrating paleontological and molecular evidence. Annual Review of Ecology, Evolution, and Systematics, 51:1-25.
3. Giribet, G. and Edgecombe, G.D. 2019. The phylogeny and evolutionary history of arthropods. Current Biology, 29: R592-R602.
4. Paterson, J.R., Edgecombe, G.D. and García-Bellido, D.C. 2020. Disparate compound eyes of Cambrian radiodonts reveal their developmental growth mode and diverse visual ecology. Science Advances, 6, eabc6721.

Interesting Places 1

Icelandic Volcanic Eruption

Iceland saw a volcano erupt on the flank of Mt. Fagradalsfjall on the Reykjanes Peninsula. (CREDIT: Jeremie Richard/AFP via Getty)

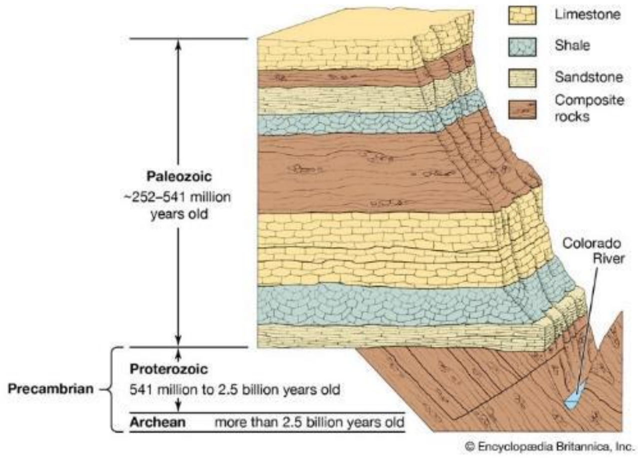
Thousands of people have flocked to a volcano in Iceland which erupted near the capital, Reykjavik. Lava started to burst through a crack in Mount Fagradalsfjall on the evening of 19 March 2021, in the first eruption of its kind for more than 800 years.

The current eruption activity can be viewed online: go to YouTube "Iceland Volcano - Live feed". This feed is maintained by the Iceland Broadcasting Corporation & currently focussed on Geldingadair Volcano nr Reykjavik. Use your mouse to slowly track back along the timeline to detect highlights. Compulsive watching! *Alan Whitehead*

Sun glinting off The Thames as viewed from Orbit

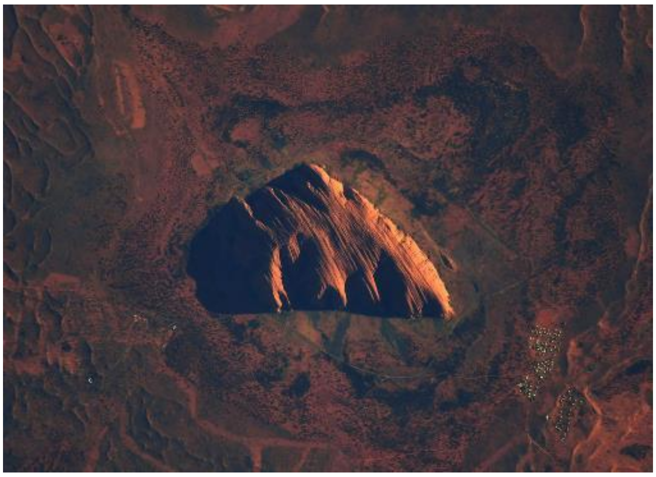
Thomas Pesquet: “This picture highlights London; see how the sunset shines off the Thames River and brings the attention to the capital city in particular”. *(Credits: ESA/NASA-T. Pesquet)*

Grand Canyon Rock Layering



The steep walls of the Grand Canyon contain a number of layers of sedimentary rock laid down over millions of years. The lower formations belong to the early Precambrian age, while the upper layers are of the Palaeozoic age. The line between the two sets of formations is called the Great Unconformity. *(Image: © Encyclopædia Britannica, Inc.)*

Uluru



June 1, 2021

Thomas Pesquet: “Uluru in the morning, this sacred site is understandably revered when you see it like this from space. Awe-inspiring!”

“The sandstone rock is known for changing colour, and from space I agree a sunrise or sunset changes its tone, glowing in the different lighting. The shadows in this picture made it easier to spot and helps it stand out, but the huge sandstone structure that is almost 3 km across is hard to miss”. (*Source: ESA*)

Article

UNESCO Geoparks

In this article **Liz Aston** describes the Geoparks of mainland Spain.

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.

Figure 1: Political Map showing Iberian Geoparks (in red).
(Image: https://www.onestopmap.com/iberian-peninsula-733/)

MAINLAND SPAIN'S GEOPARKS

The Courel Mountains

The Courel Mountains (Fig. 1, C) are located in the quiet NW corner of Spain, on the WAL (West Asturian Leonese) Zone *(see FGS Newsletter, May 2021, page 15).*

The mountain ranges lie on the Iberian Massif, characterized by high peaks and deep river valleys.

The site covers a surface area of ~580 km^2 and borders the Atlantic Ocean to the NW. The strata are dominantly Lower and Middle Palaeozoic – limestones providing good karstic features and caves; turbidite deposits – sandstones and shales showing recumbent folding (Figs. 2 & 3).

Figure 2: Hill Fort, Courel Mountains.

Figure 3. Cave in Courel Geopark.

The rivers Lor, Louzara, Quiroga, Soldón and Selmo have created deep valleys and canyons and the highest summits display glacial features.

Las Loras Geopark

Las Loras Geopark (Fig. 1, LL) is located in N Castilla, between the Castilian Plateau & Cantabrian Mountains

- This transitional location gives the region a wide range of environments and biodiversity of both Euro-Siberian and Mediterranean features.
- Limestone cliffs and high-altitude moorlands alternate with gorges and deep valleys.
- The area displays the stratigraphy and sediments of Mesozoic deposits in this part of the Basque-Cantabrian basin.
- There is an almost complete record from Late Triassic to Paleogene (~215 Ma to ~60 Ma) with exceptional outcrop conditions (Figs. 4 & 5).
- Examples of the fracturing and rifting, which occurred during Alpine orogeny (Upper Jurassic-Lower Cretaceous).
- There are important paleontological sites - Upper Jurassic floral macrofossils, skeletal

remains of a *Camptosaurus* (Fig. 6) and Upper Cretaceous rudists and coral colonies.

- Karst features and Mesozoic moorlands (Loras) are the key geographical features, several forts (castros) and human activities related to these loras give an exceptional coherence to sciences.

Figure 4: Limestone Ridge, Las Loras Geopark.

Figure 5: Limestone Pavement, Las Loras.

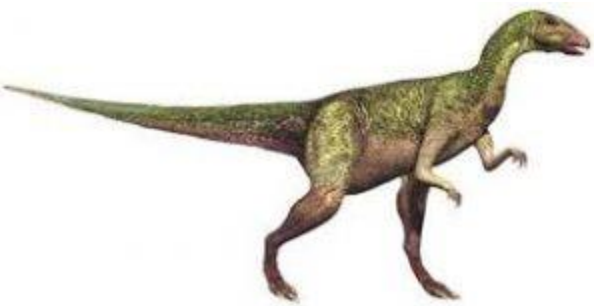


Figure 6: Camptosaurus.

The Basque Coast Geopark

The Basque Coast Geopark (Fig. 1, B) lies on the W coast of Gipuzkoa Province, Basque Country, N Spain and very close to France (Figs. 7, 8 & 9).

It is a mountainous area next to the Cantabrian Sea with heights of 1,000 m inland. The coastal strip is oriented ESE-WNW *(superb seafood!).*

- It comprises upper Triassic (215 Ma) to Middle Eocene (45 Ma) sediments with 5 mass extinctions.
- The coastal 5000 m thick flysch deposits are Palaeocene, ~60 Ma in age, formed during the opening and closure of the Bay of Biscay.
  - These flysch deposits are spectacular with all facies from proximal to distal and overbank deposits and used as a facies model for the early N Sea Palaeocene reservoirs (Forties etc.).
- The coastline shows active coastal abrasion.
- The interior has intense karstic erosion with >200 caves, pinnacle morphologies and poljes (Polish for limestone pavement).

Figure 7: Proximal Turbidite Sequences, Basque.

Figure 8: Limb of a fold with more distal turbidites, Basque.

Figure 9: Recumbent fold, part of alpine orogeny in the Pyrenees.

THE FOLLOWING GEOPARKS LIE IN CENTRAL IBERIAN MASSIF

The Villuercas Ibores Jara Geopark

The Villuercas Ibores Jara Geopark (Fig. 1, J) is located in SE Cáceres (in Extremadura, Spain).

Figure 10: Villuercas Ibores Jara Geopark

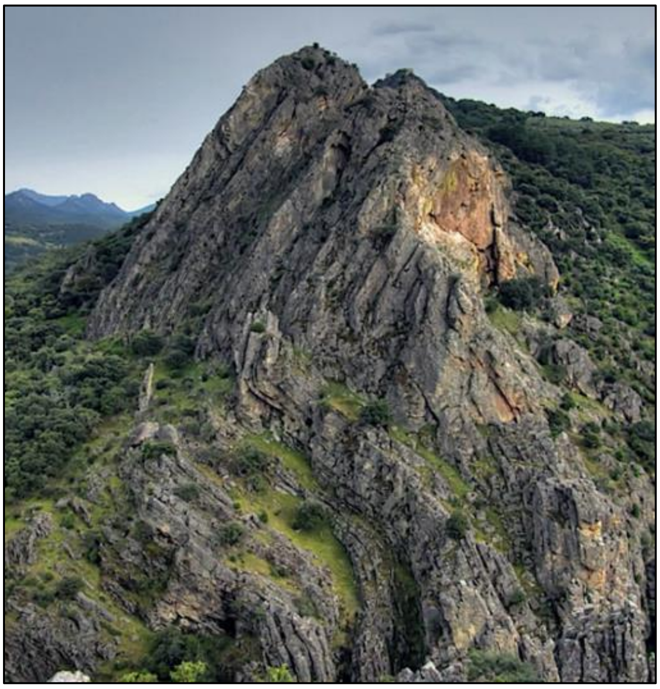


Figure 11: Villuercas Ibores Jara Geopark

The following list is present at this geopark:

- Intense folding and fracturing make an impressive landscape (Figs. 10 & 11).
- An inverted topography with elevated narrow Variscan synclines (residual Appalachian Relief) and Lower Palaeozoic siliciclastic rocks (including Armorican Quartzite), mark the highest topography.
- The anticlines include the oldest rocks in the area (Ediacaran greywackes, shale and carbonates), folded during the Cadomian Orogeny.
- The Alpine Orogeny resulted in a central (Villuercas) horst flanked by 2 graben with Neogene fluvial braided marginal sediments.
- The Pleistocene 'Rañas' include fluvial sediments that form a flat plain.
- The Ediacaran-Lower Cambrian is unique with mineralised metazoan Cloudina (Fig. 12) and ichnofossils.
- Lower Palaeozoic rocks yield trace fossils (Cruziana and Daedalus), trilobites, brachiopods and graptolites.

Figure 12: Nested cones of Cloudina.

- Important events are represented, notably the Cambrian and Ordovician explosions and the Ordovician mass extinction.
- The cave Castañar de Ibor is a Natural Monument with impressive aragonite crystal formations.
- 44 geosites are catalogued as ridges, hills and mountains, faults, river valleys, places with special geomorphological features such as synclines and anticlines, mines, and paleontological deposits.
- There are also birds, biodiversity corridors, monumental trees, and Biosphere Reserves, with cranes and raptors, griffon, black and Egyptian vultures, black storks, eagle owls and golden eagles. Some geosites have cave paintings.

Molina and Alto Tajo Geopark

Molina and Alto Tajo Geopark (Fig. 1, M) Castellana area of mountain range, between the watersheds of the rivers Ebro to the N and the Tagus to the S in the E interior of the Iberian Peninsula.

- A plateau at ~1100 m asl with mountains rising to 1500 m in the centre and 1900m in the S.
- Palaeozoic, Mesozoic and Tertiary sequences (Figs. 13 & 14).

- Palaeozoic to Mesozoic rocks were part of Pangaea with Upper Ordovician, Lower Silurian, Permo-Triassic and Lower Jurassic strata.
- The type section at Fuentelsaz includes this sedimentary record (best worldwide study area for the Toarcian-Aalenian boundary); outcrop of graptolites in Checa; Permian fossil trees in the Aragoncillo Mountains and Lower Silurian section in Checa, among others.

Figure 13: Limestone sequences Molina and Alto Tajo Geopark.

Figure 14: Typical cave in limestone rocks.

The Sierra Norte de Sevilla Geopark

The Sierra Norte de Sevilla Geopark (Fig. 1, S) in the central region of W Sierra Morena, a mountain range in S Spain, which separates the Central Plateau and the Andalusia Depression.

- It is flanked, to W by the 'Sierra de Aracena y Picos de Aroche' Park, and to the E by 'Hornachuelos' Park.
- The Geopark is part of the Iberian Massif, a part of the Variscan orogenic belt.
- All rocks are Upper Precambrian to Palaeozoic marine sediments, slightly metamorphosed.
- Several granite batholiths were emplaced during the Variscan orogeny or later.
- Overlying the Variscan mountains are sub-horizontal Upper Carboniferous, Permian and Triassic sediments - the fill of continental post-orogenic basins (Alanís San Nicolás del Puerto and Viar), are controlled by the main Variscan structures.
- Locally there are Quaternary deposits.

The Geopark has **an excellent museum** and >32 sites of geological interest including:

- The karst and mine complex (El Cerro del Hierro Monument), Lower Cambrian karst remains from Middle-Upper Cambrian erosion.
- The Valley Syncline, with Ordovician to Devonian sediments and an abundance of pelagic fossils.
- One site contains the highest concentration of impressions of Lower Cambrian jellyfish recorded in the Iberian Peninsula.

Figure 15: Tightly folded sediments, Sierra del Norte.

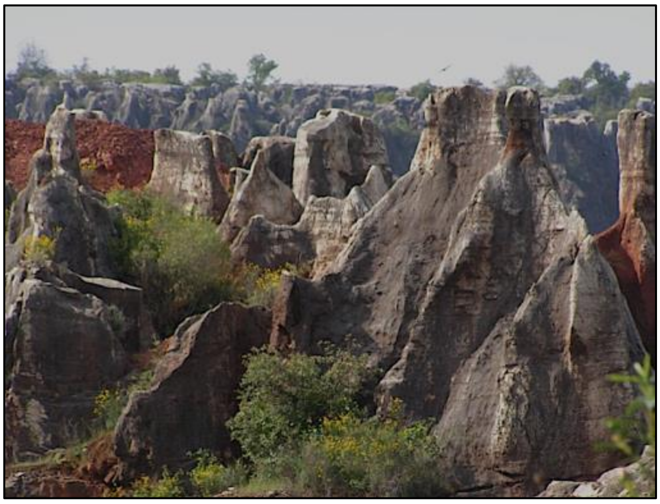


Figure 16: Heavily eroded peneplain, Sierra del Norte.

- Landscapes in the Geopark's abundant igneous rock outcrops.
- The 'Beja-Acebuches' amphibolites interpreted as remains of an ancient ocean floor, and a suture between tectonic plates.

- Permian and Triassic rocks represent the fill of post-orogenic continental basins.
- The waterfalls and travertine deposits in the Hueznar River.
- Mines and quarries, with over 30 ancient and recent mines.

Sierras Subbéticas Geopark

Sierras Subbéticas Geopark, (Fig. 1, SS) a mountainous area located in the central part of the 'Baetic Mountain Range' (South of Cordova province) coinciding with the geographical centre of Andalusia.

- The Geopark is noted for an impressive karstic landscape.

Figures 17 & 18: Vistas from the Mesozoic ammonite-rich limestones of the Sierras Subbéticas Geopark.

- Massive limestone and dolostone outcrop in the higher areas, with poljes (pavements), dolines (sinkholes), karrens (small scale solution features), a recently occurred ponor (small sink hole) and a dense network of cavities with ~900 caves and abysses.
- A continuous, well exposed series of ammonite-rich sediments from ~230 Ma ago.
- The area developed in the distal part of S Iberian Margin (External Zones of the Baetic Mt Range) during Mesozoic.
- The diversity and abundance of ammonites enable high resolution stratigraphic studies that show a complete record, especially involving the Jurassic-Cretaceous boundary.
- Aquifers provide fresh water which attracted the first humans to settle in the area during Palaeolithic times.
- The flora and fauna are particularly adapted to rocky environments and more than 1,200 plant species are catalogued; fungi are of exceptional interest, particularly truffles.

GEOPARKS LOCATED ALONG THE EASTERN MARGIN OF IBERIA

The Central Catalonia Geopark

The Central Catalonia Geopark (Fig. 1, CC), located in the heart of Catalonia with many geological and mining sites.

- >36 Ma ago, late Eocene, the Pyrenees rose and the sea covering much of Catalonia evaporated leaving marine evaporites halite, sylvite (potash) as spectacular rock formations.
- The overlying sediments are fluvio-lacustrine environments of the late Eocene to early Oligocene.
- The Catalan Potassic Basin is famous, and there are also the mountains of Montserrat and Sant Llorenç del Munt (ancient littoral fan deltas).
- Other areas have karstic elements (Saltpetre and El Toll Caves, Figs. 19 & 20) with prehistoric fauna and human remains.
- The most S areas have important Quaternary terrestrial vertebrate fossils in the fluvial terraces.

The Cabo de Gata-Níjar Geopark

The Cabo de Gata-Níjar Geopark (Fig. 1, CGN) is located in Andalusia, SE Spain, a subdesert area of Europe (Fig. 21).

- There are 39 geological sites, most are included in the Andalusian Inventory of Geological Sites.

- It faces the Mediterranean Sea, adjacent to the European / African Plate junction

Figure 19: Caves in the Geopark.

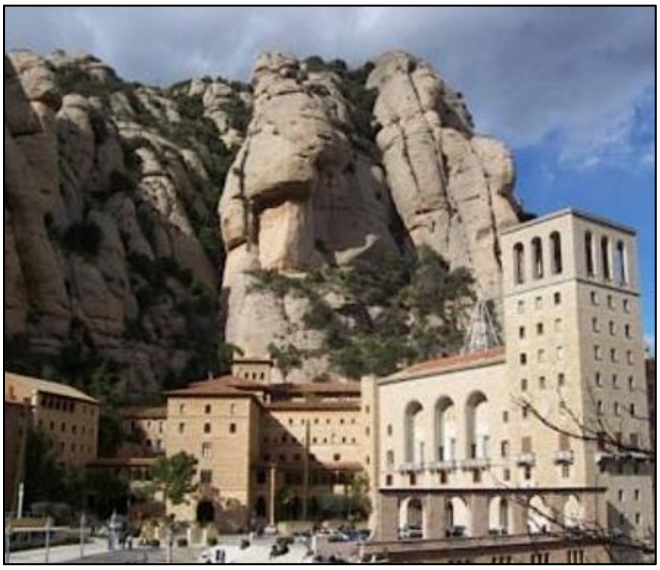


Figure 20: Limestone Cliffs.

Figure 21: Cabo de al Gata-Nijar

- The geodiversity includes:
    - Andesitic volcanic range of Cabo de Gata, an extensive complex ~16-8 Ma old with domes, lava flows, columnar jointing, & dykes. The most extensive and complex calc-alkaline volcanism in the Iberian Peninsula. Only 5% of the complex is exposed, the rest lies in the Alboran Sea.
    - Late Miocene (~11-7 Ma) reefs and Tyrrhenian Sea raised beaches, Quaternary alluvial and coastal deposits are also present – and a Wetland of International importance (Las Salinas).

Sobrarbe-Pirineos Geopark

Sobrarbe-Pirineos Geopark (Fig. 1, SP), located in N Spain, it comprises the entire territory of the Sobrarbe region, on S slopes of the Pyrenees bordering France.

- The lowest and the highest sites are a few km apart with reservoir El Grado at 475m, Llardana at 3375m. The climatic conditions range from Mediterranean to a high mountain climate.
- From N to S, this territory of 2,202km² has 4 main geomorphologic units:
    - Axial zone of Pyrenees are the oldest rocks (~500 Ma).
    - Mesozoic and Cenozoic limestones of the Inner Sierras form the most important massif in Europe, Monte Perdido, with peaks >3,000m.
- The relationship between tectonics and sedimentation are clearly visible in many sectors of the Geopark.

Figure 22

- Its main attraction is the formation of the Pyrenees: the disappearance of the Tertiary narrow sea, the collision of continents and the emergence of the mountain chain, then its erosion over the course of Ice Ages.
- Rocks cover 500 Ma - from Cambrian to Quaternary and show the effect of 2 orogenies, Variscan and Pyrenean.
- Quaternary processes - glacial, periglacial, karst and rivers were all active.
- Glaciers Monte Perdido, Marboré and Llardana are still active. Erosive and depositional

morphologies of all phases from the Pleistocene glaciers to the Little Ice Age are clearly visible in the area.

- Karst features are especially abundant and the fluviokarstic ravines are a characteristic feature of Sobrarbe.
- The Cinca and Ara rivers created terraces, the glaciers left moraines, landslides complete the wide range of morphologies and active processes present in the Geopark.

Figures 23 & 24: Images from Sobrarbe-Pirineos Geopark.

Conca de Tremp-Montsec Geopark

Conca de Tremp-Montsec Geopark (Fig. 1, CT), in NE Spain, close to the borders of France and Andorra, it lies along the ECORS-Pyrenees section, which is the most representative seismic cross-section of the Pyrenean range.

- There is a set of E-W mountain ranges and basins corresponding to the various overthrust nappes making up the S slope of the Central Pyrenees.
- In N, the Axial Pyrenean zone has the oldest rocks of the range.
- In the S, there are minor intermontane sedimentary basins developed when thrust sheets were formed (Tremp basin, Àger basin).
- The geological record covers the past 550 Ma with fossils of vertebrates, invertebrates and plants with a complete Mesozoic stratigraphy.
- It is internationally recognized as a supreme area for sedimentology, tectonics, external geodynamics, palaeontology, ore deposits and soil science.
- The Upper Cretaceous sediments have bones, tracks and eggs of the last dinosaurs in Europe.
- There are late synorogenic conglomerates (Middle Eocene-Oligocene) in some internal parts of the system. (Figs. 25 & 26).

Figure 25: Complex structure of folds and a thrust belt, note the vertical shear planes? transcurrent.

Figure 26: Mont-Rebei gorge, with its vertical walls of Upper Cretaceous limestones.

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

THE PYRENEES

The Pyrenees formed in a collisional orogen.

- In W Pyrenees, beneath N Pyrenean Zone, a continuous band of high-density material is found at ~10km, beneath the Mauleon basin and near Saint-Gaudens; it is the Result of N subduction of Iberian crust, down to 50–70km depth.
- In E Pyrenees, these main structural features are not observed.
    - The boundary between E and W domains is a major change in structure of the Cretaceous rift system.

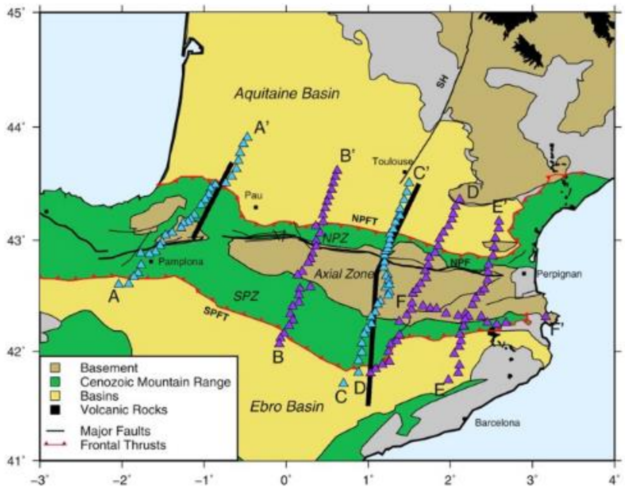


*Figure 27: Main geological and structural units of Pyrenees. **NPF:** N Pyrenean Fault. **NPFT**: N Pyrenean Front Thrust. **SPFT**: S Pyrenean Front Thrust. **SH**: Sillon Houiller (also 'Toulouse Fault'). **NPZ**: N Pyrenean Zone. **SPZ**: S Pyrenean Zone. Triangles are seismic stations.*

- The Iberian and Eurasian plates converged between late Cretaceous to early Miocene (~85 - 20 Ma).
- The mountain belt is a stack of Iberian and European crustal units (B-B', Fig. 28) forming a doubly convergent orogenic wedge:
    - The Axial Zone (AZ), Hercynian basement rocks.
    - The North Pyrenean Zone (NPZ), thick Mesozoic sediments.
    - The South Pyrenean Zone (SPZ), a fold-and-thrust belt.
    - Junction between AZ and NPZ is the North Pyrenean Fault (NPF), a major thrust fault and interpreted as the former plate boundary between the Iberian and European plates (D-D', Fig. 28).

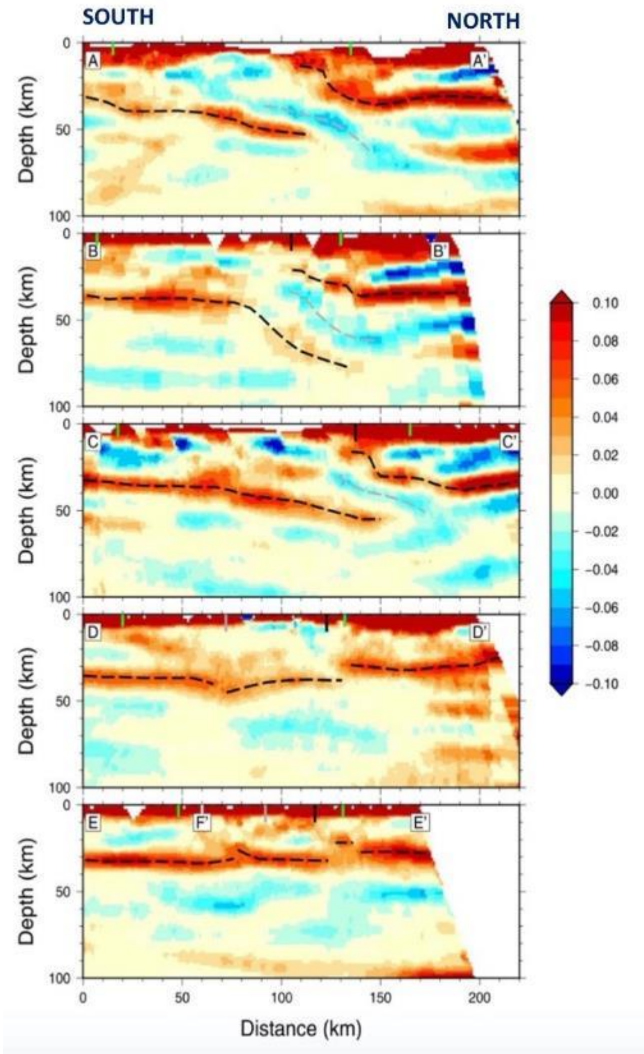


Figure 28: Sections through the crust and upper mantle. Lines shown in Figure 27; top to bottom: (A-A'), (B-B'), (C-C'), (D-D'), (E-E').
Black dashed lines: Iberian and European Moho's.
Grey dashed line: top of subducting Iberian crust.
Vertical lines: Faults SPFT, NPFT (green); NPF (black); Têt F (grey).

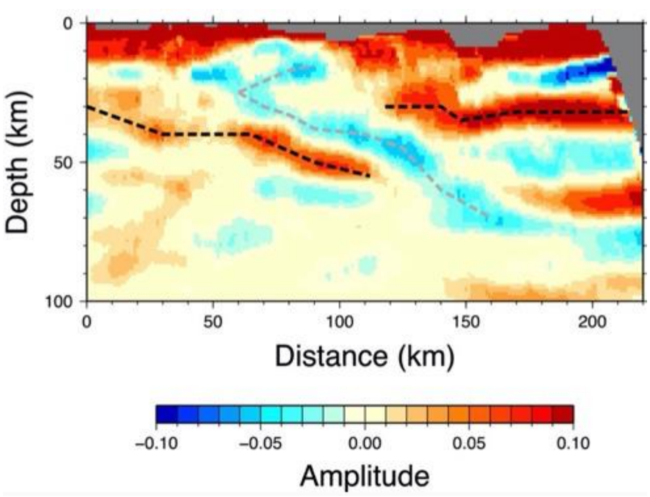


Figure 29: Expanded view of W Transect of A-A' in Figure 28.

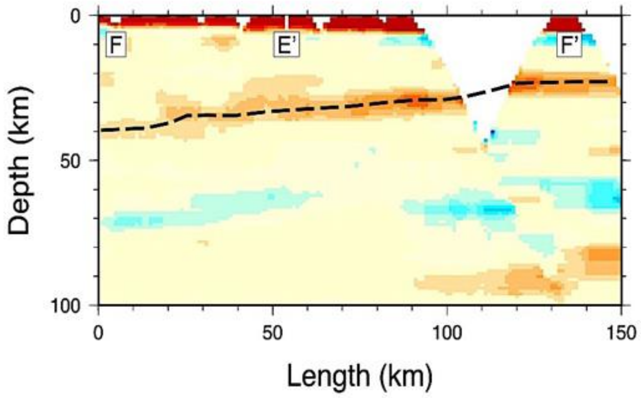


Figure 30: Crossing of E-E' with F-F'. The crossing point is shown as 'E' online F-F' and as 'F' on line E-E' on Figure 28.

Figs. 31 & 32 show simpler views of the convergent wedge formed by the collision of two separate crustal units (i.e., cratons) – Iberia in the S and Europe in the N. Note the junction between the Iberian and the Eurasian Plates extends down into the mantle.

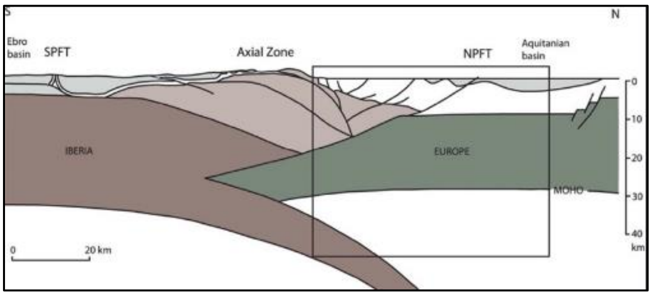


Figure 31: Geological cross-section of the Pyrenees showing the Ebro and Aquitaine Basins.

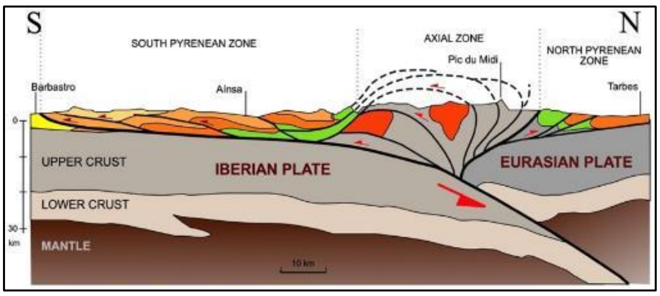


Figure 32: Geological cross-section of Pyrenees showing the true structural complexities.

- The South Pyrenean Frontal Thrust (SPFT, Figs. 31 & 32) comprises thrust slices from the Sierras Marginales and lateral equivalents which are displaced S over the Ebro Basin.
- The Pyrenees are flanked by two foreland basins, the Aquitaine (AB) and Ebro (EB) basins, which are respectively overthrust by the NPZ and the SPZ (Fig. 28, C-C').
- The roots of the Pyrenees are clearly asymmetrical (Figs. 28, 31 & 32).

Figure 33: Ossoue glacier and Pic Montferrat in the Vignemale massif. (Photo: Thibautsl - own work)

Figure 34: Pic du Midi d'Ossau, remnant of a Permian volcanic edifice

- Strong positive anomalies are seen on N flank of the mountain belt, in the NPZ, produced by a mantle body lying at ~10km depth (black dashed lines on Fig. 28).
- Mantle exhumation (uplift and erosion) occurred during Aptian rifting.
- There is N underthrusting of the Iberian plate (Fig. 28, B-B') beneath the European and the mountain root is made of thickened Iberian crust there.
  - Underthrusting of the Iberian plate only occurs in W and Central Pyrenees and exhumed mantle is present in the N Pyrenean Zone (Fig. 29).

Description of Pyrenees *(Wikipedia)*

- The Pyrenees are 430km long, striking ~WNW-ESE, from Bay of Biscay (in W) to Golfe du Lion and Golf de Roses (in E), and varying between 65-150km wide.
- The mountain chain now divides France, Spain, and Andorra.
- The rocks date back to the Precambrian.

- The collision of the plates was from ~100 to 55-25 Ma, i.e., Upper Cretaceous (Albian / Cenomanian) to Palaeogene (Eocene/Oligocene).
- After uplift, there was intense erosion and isostatic readjustments.
- The cross-section shows an asymmetric flower-like structure with steeper dips on N, French, side.
- There is also an important sinistral shearing as the peninsula swung round and the Bay of Biscay opened.

Geologically, the Pyrenees continue further W into the Basque-Cantabrian chain, disappearing at Asturias. Likewise further E, they reappear as the nappes of Corbières into Bas Languedoc and S Provence, where typical Pyrenean fold trends are superimposed by Alpine structures and finally cut off by the W Alps arc. The Pyrenean chain in this larger sense is ~1000km long.

Typical views are shown below in Figs. 35 & 36. Structural map and interpretations are shown in Fig. 37.

Figure 35: Monte Perdido an internal sedimentary thrust unit of NW S Pyrenean Zone.

Figure 36: Maladeta, granodiorite massif, Axial Zone, glacier, and Palaeozoic cover sediments (in front).

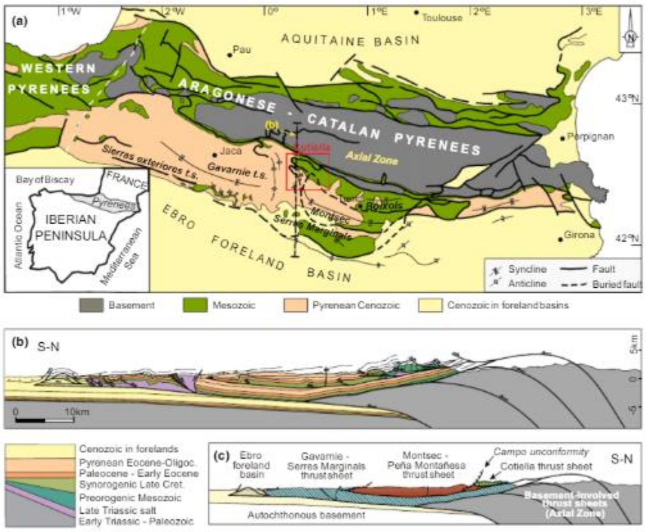


Figure 37: Another version of the structural units or tectonic zones - nappes and thrusts.
López-Mir et al, 2014. Fig. 1: Location of the Cotiella basin in the south-central Pyrenees.
a. Structural sketch showing the main structural units of the Pyrenees (modified from Muñoz et al. 2000). The location of the studied area is depicted in red, and the location of the cross section below is represented with a thick dashed line.
b. Cross section depicting the regional-scale structure of the central portions of the South Pyrenean thrust system. Note that the cross section is sometimes oblique to the plunge of the structure. It results from a compilation of existing works (Losantos et al. 1988; Teixell and García-Senz 1994; Sans et al. 1996; Teixell and Muñoz 2000).
c. Structural sketch indicating the structural units depicted in the cross section above.

There were 2 major orogenic cycles:

First Pre-Alpine Orogenic Cycle

- Neoproterozoic Precambrian (? Cadomian) remnants seen in basement of Canigou massif, Agly:
    - Gneisses, meta-sediments (~580 Ma old, thick flysch deposits of mudstone-sandstones) and migmatites of amphibolites and granulites intruded by meta-granites.
    - These remnants were later incorporated into the Variscan orogen by tectonic movements and associated metamorphism.
    - Ordovician conglomerates, sandstones, limestones and volcanic rocks, accumulated in a partly glaciomarine

environment with unstable tectonic conditions.

- Fossiliferous Silurian sediments include clean sandstones, shales, with calcareous horizons and nodules – the shales have acted as major décollement surfaces.
- The Devonian is marine and rich in fossils - in W Pyrenees with shallow marine reef limestones, and sandstones; in E Pyrenees, deep water turbidites predominate.
- In W Pyrenees, an unconformity separates Devonian and Lower Carboniferous; limestones are overlain by pre-orogenic cherts with black, phosphate nodules and black shales, ending with pyroclastics and grey nodular limestones.
- These pass up into synorogenic turbidites with limestones, conglomerates, carbonaceous breccias and olistoliths (canyon deposits) and as submarine fans in a SW migrating foredeep.

Variscan Orogeny

The Variscan orogeny is represented by a major unconformity within the Carboniferous succession, ~310 Ma ago. The effects of this orogeny are:

1. Compressional stresses that folded the Palaeozoic sediments
    a. several periods of fold are sometimes superimposed on each other.
2. Metamorphosed under HPLT conditions, sometimes melting the rocks.
3. Late-orogenic magmatism with granites and occasional gabbros; some are deep-seated, rather diffuse, intrusive bodies associated with migmatites, others are well-defined plutons rising into the cores of anticlines within the Variscan fold-belt.
4. The main magmatism was from 310–270 Ma (late Carboniferous to early Permian), e.g., Maladeta granodiorite 280 Ma old.
5. Late-stage fracturing was under brittle conditions due to reactivation of Palaeozoic faults. These fault zones run WNW-ESE, the Pyrenean trend, e.g., N Pyrenean Fault.
6. These fault zones played a decisive role during subsequent tectonic events.

Figure 38: Part of the ophiolite peridotite from N Pyrenean Zone, L'Étang de Lers, Ariège.

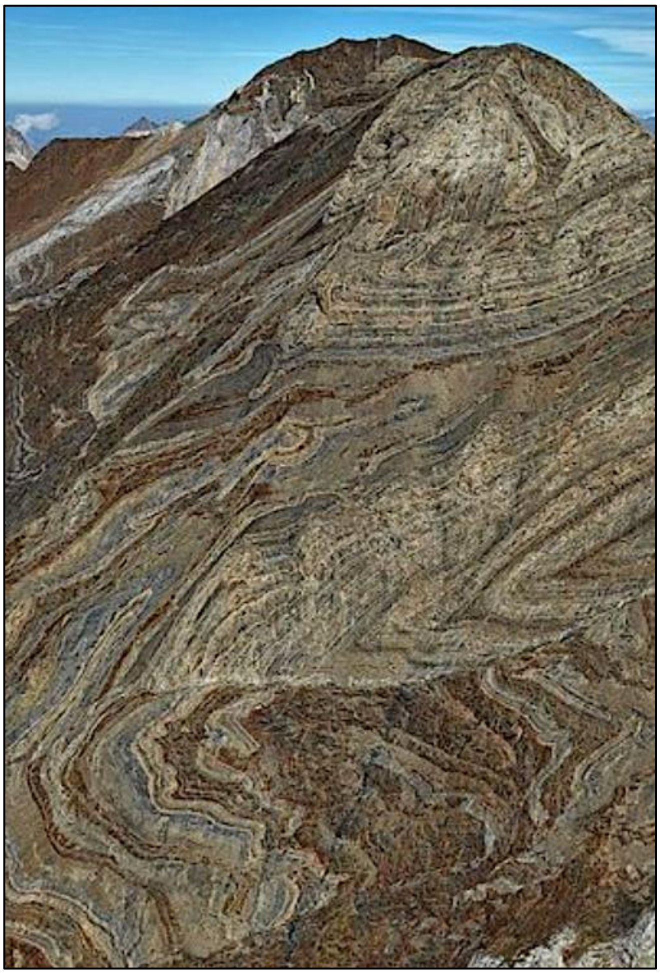


Figure 39: Llardana massif, Central Pyrenees. Result of Alpine Orogeny collision between Spain and Europe during Upper Cretaceous and Palaeocene time. Tight synforms in nappes overlying left dipping thrust planes. A classic example of the minor structures showing the major structures – enormous nappes in this case (refer back to Figs. 32 & 37b).

Alpine Orogeny

Rapid erosion of the Variscan mountain chains resulted in deposition of 2500m of Upper Carboniferous to Upper Triassic terrestrial red beds, coal measures and basaltic-andesitic lavas (Fig. 34). These sequences occur in the Basque Pyrenees and Axial Zone. The trigger for the volcanism was wrenching of Iberia relative to the Eurasian Plate.

A gradual marine transgression spread over the entire Pyrenean domain with varied evaporites forming in lagoons and graben. The evaporites served later as major decollement horizons. Later submarine fissure eruptions and a carbonate platform developed. The basin was under tension with long horst/graben formed by Variscan fractures.

Further transgressions in Triassic and Jurassic then reversed into a regression leaving evaporites. Later, open-marine conditions continued for much of the Lower Jurassic, then falling sea levels continued into the Middle Jurassic. Near Pau an oolite barrier grew and extended N to Poitiers. It divided the sedimentary basin into two domains: a deeper W domain opened to the Atlantic and a shallow, enclosed, E domain. Towards the end of the Middle Jurassic, sea levels fell even further.

Cenozoic

There were distinct differences between E and W Pyrenees:

- In the W, marine shelf facies and the flysch basin carried on subsiding, with deposits of limestones, marls, sandstones with shallow and benthic water fauna.
- In the E, continental red beds accumulated, mainly alluvial and swamp facies. At the same time, the first tectonic uplifts affected the E Pyrenees.
- In the N Pyrenean Zone short-lived transgressions and regressions occurred with some conglomerates. A very thick conglomerate, Poudingues de Palassou, represents the Pyrenean Main Phase, which was accompanied by very strong folding and uplift - ~50 to 40 Ma ago.
- On the S side of Pyrenees in Catalonia, folded conglomerates are 44 to 37 Ma old.

The **Pyrenean Main Phase** - on both sides of the axial zone there are reverse faults and thrusts with large displacements. In N thrusting was to the N, and in S to the S; this was not symmetrical; the S (Spanish) side has lower dipping structures.

In Miocene times, the uplifted orogen underwent severe erosion with molasse deposits being deposited in the foreland basins - the Aquitaine Basin. In the Pliocene, renewed uplift led to the formation of huge alluvial fans at the mountain front, e.g., Lannemezan alluvial fan. Several peneplanes occur at different heights (3000-2000m in Axial Zone, ~ 1000m in Pays de Sault, ~400m in Agly massif and ~100m in Corbières). They generally become lower in the east.

Neogene sediments are preserved in small graben close to the Mediterranean (Cerdagne); these have repeatedly been flooded by the Mediterranean (Ampurdan and Roussillon).

During the Quaternary, the Pyrenees experienced several glaciations, but of far less intensity than the Alps. Large glaciers advanced through the valleys of the Gave d'Ossau (Fig. 33), Gave de Pau, Garonne, and Ariège in N. Today about 20 smaller true glaciers as well as cirques and glacier remnants subsist (Aneto glacier, Ossoue glacier, Vignemale, glaciers on Maladeta and Monte Perdido). All these glaciers have undergone a large retreat since 1850 due to global warming. The total glaciated surface area amounted to 45 km^2 in 1870, whereas in 2005 a mere 5 km^2 were left.

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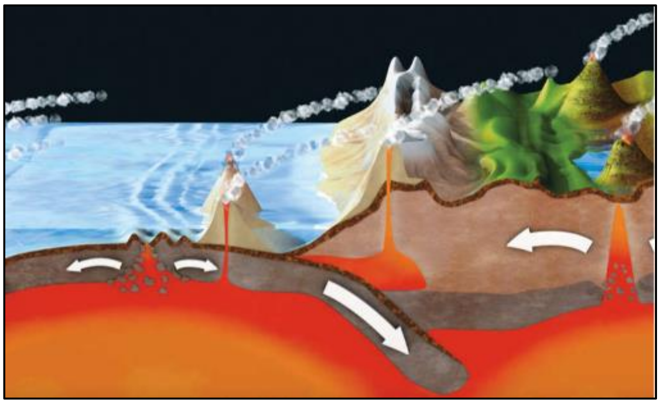
Earth's liquid hot interior is 'swallowing up' more carbon than thought

Harry Cockburn, The Independent
28 July 2021

The tectonic plates that make up the Earth's crust are in perpetual slow motion – colliding, pulling apart, or rubbing past one another in a slow dance of creation and destruction on an epic scale.



The movement of the tectonic plates cause volcanoes and create mountains, and ocean trenches. (Image: Getty©)

But new research has revealed that these huge geological movements — which we feel as earthquakes and whose power we see as volcanoes, tsunamis, mountains or trenches — actually play a role in sequestering carbon.

Scientists from Cambridge University and Nanyang Technological University in Singapore have found the collisions of tectonic plates drag more carbon into Earth's interior than previously thought.

Their research has revealed that the carbon drawn into Earth's interior at subduction zones – where tectonic plates collide and dive into our planet's molten interior – tends to stay locked away at depth, rather than then resurfacing in the form of volcanic emissions.

The study suggests only about a third of the carbon recycled beneath volcanic chains returns to the surface via recycling, in contrast to previous theories that what goes down mostly comes back up. This could have implications for understanding the climate crisis we face today.

One of the solutions for tackling the environment emergency caused by runaway greenhouse gas emissions is to find ways to reduce the amount of CO_2 in Earth's atmosphere.

By studying how carbon behaves in the "deep Earth", which houses the majority of our planet's carbon, scientists can better understand the entire lifecycle of carbon on Earth, and how it flows between the atmosphere, oceans and life at the surface.

Currently, the most closely studied parts of our planet's carbon cycle are the processes occurring at or near the Earth's surface.

However, deep carbon stores also play a key role in maintaining the habitability of our planet by regulating atmospheric CO2 levels, the scientists said.

"We currently have a relatively good understanding of the surface reservoirs of carbon and the fluxes between them, but know much less about Earth's interior carbon stores, which cycle carbon over millions of years," said lead author Stefan Farsang, who conducted the research at Cambridge's Department of Earth Sciences.

There are a number of ways for carbon to be released into the Earth's atmosphere as CO2, but there is only one path in which it can return to the Earth's interior: via the slow process of plate subduction.

When this occurs, surface carbon, for instance in the form of seashells and micro-organisms which have locked atmospheric CO2 into their shells, is gobbled up into the Earth's liquid-hot interior.

Scientists had thought that much of this carbon was then returned to the atmosphere as CO2 via emissions from volcanoes. But the new study reveals that chemical reactions taking place in rocks swallowed up at subduction zones trap carbon and send it deeper into Earth's interior, thereby stopping some of it coming back to Earth's surface.

The research is published in the journal *Nature Communications.*

Reference:

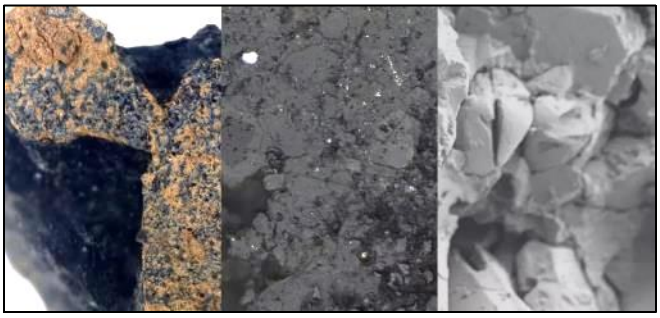
1. https://www.msn.com/en-gb/news/world/earth-s-liquid-hot-interior-is-swallowing-up-more-carbon-than-thought/ar-AAMDeKi?ocid=msedgdhp&pc=U531
2. https://www.independent.co.uk/climate-change/news/carbon-tectonic-plates-subduction-environment-b1891612.html

Another specimen of the Carbonaceous Chondrite found in March 2021

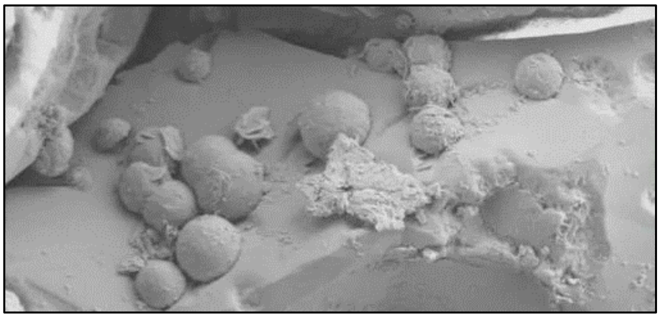
21 July 2021

A crumbling piece of rock was found in a field in Gloucestershire in March by Derek Robson, a resident of Loughborough and the director of astrochemistry at the East Anglian Astrophysical Research Organisation. The meteorite was sitting in the imprint of a horseshoe left behind in a field.

It is a carbonaceous chondrite, a rare category of meteorites that makes up only 4% to 5% of meteorites that are found on Earth. These meteorites hail from the asteroid belt between Mars and Jupiter and formed early in the history of the solar system about 4.567 Ga ago.



Three views of a rare carbonaceous chondrite found in England: with the naked eye (left), with an optical microscope (middle) and with an electron microscope (right). This type of meteorite is commonly formed of a collection of particles held together relatively loosely. (Image credit: Derek Robson/The Loughborough Materials Characterisation Centre)



At high magnification using an electron microscope, spherical mineral beads called chondrules (<1mm) are visible, embedded in the meteorite. (Image credit: The Loughborough Materials Characterisation Centre)

The meteorite contains organic, or carbon-bearing, compounds, including the amino acids that make up the basic building blocks of life. This raises questions about whether these meteorites hold clues to how living things first emerged in the solar system.

The rock is small, charcoal-coloured, and fragile and made of olivine* and phyllosilicates** mainly with round grains called chondrules (partially molten beads from the Solar Nebula) incorporated into the rock when it first formed.

"The composition is different to anything you would find here on Earth and potentially unlike any other meteorites we've found — possibly containing some previously unknown chemistry or physical structure never before seen in other recorded meteorite samples," Shaun Fowler, a microscopist at Loughborough University, said.

"At this stage, we have learned a good deal about it, but we've barely scratched the surface," Sandie Dann, a chemist at Loughborough University, said in the statement.

**Olivine is a common mineral ((Mg, Fe) SiO_4) on Earth found in basalt lavas, oceanic crust and the mantle of the Earth).*

***Phyllosilicates are also common minerals on Earth - mica, chlorite, serpentine, talc, clay minerals.*

Reference:

Originally published in *Live Science*. Summary of article by Stephanie Pappas in *Space.com*, July 2021. Modified by Liz Aston, B.SC., ULSS, CGeol, FGS Chair, Farnham Geological Society

https://www.livescience.com/rare-carbonaceous-carbonate-meteorite-found.html

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'Part-time adventurers': amateur fossil hunters get record haul in Cotswolds

More than 1,000 scientifically significant specimens taken from former quarry after discovery

Miranda Bryant, The Guardian
21 July 2021

When Sally and Neville Hollingworth started going stir crazy in lockdown, rather than baking bread or doing quizzes on Zoom, the amateur palaeontologists turned to Google Earth.

The couple passed the time planning for their next trip – using the satellite images to inspect sites that had previously yielded fossils – when they stumbled across a quarry in the Cotswolds. From the exposure of the geology Neville, who has a PhD in geology, could tell the site was promising, but he was not expecting it to yield one of the best fossil finds in the UK in decades.

Sally Hollingworth (left) with her husband Neville (centre) and Dr. Tim Ewin from the Natural History Museum as they inspect a slab during the dig in the north Cotswolds.
Photograph Credit: Andrew Matthews/PA

Their 167 Ma discovery has been described by the Natural History Museum as the largest find of Jurassic echinoderms – a group of animals that includes starfish, brittle stars, and feather stars – ever found in the UK.

"As soon as lockdown lifted, we got permission and had a look around the quarry," said Sally, 50, who works in accounts for a construction company in Swindon.

Initially, she said the slab they took home from the quarry "looked a little bit boring" but after preparing it in the garage, Neville, 60, was soon shouting for her to come and have a look.

Frozen in time: Fossilised seafloor animals from the Jurassic, all piled on top of each other. Photograph: BBC Science

So far, more than 1,000 scientifically significant specimens have been excavated from the site – the exact location of which is not being made public – including an unprecedented collection of rare feather stars, sea lilies and starfish fossils. They have also found three new species: a type of feather star, a brittle star, and a sea cucumber. Experts say the discovery will provide key information that will contribute to explaining the evolutionary history of these sea creatures.

"They look pretty boring and then you start revealing all this detail and the preservation is just amazing," she said. "I'm looking at this poor little critter, 167 Ma old. It's unreal isn't it. These little guys were around when the dinosaurs were about."

When they realised the importance of what they had found, the couple contacted Dr. Tim Ewin, a senior curator for invertebrate palaeontology at the Natural History Museum, at the end of last year. He said he immediately knew from the pictures that "we had something quite special on our hands". But because of coronavirus restrictions it was months before he could investigate further.

Ewin said: "We couldn't act straight away because of Covid restrictions and things like that, which just got worse and worse. So, it was a little bit frustrating having to sort of hang on tenterhooks for the restrictions to ease so we could go out and investigate the site a bit more."

After a week extracting specimens from the site – which is no bigger than two tennis courts and would have been underwater 167 Ma ago – he confirmed the find was of global significance.

He said: "It's the greatest collection in terms of the quality of the preservation, just the sheer numbers of the individuals and the diversity of the individuals."

The single specimen discovered by the Hollingworths was in itself "really exciting". But, he added, the fact that they could trace the bed across the quarry floor "and get even more specimens in greater numbers is just unprecedented and incredibly exciting".

He added: "I feel very honoured to be lucky enough to be alive at the right time that this find was made."

The Hollingworths have previously found a complete mammoth skull from the ice age, but nothing of this gravity. "We say we're full-time admin bods but part-time adventurers," said Sally, who returned to the site earlier this year to celebrate her 50th birthday with a picnic.

"We always say let's go out, travel with hope and not expectation and take a good picnic and have a good day out and if we find any treasure it's a bonus. But I think this has been a crazy journey so far and of course this is just the beginning of the journey."

After three days of excavating the site, the team have collected 100 slabs of clay, which are being prepared for future study and which the museum hopes to put on public display.

Note

Dr. Tim Ewin presented to the FGS on 9 October 2020. His excellent talk introduced members to the exquisitely preserved Ophiuroids (commonly known as "brittle stars") discovered by Robert Randall in 2013 in the Southerham Grey Pit, a 21-acre geological Site of Special Interest, southeast of Lewes in East Sussex. It is a Geological Conservation Review site.

Dr. Tim Ewin is a senior curator at the Natural History Museum with specific responsibilities for the fossil echinoderm collections. He is also manager of the Earth Sciences Invertebrates and Plants 'A' Division.

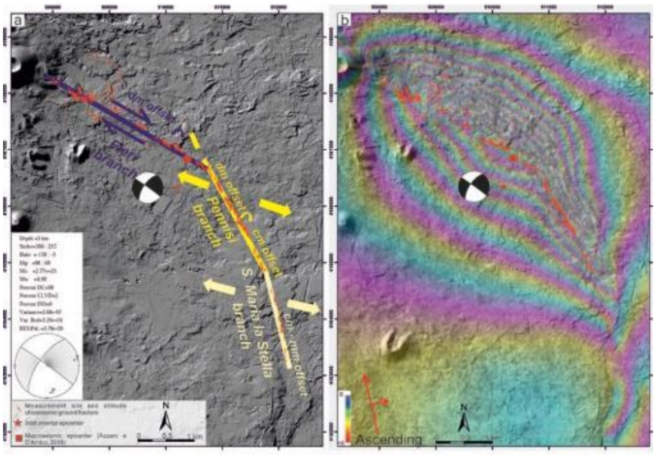
Reference:

1. https://www.theguardian.com/science/2021/jul/21/part-time-adventurers-amateur-fossil-hunters-get-record-haul-in-cotswolds
2. https://www.bbc.co.uk/news/science-environment-57853537

Volcano — Tectonic interactions at Etna

Mapping of a 2018 earthquake that ruptured the eastern flank of Mount Etna shows that it occurred on a tectonic lineament that predates the volcano, and the kinematics match nearby tectonic domains.

By Judith Hubbard, Associate Editor, Tectonics
6 July 2021



An arc-shaped coseismic shear belt associated with the 2018 Mw 4.9 earthquake at Etna volcano shows up on both mapping and InSAR.

Mapping and InSAR both highlight the arc-shaped coseismic shear belt associated with the 2018 Mw 4.9 earthquake at Etna volcano. The various dextral strike-slip fractures along the Fleri branch match the stress field of the broad Sicily collision zone, which controls the Late Quaternary contractional deformation in the southwestern portion of Mount Etna. In contrast, the two branches to the southeast, which together form the northern section of the Fiandaca normal fault, produced oblique (dextral) normal faulting and are associated with a major tectonic boundary that was active as an extensional feature throughout the Late Quaternary. Credit: Romagnoli et al. [2021], Figure 17

Volcanoes and earthquakes are intrinsically linked: both are outcomes of Earth's dynamic plate tectonics. However, they are hard to study in unison. This is because they are often spatially separated by hundreds of kilometres, they are largely based in different types of science (earthquakes occur in the brittle crust; volcanoes are driven by melt), and approaches to monitoring them can be very different, since volcano science aims for predictions while earthquake science relies primarily on long-term forecasts.

When an earthquake occurs on a volcano, it is therefore often treated as a volcanic event – one not only triggered by volcano-related deformation, but also responding to the volcano and providing information about the volcano.

When a Mw 4.9 earthquake occurred on the eastern flank of Mount Etna, several papers promptly described how the earthquake indeed matched to a dyke intrusion. In contrast, *Romagnoli et al. [2021]* take a broader view. Their careful measurements of fault offset, and interpretation of the tectonic setting led them to a different conclusion: while the event may have been triggered by the volcano, the deformation patterns are controlled by long-term tectonics. The geometry of the south-eastern part of the rupture matches to a major tectonically active lineament that extends offshore, accommodating tectonic extension. To the northwest, approaching the volcano, the rupture splinters into a series of en echelon conjugate fractures; here, the slip patterns match the stress field of the broad Sicily collisional zone, which controls the deformation in this region.

Thus, long-term tectonics, rather than short-term volcanic deformation, seems to be responsible for both the geometry and the slip patterns in this event – although the volcano may have helped to trigger it.

This leaves room for further studies, as the authors point out: if earthquakes are telling us about regional tectonics rather than transient volcanic behaviour, we may be able to use observations of past earthquake deformation to better understand the tectonics, and then leverage that understanding into a better forecast of future earthquakes.

Reference:

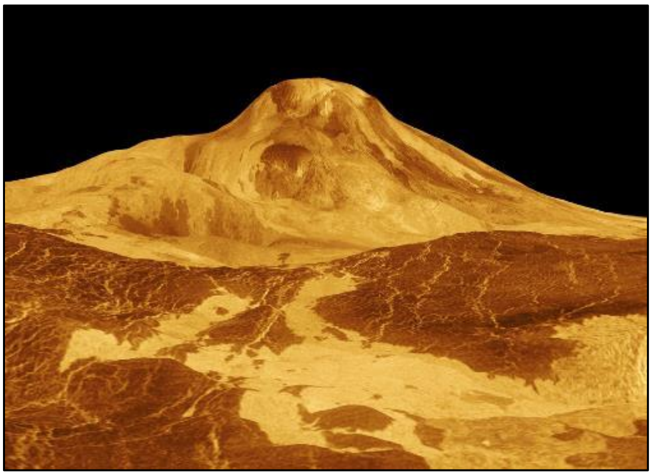
1. Romagnoli, G., Pavano, F., Tortorici, G., & Catalano, S. [2021]. The 2018 Mount Etna earthquake (Mw 4.9): Depicting a natural model of a composite fault system from coseismic surface breaks. Tectonics, 40, e2020TC006286. https://doi.org/10.1029/2020TC006286
2. https://eos.org/editor-highlights/volcano-tectonic-interactions-at-etna&utm_campaign=ealert

New research suggests explosive volcanic activity on Venus

Press Release: CORNELL UNIVERSITY
12 July 2021

Traces of the gas phosphine point to volcanic activity on Venus, according to new research from Cornell University.

Last autumn, scientists revealed that phosphine was found in trace amounts in the planet's upper atmosphere. That discovery promised the slim possibility that phosphine serves as a biological signature for the hot, toxic planet.



Venusian volcano (Image: ©NASA)

Now Cornell scientists say the chemical fingerprint support a different and important scientific find: a geological signature, showing evidence of explosive volcanoes on the mysterious planet.

"The phosphine is not telling us about the biology of Venus," said Jonathan Lunine, professor of physical sciences and chair of the astronomy department at Cornell. "It's telling us about the geology. Science is pointing to a planet that has active explosive volcanism today or in the very recent past."

Lunine and Ngoc Truong, a doctoral candidate in geology, authored the study, "Volcanically Extruded Phosphides as an Abiotic Source of Venusian Phosphine," published July 12 in the *Proceedings of the National Academy of Sciences*.

Truong and Lunine argue that volcanism is the means for phosphine to get into Venus' upper atmosphere, after examining observations from the ground-based, submillimetre-wavelength James Clerk Maxwell Telescope atop Mauna Kea in Hawaii, and the Atacama Large Millimetre/submillimetre Array (ALMA) in northern Chile.

If Venus has phosphide - a form of phosphorous present in the planet's deep mantle - and, if it is brought to the surface in an explosive, volcanic way and then injected into the atmosphere, those phosphides react with the Venusian atmosphere's sulfuric acid to form phosphine, Truong said.

Lunine said their phosphine model "suggests explosive volcanism occurring," while "radar images from the Magellan spacecraft in the 1990s show some geologic features could support this."

In 1978, on NASA's Pioneer Venus orbiter mission, scientists uncovered variations of sulfur dioxide in Venus' upper atmosphere, hinting at the prospect of explosive volcanism, Truong said, similar to the scale of Earth's Krakatoa volcanic eruption in Indonesia in 1883.

But, Truong said, "confirming explosive volcanism on Venus through the gas phosphine was totally unexpected."

Reference:

http://spaceref.com/venus/new-research-suggests-explosive-volcanic-activity-on-venus.html

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Scientists say new dinosaur species is largest found in Australia

BBC Science
8 June 2021

An artist's impression of the Australotitan - Australia's largest dinosaur. (IMAGE COPYRIGHT: QUEENSLAND MUSEUM)

Scientists in Australia have classified a new species of dinosaur, discovered in 2007, as the largest ever found on the continent. The *Australotitan cooperensis* or "the southern titan", is among the 15 largest dinosaurs found worldwide.

Experts said the titanosaur would have been up to 6.5m tall and 30m long, or "as long as a basketball court".

Its skeleton was first discovered on a farm in south-west Queensland. Palaeontologists had worked over the past decade to identify the dinosaur - distinguishing it from other known species by comparing scans of its bones to those of other sauropods.

Sauropods were plant-eating dinosaurs known for their size. They had small heads, very long necks, long tails, and thick, pillar-like legs.

These dinosaurs roamed the continent during the Cretaceous Period, about 92 to 96 Ma ago.

The team of researchers had nicknamed the dinosaur Cooper while working on it, after the nearby Cooper Creek where it was found.

The identifying process had been a lengthy one due to the remote location of the bones and their size and delicate condition. But many of the remains were found intact, said researchers from the Queensland Museum and the Eromanga Natural History Museum.

The team found the Australotitan was closely related to three other sauropod species - the Wintonotitan, Diamantinasaurus and Savannasaurus.

"It looks like Australia's largest dinosaurs were all part of one big happy family," said Dr Scott Hocknull, one of the lead researchers.

The bones were first found in 2007 on a family farm near Eromanga, which was owned by two of the dinosaur researchers, Robyn and Stuart Mackenzie.

"It's amazing to think from the first bones discovered by our son, the first digs with the Queensland Museum, through to the development of a not-for-profit museum that runs annual dinosaur digs, all have helped us to get to this point, it's a real privilege," Stuart Mackenzie said.

The Queensland state government welcomed the classification on Tuesday, calling it a boon for local dinosaur discovery.

"Australia is one of the last frontiers for dinosaur discovery and Queensland is quickly cementing itself as the palaeo-capital of the nation - there is still plenty more to discover," said Dr Jim Thompson, chief executive of the Queensland Museum Network.

Reference:

https://www.bbc.co.uk/news/world-australia-57394830

Underwater avalanche continued for two whole days

Jonathan Amos, BBC Science correspondent 7 June 2021

Scientists are reporting what they say is the longest sediment avalanche yet measured in action.

It occurred underwater off West Africa, in a deep canyon leading away from the mouth of the Congo River. Something in excess of a cubic kilometre of sand and mud descended into the deep. This colossal flow kept moving for two whole days and ran out for more than 1,100km across the floor of the Atlantic Ocean.

The event would have gone unrecorded were it not for the fact that the slide broke two submarine telecommunications cables, slowing the internet and other data traffic between Nigeria and South Africa in the process.

And also because of the prescient action of researchers who had lined the length of the Congo Canyon with instruments capable of measuring current and sediment velocities.

"We had a series of oceanographic moorings that were hit by the event, which broke them from their seafloor anchors so that they popped up to send us an email," said Prof Peter Talling from Durham University, UK. "This thing gradually got faster and faster. Because it erodes the seabed as it goes, it picks up sand and mud, which makes the flow denser and even quicker. So, it has this positive feedback where it can build and build and build," he told BBC News.

The underwater avalanche - more properly called a turbidity current - was initiated on 14 January last year. It's only being reported now because scientists needed time to recover the sensors and fully analyse their data.

The Lower Congo River ('Livingston rapids')

Source: Nasa WorldView BBC

The flood in December 2019 saw 70,000 cubic metres of water per second pass Kinshasa. This deluge was responsible for pushing sediment to the head of the offshore canyon.

The team says two factors combined to prime and then trigger the prodigious flow. The first was an exceptionally large flood along the Congo River in late December 2019. A 1-in-50-year occurrence, this delivered vast quantities of sand and mud to the head of the underwater canyon. But this was still two weeks before the slide.

What followed in January, however, were some unusually big spring tides.

"The turbidity current we think was triggered at low water, at low tide," said Prof Dan Parsons from Hull University. "As the loading of the ocean above declines, so you get a change in the pore water pressure within the sediment - and that's what allows it to fail.

"But first you have to load the dice by delivering the sediment. Then the tidal signature can kick everything off."

The analysis shows the turbidity current reached the shallowest of the team's velocity profilers at 22:31 GMT on 14 January 2020 and arrived at the final instrument almost 24 hours later at 21:01 GMT on 16 January. By that stage the slide had reached an ocean depth of more than 4,500m.

The team had an early assessment of the speeds involved simply by noting the times when their sensors surfaced.

The recovery of the profilers, though, enabled the rough velocity calculations to be properly calibrated.

This showed the flow initially travelled at 5.2m/s in the upper canyon, but then continuously sped up to 8m/s by the time it reached the end of the channel.

Prof Talling and colleagues have detailed the event in a White Paper aimed particularly at the international submarine cable sector.

There are important lessons on how to mitigate risks.

It's obviously not possible to predict with certainty when a damaging turbidity current will occur but knowing something about the conditions that trigger sediment failures could influence the global positioning of cable repair ships.

The occurrence of another flood along the Congo River like the one experienced in December 2019 would make it wise to keep a vessel on standby in the region, for example.

The two cables that broke in mid-January 2020 - the South Atlantic 3/West Africa (SAT-3/WASC) cable and the West Africa Cable System (WACS) - were repaired within a few weeks. But there have been additional breaks since as further sediment has tumbled downslope.

One interesting finding concerns why some cables get severed and others do not. This may relate to differences in erosion rates along the flow path.

In some areas, the turbidity current will dig deep into the seafloor, while in others, large amounts of sand and mud are dumped.

The Congo study is the first to document this patchwork effect of erosion and deposition.

"This is new information for the cable industry and is being used to design new routes in this and other canyons - to avoid the areas that are most likely to experience deep erosion (immediately upstream of steep steps in the canyon that look like underwater waterfalls, known as 'knickpoints') as this will leave the cable more vulnerable to damage," explained Dr Mike Clare, a marine geoscientist at the UK's National Oceanography Centre and who advises the International Cable Protection Committee.

It's hard to overstate the importance of the global submarine cable network. More than 99% of all data traffic between continents goes through these connections, including daily money transfers to the value of trillions of dollars.

The research in the Congo Canyon has wide-ranging participation, including from IFREMER (Institut Français de Recherche pour l'Exploitation de la MER) in France and GEOMAR Helmholtz Centre for Ocean Research in Germany. The project is co-led from Durham and Angola Cables.

Reference:

https://www.bbc.co.uk/news/science-environment-57382529

The rise and fall of the world's largest lake

Sid Perkins, Science
4 June 2021

When continental plates smashed together about 12 Ma ago, they didn't just raise new mountains in central Europe—they created the largest lake the world has ever known. This vast body of water—the Paratethys Sea—came to host species found nowhere else, including the world's smallest whales. Two new studies reveal how the ancient body of water took shape and how surrounding changes helped give rise to elephants, giraffes, and other large mammals that wander the planet today.

At its largest, the megalake Paratethys (shown superimposed on modern geography) stretched from the eastern Alps to today's Kazakhstan. (Image: DAN PALCU; NATURAL EARTH)

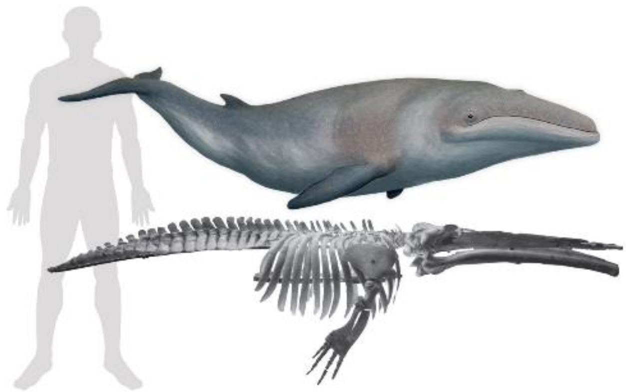
To build that timeline, paleo-oceanographer Dan Palcu of the University of São Paulo and his colleagues at the main campus assembled clues from geological and fossil records. At its largest, the body of water—which some scientists consider to have been an inland sea—stretched from the eastern Alps into what is now Kazakhstan, covering more than 2.8 million square kilometres. That's an area larger than today's Mediterranean Sea, they write this week in *Scientific Reports*. Their analyses further estimate the lake once contained more than 1.77 million cubic kilometres of water, more than 10 times the volume found in all of today's fresh- and saltwater lakes combined.

But climate shifts caused the lake to shrink dramatically at least four times in its 5 Ma lifetime, with water levels falling by as much as 250 meters between 7.65 Ma and 7.9 Ma ago. During that largest episode of contraction, the lake lost as much as one-third of its water and more than two-thirds of its surface area. That sent water salinity in the lake's central basin—which closely matches the outlines of today's Black Sea—skyrocketing, from about one-third as salty as today's oceans to a level on par with seawater.

Those shifts wiped out many aquatic species, including numerous species of single-celled algae and other small free-floating organisms, the researchers report. Creatures that could survive the brackish water, including some molluscs, survived to repopulate the lake when it expanded during wetter times, Palcu says.

The Paratethys soon became home to a wide variety of molluscs, crustaceans, and marine mammals found nowhere else on Earth. Many of the whales, dolphins, and seals living there were miniature versions of those found in open seas, says evolutionary biologist Pavel Gol'din of the National Academy of Sciences of Ukraine's I. I. Schmalhausen Institute of Zoology, who was not involved with the work. One species, the 3-meter-long *Cetotherium riabinini*—1 meter shorter than today's bottlenose dolphin—is the smallest whale ever found in the fossil record. Such dwarfism might have helped these animals adapt to a shrinking Paratethys, Gol'din says.

The changes to the climate that triggered lake shrinkage also influenced the evolution of land animals, says evolutionary biologist Madelaine Böhme of the University of Tübingen. As water levels dropped, the newly exposed shorelines became grasslands—and hot spots for evolution, she notes.



The Paratethys Sea was home to many species found nowhere else, including Cetotherium riabinini (depicted with human for scale), the smallest known whale in the fossil record.
(Image: PAVEL GOL'DIN; LENA GODLEVSKA/WIKIMEDIA COMMONS)

Recently, Böhme and her colleagues focused on the geological record in western Iran, where sediments chronicle repeated long-term changes in climate. The fossil record shows that in areas north of the Paratethys, the ancestors of modern-day sheep and goats roamed side by side with primitive antelope. And in what is now western Iran, south of the lake, the progenitors of today's giraffes and elephants thrived.

Four lengthy dry periods that occurred between 6.25 Ma and 8.75 Ma ago likely drove those creatures to migrate south-westward into Africa, Böhme and her colleagues reported last month in *Communications Earth & Environment*. Here, they evolved to produce the diversity of creatures for which today's African savanna is famous.

The Paratethys was destined for a sadder fate. It ceased to exist sometime between 6.7 Ma and 6.9 Ma ago, when erosion created an outlet at the lake's southwestern edge. This outlet—which is likely now submerged beneath the Aegean Sea—

birthed a short river that eventually found its way to the Mediterranean. But the massive lake had one last hurrah, Palcu says: The water draining from it likely carved "an impressive waterfall" as it flowed down to the sea.

Reference:

Posted in: EarthOceanography
doi:10.1126/science.abj8351
https://www.sciencemag.org/news/2021/06/rise-and-fall-world-s-largest-lake?utm_source=Nature+Briefing&utm_campaign=d53d405e33-briefing-dy-20210611&utm_medium=email&utm_term=0_c9dfd39373-d53d405e33-45768786

NASA plans return to Venus with two missions by 2030

Nasa sets aside $1bn for two ventures, which will be first US exploration of the planet since 1989

Richard Luscombe,
The Guardian Science
2 Jun 2021

Nasa is returning to Venus for the first time in more than three decades to gain a better understanding of the history of what scientists believe could have been the first habitable planet in the solar system.

Plans for two separate and ambitious deep space missions to Earth's nearest neighbour were announced on Wednesday by the head of the US space agency, Bill Nelson. Launches were targeted for a 2028-2030 time frame, he said.

'It will be as if we have rediscovered the planet,' said Tom Wagner, lead scientist of Nasa's discovery program. (Photograph: NASA/JPL-CALTECH/AFP/Getty Images)

Nasa has set aside $1bn (£700m) in developmental funding for the two ventures, which will be the first US exploration of the planet since 1989. The Magellan spacecraft that managers sent plunging into the oblivion of Venus's atmosphere in 1994 at the end of its five-year mission provided never-before-seen imagery of the planet's cratered and volcanic surface that Nasa now seeks to research further.

"It is astounding how little we know about Venus, but the combined results of these missions will tell us about the planet from the clouds in its sky through the volcanoes on its surface all the way down to its very core," Tom Wagner, lead scientist of Nasa's discovery program, said. "It will be as if we have rediscovered the planet."

The first mission selected by the space agency from a shortlist of four concepts first announced in February 2020 is **Davinci+** (deep atmosphere Venus investigation of noble gases, chemistry and imaging).

It will measure the composition of the planet's atmosphere to understand how it formed and evolved, as well as determine whether the planet ever had an ocean, Nasa said.

It will also send back the first high-resolution pictures of Venus's geological features known as tesserae, which scientists believe are comparable to Earth's continents.

The second mission, known as **Veritas** (Venus emissivity, radio science, InSAR, topography and spectroscopy), will map Venus's surface to determine the planet's geologic history and understand why it developed so differently than Earth. Images of surface elevations will allow the creation of 3D reconstructions of topography and provide clues to whether volcanic activity is still taking place.

The magazine *Scientific American* heralded the announcement as Nasa breaking its so-called "Venus curse", in which the space agency is perceived to have allowed explorations of other planets to languish at the expense of a recent focus on Mars.

Thomas Zurbuchen, Nasa's associate administrator for science, hailed what he called "a decade of Venus, to understand how an Earth-like planet can become a hothouse".

"Our goals are profound," he said. "It is not just understanding the evolution of planets and habitability in our own solar system, but extending beyond these boundaries to exoplanets, an exciting and emerging area of research for Nasa."

Reference:

https://www.theguardian.com/science/2021/jun/02/nasa-venus-return-two-missions

Giant tortoise found in Galápagos a species considered extinct a century ago

Reuters in Quito
26 May 2021

Galápagos tortoise found alive revealed as species thought extinct 100 years ago. (Photo by Rodrigo BUENDIA / AFP)

Ecuador has confirmed that a giant tortoise found in 2019 in the Galápagos Islands is a species considered extinct a century ago.

The Galápagos national park is preparing an expedition to search for more of the giant tortoises in an attempt to save the species.

The turtle was found two years ago on Fernandina Island, one of the youngest and most pristine in the archipelago, during a joint expedition between the Galápagos national park and the Galápagos Conservancy.

Scientists from Yale University then identified it as the *Chelonoidis phantasticus* species, which had been considered extinct more than a century ago.

"Yale University revealed the results of genetic studies and the respective DNA comparison that was made with a specimen extracted in 1906," the Galápagos Park said in a statement.

In the Galápagos Islands, which served as the basis for the British scientist Charles Darwin's theory of the evolution of species in the 19th century, many varieties of tortoises live together with flamingos, boobies, albatrosses and cormorants, a family of species of aquatic birds. It also houses a large amount of flora and fauna in danger of extinction.

"It was believed extinct more than 100 years ago! We have reconfirmed its existence," the environment minister, Gustavo Manrique, wrote on his Twitter account.

The current population of giant tortoises from various species is estimated at 60,000, according to data from the Galápagos national park.

One was known as "Lonesome George", a male Pinta Island tortoise, the last known of the species, who died in 2012 without leaving any offspring.

Reference:

https://www.theguardian.com/world/2021/may/26/galapagos-giant-tortoise-found-species-considered-extinct

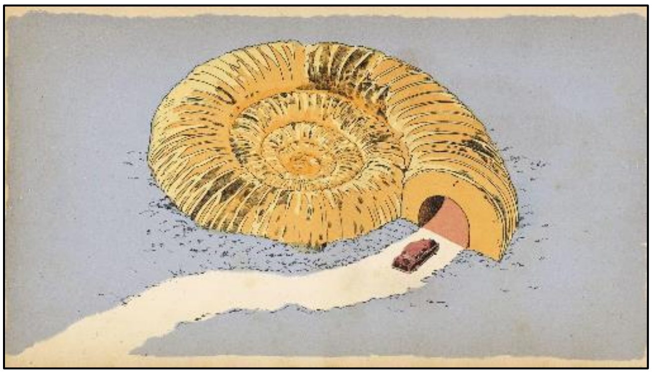
How will our cities fossilise?

By David Farrier
6 May 2021

The grand metropolises of 21st Century civilisation will leave a geological legacy that will last for millennia, but as the author David Farrier writes, some things will endure far longer than others.

It seemed as though the whole world had been buried in concrete. Perhaps it was jetlag, but the view was dizzying: the city, pouring away to the horizon in every direction. Shanghai is one of the world's largest metropolises. From the viewing platform of the Shanghai Tower, the second tallest building in the world, it looked endless – a wave of skyscrapers rippling outwards, fading to a blue blur of residential blocks in the far distance.

The modern cityscape is as much geological as it is urban. If Shanghai is a concrete desert, New York is the original canyon city, its skyscraper-lined streets forming deep valleys of the kind that, in the past, only great rivers could create over thousands of years. In a late essay, Virginia Woolf pictured herself swooping like a bird over the Hudson estuary, past Staten Island and the Statue of Liberty to the concrete chasms of Manhattan. "The City of New York, over which I am hovering," she wrote in 1938, "looks as if it had been scraped and scrubbed only the night before. It has no houses. It is made of immensely high towers, each pierced by a million holes."



(Image credit: Emmanuel Lafont)

The first cities replicated the environments that once-nomadic people depended on, concentrating shelter and sustenance in one place. The metropolis of the present offers its inhabitants the whole planet in microcosm. As the author Gaia Vince writes, the buildings and infrastructure of the urban landscape simulate "the high view of mountains, the protection of dry caves, the fresh water of lakes and rivers".

If cities have a geological character, it begs the question of what they will leave behind in the stratigraphy of the 21st Century. Fossils are a kind of planetary memory of the shapes the world once wore. Just as the landscapes of the deep past are not forgotten, how will the rock record of the deep future remember Shanghai, New York and other great cities?

You might assume that cities are too ephemeral to leave behind a fossil. "Most buildings are designed to last for 60 years," says Roma Agrawal, structural engineer for the Shard skyscraper in London. "And I always thought, that feels really short, because that's my lifetime." If you wanted to build something that would stand in tens of thousands of years, "then the forces that you need to contend with become huge", she explains. Most engineers don't look that far ahead.

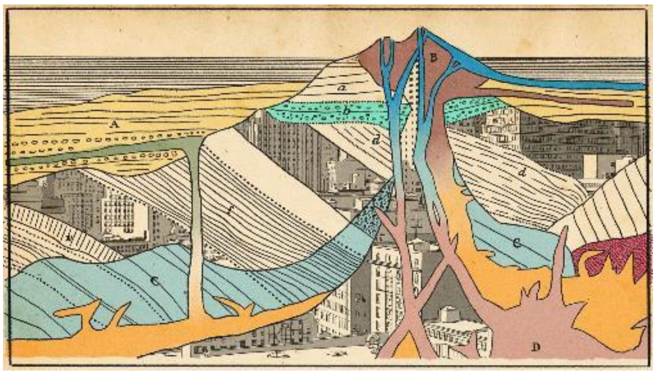
But while a building might not be designed to stand tall for millennia, that does not mean it will lack a geological legacy. According to Jan Zalasiewicz, emeritus professor of palaeobiology at the University of Leicester, it is "a quite reasonable, even prosaic, geological prediction" that a megacity will leave a fossil. I asked him how he could be so certain. "As a geologist, you'd almost put the question the other way around," he replied. "How can you prevent this?"

It's a matter, he says, of durability, abundance, and location. The main components of a modern city have their origins in geology and are therefore, in their different ways, highly durable. The majority of the world's iron ore formed nearly two billion years ago. The sand, gravel, and quartz in concrete are among the most resilient substances on Earth. These hard-wearing materials once existed in natural deposits. But where before it was only water, gravity, or tectonic activity that moved them, now it's a combination of human initiative and hydrocarbon fuels.

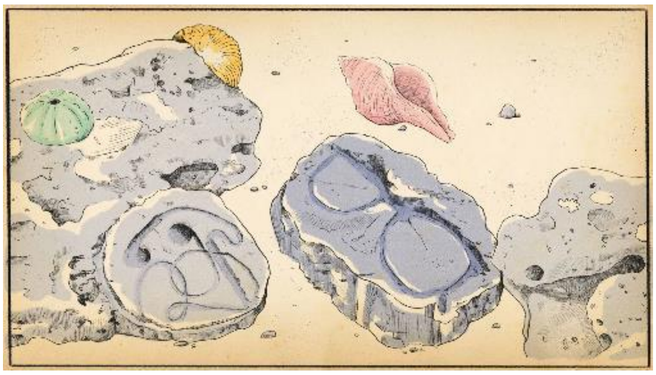
With skyscrapers at its core, Shanghai's concrete desert stretches to the horizon. (Credit: Emmanuel Lafont)

We live in the greatest age of city-building the world has ever seen. Three hundred years ago, there was only one city with a population of one million (Edo, modern-day Tokyo). Today there are more than 500, all of them dwarfed by megacities like Mexico City (population: 21 million), Shanghai (24 million), and Tokyo (now 37 million). As I discovered while researching my book *Footprints: In Search of Future Fossils*, the quantities of materials involved are staggering. Every 100 years, the mining and construction industries move enough rock around the planet to create a new mountain range, 40km wide, 100km long, and 4km high (25 x 62 x 2.5 miles). Enough concrete has been cast since World War Two to cover the entire planet, land and sea. According to a recent study in the journal Nature, there is now a greater mass of buildings and infrastructure on the planet (1,100 Gigatonnes) than trees and shrubs (900 Gigatonnes).

Location matters in determining the kind of fossil a city will leave. In geological terms, land is never static – either climbing or sinking on a "tectonic elevator". A city like Manchester in the UK, which is situated on ground still rising after the last ice age, will erode entirely over time, washing a trail of brick, concrete, and plastic particles out into the Irish Sea. "But many of the world's largest cities are deeply anchored in the mouths of deltas and coastal plains," says Zalasiewicz. "And they're subsiding. Deltas sink, that's what deltas do." In many cases, human activity is massively hastening this process. Since 1900, Shanghai has sunk by



From plastic to glass, a city's components are geological in nature, and much will be preserved. (Credit: Emmanuel Lafont)



Many human-made objects – the paraphernalia of a city – will endure. (Credit: Emmanuel Lafont)

2.5m (8ft) due to groundwater extraction and the weight of its buildings pressing into marshy ground. Added to which is sea level rise, which could exceed a metre by 2100. "But even without sea level rise," says Zalasiewicz, "it would be inexorable, because the subsidence is steady."

What about a particular structure? Shanghai Tower weighs 850,000 tonnes: a 632m-tall (2,073ft) steel framework with more than 20,000 panes of glass, and 60,000 cubic metres (2.1 million cubic feet) of concrete. How will it fossilise?

"Let’s say Shanghai will behave as Amsterdam and parts of the Mississippi delta are behaving now, where sediment is pouring in," says Zalasiewicz. "You will get progressive changes over thousands and hundreds of thousands, and millions and then tens of millions of years."

Like other wealthy cities, Shanghai will be vigorously defended against sea level rise, but climate feedback loops mean that the oceans will creep upwards for centuries to come. When the water does become unmanageable, there will likely be a slow abandonment, with the wealthiest leaving first. Poorer people, with nowhere to go, may have to adapt to semi-submerged conditions. Over several hundred years, the upper levels of Shanghai Tower will decay as wind and water erode them. Perhaps they’ll be weakened, too, by scavengers harvesting valuable materials. If the lowest levels have managed to remain above water, only the bottom one or two storeys will remain standing, surrounded by a rubble layer of fallen debris.

The inevitable inundation may come from the sea, or from the collapse of the massive Three Gorges Dam higher up the Yangtze River. But as it floods, the water will bring vast amounts of mud and sediment that will cover the ground floor and subsurface levels like a wax seal. After 500 years, only a low-lying island would remain where the tower once stood, streaked red by oxidised iron left over from the four immense steel super columns that once held it in place. The real story will be below ground.

Shanghai Tower has five subsurface levels, including shops and restaurants and parking space for 1,800 vehicles. Entombed in thick mud, these spaces will be preserved against erosion and begin to fossilise – "the Pompeii effect, if you like," says Zalasiewicz.

Almost immediately, water making its way down to the lowest levels it will react with the calcareous material in concrete, to form cathelmites – stalactite- and stalagmite-like growths that form in human-made environments. These will continue to grow for thousands of years, transforming the shopping mall into something akin to a horror movie set. If humanity is still around, most things of value will have been stripped out before the Tower is completely abandoned, but perhaps not everything. Aluminium in the ventilation system, stainless steel in the food court – maybe even a few cars in the garage levels will be left to perform remarkable transformations.

At first the car will simply rust but, as iron dissolves well in anoxic water, once the oxygen level decreases its metal components will begin to dissolve. Or perhaps a part of the chassis will mineralise, reacting with sulphides to form pyrite. The iron in steel beams or embedded in reinforced concrete, kitchen implements, or even tiny quantities of iron in the speaker of a mobile phone will all acquire a glittering sheen. Even whole rooms – a food court kitchen fitted with stainless steel worktops – might be transformed into fool’s gold.

Plastics, protected from the harsh effects of weathering and UV light, will be among the most patient materials. "No one knows exactly how long they will last," says Zalasiewicz, "but an analogy might be drawn with another long-chained

What will our descendants make of the glass screens and rare earth metals of our smartphones? (Credit: Emmanuel Lafont)

polymer." If a bug happens to become stuck in some melted plastic before the Tower is sealed off, it may be preserved like the insect in amber in Jurassic Park.

Over time, the plastic will carbonise and become brittle. Sheets of aluminium in heating ducts will link up with silicates and slowly change into China clay, providing a perfect environment for fossilisation. One hundred thousand years after the tower was abandoned, the clay will have hardened into shale studded with the ghostly impression of plastic knife handles, light switches, or the knob of a gear stick.

The story continues even deeper underground. The entire Shanghai Tower sits on top of a concrete raft, one metre thick and covering nearly 9,000 sq m (97,000 sq ft). Beneath this are 955 concrete-and-steel piles, each a metre in diameter, driven up to 86m (282ft) deep into soft ground. After several million years, as the weight of the sea water and sediment warps the subterranean layers beyond recognition, some of the foundation piles will fracture, twisting within compacting mudrock formations like the fossil roots of an immense, long-vanished tree.

As millions of years stretch into tens of millions, the transformations come more slowly. Rare earth minerals, leached from discarded mobile phones and other electronic devices, may begin to form secondary mineral crystals. Glass from windshields and shop windows will devitrify, darkening just as obsidian does after long burial. By now, the entire city is compressed to a layer perhaps only a few metres thick in the strata. All that is left of Shanghai Tower is a geological anomaly studded with the fossil outlines of chopsticks, chairs, sim cards, and hair clips.

All of this will be deeply buried, in some cases thousands of metres down. But geology never stands still. After around one hundred million

Our fossils will tell the story of how we got around. (Credit: Emmanuel Lafont)

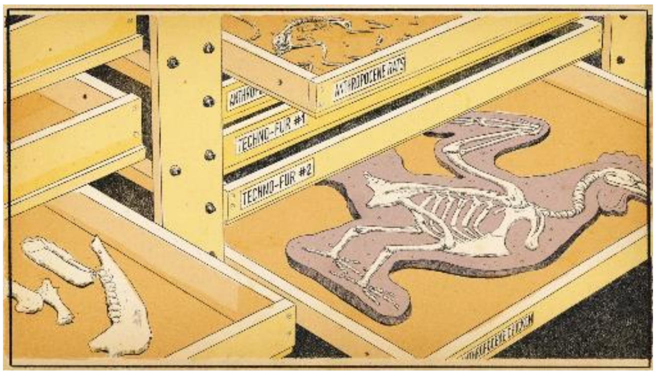
years, as new mountain ranges begin to form, the layer of compacted rubble that was once Shanghai Tower may be pushed upwards and revealed.

"Structures have stories," writes Roma Agrawal in her book *Built*. They tell the stories of the people who lived in them and the world they were made for. The same goes for the remains of Shanghai Tower, even after such so much time has passed. Any future explorers, whether an evolved form of life on this planet or from another world, would be able to recreate a picture of 21st Century life in astonishing detail, provided they can use the same techniques that geologists use today.

Fossilised bicycles or rubber boots will indicate we were bipedal, a fossil keyboard will suggest the shape of our hands, and spectacles or hearing aids will disclose how we perceived the world. The outline of a set of dentures, a motorcycle helmet, a wheelchair, a neoprene wetsuit or even a shop mannequin, will recall the contours of our bodies, perhaps even that we were sexually dimorphic.

Archaeologically-speaking, clothes have not been very hard-wearing for much of human history, says Zalasiewicz. "But as soon as plastic came along, we suddenly have super durable techno-fur, as it were – detachable techno-fur."

It isn't just our bodies that will be remembered: our minds will leave a trace as well. The scale and complexity of our fossil cities will testify that we were social beings. Perhaps a deep-future geologist might conclude we were a hive species like termites, but it's likely that there will be enough evidence of individual invention in the sheer variety of fossil imprints, what Zalasiewicz calls "technofossils," to suggest otherwise. Moreover, the ingenuity needed to create something like a mobile phone – extracting deeply-buried hydrocarbons and metals, then transporting them between continents to be manipulated and combined in highly complex assemblages – will record the scale of our invention.

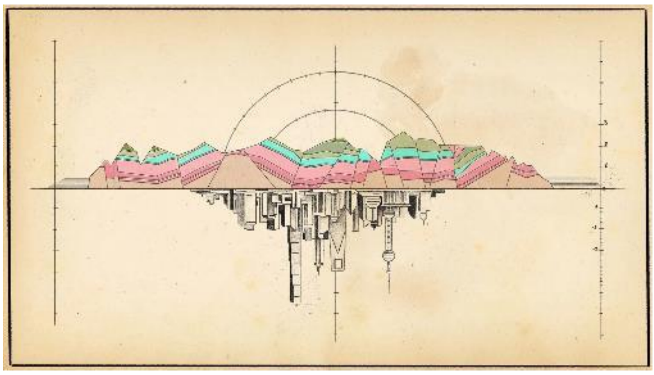


Will the animals of the Anthropocene and "techno-fur" define our time? (Credit: Emmanuel Lafont)

Like the fossilised burrows and tracks left by ancient creatures, our trace fossils will show how we moved. But they'll also record that we didn't only depend on our own locomotion. There are more than 300km (186 miles) of subway line beneath Shanghai. Protected against erosion, it's possible that whole lengths of track may be preserved, even a train carriage. Preserved lengths of road tunnels – complete with kerb stones, ventilation systems, and the glass and copper wiring of electric lighting – will hint at the 50 million km-long (31 million mile) network that once wrapped around the planet. Thick deposits of clinker in the harbours of major port cities, dumped overboard by coal-powered steam ships in the 19th Century, will be read like nodes in a map of global seafaring.

The fossil remains of Shanghai Tower could be matched to the remnants of other tall buildings in other cities, to form a portrait of a global culture of city dwellers who built with the same synthetic materials and used many of the same objects day-to-day. This homogeneity would also express itself in future palaeobiology. Fossils of the same handful of species will turn up again and again on every continent other than Antarctica. The "Anthropocene rat" will be a signature species of the great age of city-building. Mixed with the rubble and plastic in landfill sites across the world will be the bones of some of the 60 billion chickens killed for human consumption each year.

In fact, it's likely that landfill, rather than the remains of cities themselves, will tell the most richly-detailed stories. Modern landfill sites can build up thicknesses of several tens of metres and cover many square kilometres. Lined with durable neoprene, they are filled with individual plastic bags full of waste, creating a double seal against the corrosive influence of UV light, oxygen, water, and chemical leachates. For each relic city there will be a shadow city, vast fossil middens



Even the grandest city has no power against nature and time. (Credit: Emmanuel Lafont)

punctuated with the outlines of all that we discarded.

The future rock record will testify that not all of us had the same impact – that those settled near sites of extraction lived far less fossil fuel-intensive lives than those in cities. Future fossils will hint at this tale of global inequality. They may also tell of the impact we had on generations yet to be born, who were forced to live with the consequences of our carbon addiction.

Of course, there may be no-one to find or make sense of what is left of our cities. But that doesn't mean that we should not seek to imagine the long-term legacies we are leaving behind. We might all do well to think more like geologists. The earth scientist Marcia Bjornerud calls for the cultivation of "timefulness", which she describes as "a feeling for distances and proximities in the geography of deep time". Her approach encourages us to think more timefully about the scale of our impact on the planet and consider what story we want our future fossils to tell.

After visiting Shanghai Tower, I took a train to Nanhui, a new city built on the Pudong coast to accommodate Shanghai's over-spilling population. The tide was out when I arrived on the beach. At my back, a wall just taller than me, curving like a cresting wave, faced out to sea. Shanghai has constructed 520km (323 miles) of these sea barriers, but the ocean will take the city eventually. Whether in 100 or 10,000 years from now, what once was one of the world's greatest cities will begin a slow transformation into geology. "Let me show you the tide / that comes for us," write Kathy Jetñil-Kijiner and Aka Niviâna in their poem *Rise*, "forcing us to imagine / turn ourselves into stone."

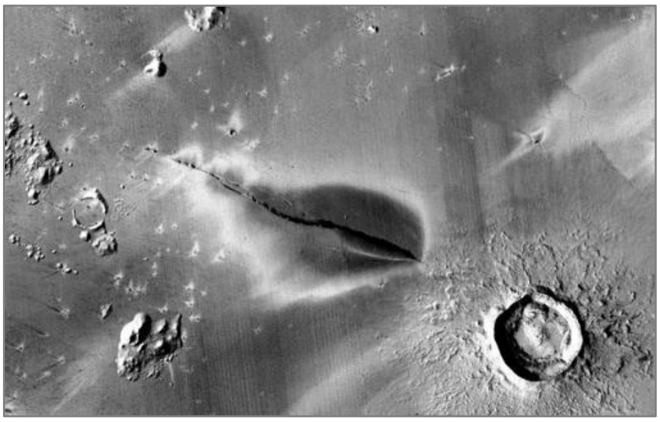
** David Farrier is a professor of literature and the environment at the University of Edinburgh. This article is adapted from his book "Footprints: In Search of Future Fossils", which is available in the US and the UK.*

Reference:

https://www.bbc.com/future/article/20210505-how-cities-will-fossilise

Volcanoes on Mars could be active, raise possibility of recent habitable conditions

Astrobiology
Source: Planetary Science Institute
6 May 2021



Recent explosive volcanic deposit around a fissure of the Cerberus Fossae system. Credit: NASA/JPL/MSSS/The Murray Lab).

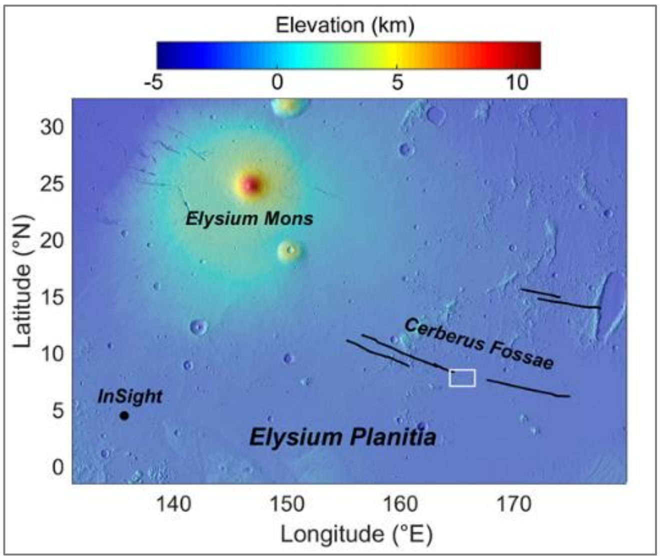
Evidence of recent volcanic activity on Mars shows that eruptions could have taken place within the past 50,000 years, a paper by Planetary Science Institute Research Scientist David Horvath says.

Most volcanism on the red planet occurred between 3 and 4 Ga ago, with smaller eruptions in isolated locales continuing perhaps as recently as 3 Ma ago. But, until now, there was no evidence to indicate whether Mars could still be volcanically active.

Using data from satellites orbiting Mars, the research team found evidence of an eruption in a region called *Elysium Planitia* that would be the youngest known volcanic eruption on Mars, said Horvath, lead author on "Evidence for geologically recent explosive volcanism in Elysium Planitia, Mars" *(Ref. 1)* that appears in *Icarus*.

"This feature is a mysterious dark deposit, covering an area slightly larger than Washington D.C. It has a high thermal inertia, includes high-calcium pyroxene-rich material, and is distributed symmetrically around a segment of the Cerberus Fossae fissure system in Elysium Planitia, atypical of aeolian, or wind-driven, deposits in the region. This feature is similar to dark spots on the Moon and Mercury suggested to be explosive volcanic eruptions," Horvath said. "This may be the youngest volcanic deposit yet documented on Mars. If we were to compress Mars geologic history into a single day, this would have occurred in the very last second."

The majority of volcanism in the Elysium Planitia region and elsewhere on Mars consists of lava flowing at the surface, though there are numerous examples of explosive volcanism on Mars. However, this deposit appears to be different. "This feature overlies the surrounding lava flows and appears to be a relatively fresh deposit of ash and rock, representing a different style and time



Elysium Plantia, the region of recent explosive volcanism (white box) and the InSight lander. (Credit: MOLA Science Team)

period of eruption than previously identified pyroclastic features," Horvath said. "This eruption could have spewed ash as high as 10 kms into the Martian atmosphere but likely represents a last gasp of erupted material. Elysium Planitia hosts some of the youngest volcanism on Mars, dating around 3 Ma ago, so it is not entirely unexpected. It is possible that these sorts of deposits were more common but have been eroded or buried."

The site of the recent eruption is about 1,600 kms from NASA's InSight lander, which has been studying tectonic activity on Mars since 2018. Two Marsquakes have been localized to the region around the Cerberus Fossae and recent work has suggested the possibility that these could be due to the movement of magma at depth.

"The young age of this deposit absolutely raises the possibility that there could still be volcanic activity on Mars, and it is intriguing that recent

Marsquakes detected by the InSight mission are sourced from the Cerberus Fossae," Horvath said. "However, sustaining magma near the surface of Mars so late in Mars history with no associated lava flows would be difficult and thus a deeper magmatic source would likely be required to create this eruption."

A volcanic deposit such as this also raises the possibility for habitable conditions in the near surface of Mars in recent history, says Horvath. "The interaction of ascending magma and the icy substrate of this region could have provided favourable conditions for microbial life fairly recently and raises the possibility of extant life in this region."

Horvath's work on the research took place when he was a postdoctoral researcher at the University of Arizona's Lunar and Planetary Lab. He is now a Research Scientist at the Planetary Science Institute.

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Billion-year-old fossil found preserved in Torridon rocks

BBC Science News
29 April 2021

A billion-year-old fossil found in the Highlands could be the earliest multicellular animal recorded by science so far.

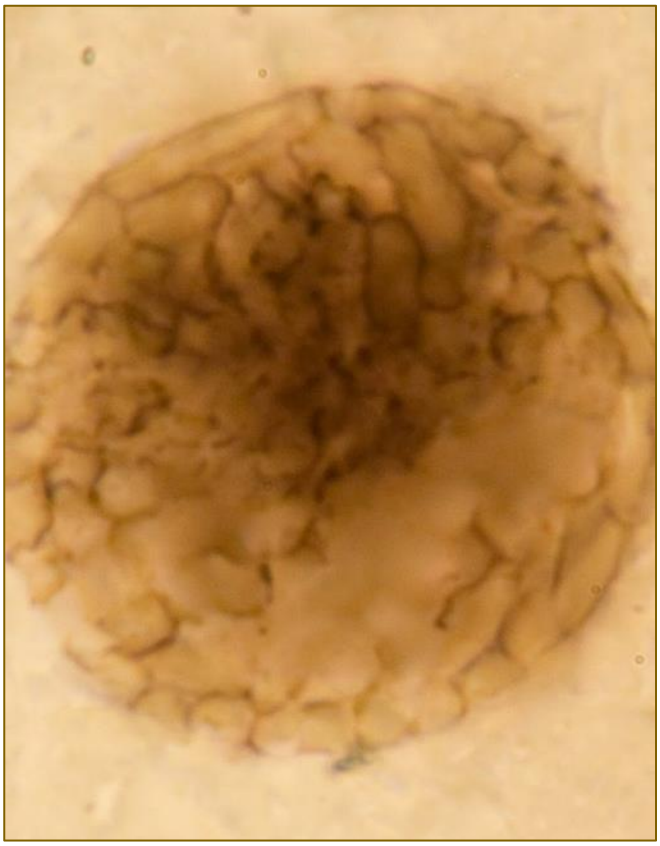
The microscopic fossil was discovered at Loch Torridon in Wester Ross by researchers led by the University of Sheffield and the US's Boston College.

Scientists said it could prove a new link in the evolution of animals.

Researchers could identify it contained two distinct cell types, thanks to the fossil's "exceptional preservation".

The fossil gives a new insight into the transition of single-celled organisms to complex multicellular animals.

It has been named *Bicellum Brasieri* and is described in a new research paper published in *Current Biology.*



The microfossil has two distinct cell types. (Image Copyright: Paul Strother/The University of Sheffield)

Prof Charles Wellman, of the University of Sheffield, said: "The origins of complex multicellularity and the origin of animals are considered two of the most important events in the history of life on Earth, our discovery sheds new light on both of these.

"We have found a primitive spherical organism made up of an arrangement of two distinct cell types, the first step towards a complex multicellular structure, something which has never been described before in the fossil record.

"The discovery suggests that the evolution of multicellular animals occurred at least one billion years ago and that early events prior to the evolution of animals may have occurred in freshwater like lakes, rather than the ocean."

The research team now hopes to examine other samples taken from the Torridon area's ancient rocks and find more fossils that could provide further insights into the evolution of multicellular organisms.

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New duckbilled dinosaur discovered in Japan

by Southern Methodist University
27 April 2021

Artist's illustration of Yamatosaurus izanagii (centre) represents its ancestry to more advanced hadrosaurs (in the background). (Credit: Masato Hattori)

An international team of palaeontologists has identified a new genus and species of hadrosaur or duck-billed dinosaur, *Yamatosaurus izanagii*, on one of Japan's southern islands.

The fossilized discovery yields new information about hadrosaur migration, suggesting that the herbivores migrated from Asia to North America instead of vice versa. The discovery also illustrates an evolutionary step as the giant creatures evolved from walking upright to walking on all fours. Most of all, the discovery provides new information and asks new questions about dinosaurs in Japan.

The research, *"A New Basal Hadrosaurid (Dinosauria: Ornithischia) From the latest Cretaceous Kita-ama Formation in Japan implies the origin of Hadrosaurids,"* was recently published in *Scientific Reports*. Authors include Yoshitsugu Kobayashi of Hokkaido University Museum, Ryuji Takasaki of Okayama University of Science, Katsuhiro Kubota of Museum of Nature and Human Activities, Hyogo, and Anthony R. Fiorillo of Southern Methodist University.

Hadrosaurs, known for their broad, flattened snouts, are the most commonly found of all dinosaurs. The plant-eating dinosaurs lived in the Late Cretaceous period more than 65 Ma ago and their fossilized remains have been found in North America, Europe, Africa and Asia.

Uniquely adapted to chewing, hadrosaurs had hundreds of closely spaced teeth in their cheeks. As their teeth wore down and fell out, new teeth in the dental battery, or rows of teeth below existing teeth, grew in as replacements. Hadrosaurs' efficient ability to chew vegetation is among the factors that led to its diversity, abundance and widespread population, researchers say.

The Yamatosaurus' dental structure distinguishes it from known hadrosaurs, says Fiorillo, senior fellow at SMU's Institute for the Study of Earth and Man. Unlike other hadrosaurs, he explains, the new hadrosaur has just one functional tooth in several battery positions and no branched ridges on the chewing surfaces, suggesting that it evolved to devour different types of vegetation than other hadrosaurs.

Yamatosaurus also is distinguished by the development of its shoulder and forelimbs, an evolutionary step in hadrosaurid's gait change from a bipedal to a quadrupedal dinosaur, he says.

"In the far north, where much of our work occurs, hadrosaurs are known as the caribou of the Cretaceous," says Fiorillo. They most likely used the Bering Land Bridge to cross from Asia to present-day Alaska and then spread across North America as far east as Appalachia, he says. When hadrosaurs roamed Japan, the island country was attached to the eastern coast of Asia. Tectonic activity separated the islands from the mainland about 15 Ma ago, long after dinosaurs became extinct.

The partial specimen of the Yamatosaurus was discovered in 2004 by an amateur fossil hunter in an approximately 71 to 72 Ma old layer of sediment in a cement quarry on Japan's Awaji Island. The preserved lower jaw, teeth, neck vertebrae, shoulder bone and tail vertebra were found by Mr. Shingo Kishimoto and given to Japan's Museum of Nature and Human Activities in the Hyogo Prefecture, where they were stored until studied by the team.

"Japan is mostly covered with vegetation with few outcrops for fossil-hunting," says Yoshitsugu

Kobayashi, professor at Hokkaido University Museum. "The help of amateur fossil-hunters has been very important."

Kobayashi has worked with SMU palaeontologists Tony Fiorillo since 1999 when he studied under Fiorillo as a Ph.D. student. They have collaborated to study hadrosaurs and other dinosaurs in Alaska, Mongolia, and Japan. Together they created their latest discovery's name. Yamato is the ancient name for Japan and Izanagi is a god from Japanese mythology who created the Japanese islands, beginning with Awaji Island, where Yamatosaurus was found.

Yamatosaurus is the second new species of hadrosaurid that Kobayashi and Fiorillo have identified in Japan. In 2019 they reported the discovery of the largest dinosaur skeleton found in Japan, another hadrosaurid, Kamuysaurus, discovered on the northern Japanese island of Hokkaido.

"These are the first dinosaurs discovered in Japan from the late Cretaceous period," Kobayashi says. "Until now, we had no idea what dinosaurs lived in Japan at the end of the dinosaur age," he says. "The discovery of these Japanese dinosaurs will help us to fill a piece of our bigger vision of how dinosaurs migrated between these two continents," Kobayashi says.

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Interesting Places 2

Mount Fuji

Japan’s iconic Mount Fuji from space. The photo was taken by an astronaut onboard the International Space Station on 27 May 2010. Mount Fuji, located on Honshu Island, is the highest mountain in Japan at 3,776.24m. An active stratovolcano that last erupted in 1707–08, Mount Fuji lies about 100kms southwest of Tokyo and can be seen from there on a clear day. Mount Fuji’s exceptionally symmetrical cone is snow-capped several months a year. *(Image Credit: NASA)*

Yukon-Kuskokswim Delta

The Yukon-Kuskokswim Delta is one of the world’s largest deltas, and it stands as a remarkable example of how water and ice can shape the land.

These images show the delta's northern lobe, where the Yukon River spills into the Bering Sea along the west coast of Alaska. *(NASA Earth Observatory image by Joshua Stevens, using Landsat data from the U.S. Geological Survey)*

City of Conakry, Guinea

The city of Conakry, Guinea on the west coast of Africa seems to be attracted to the coast and the Loos islands ... like an organism seen under a microscope. *(Credits: ESA/NASA-T. Pesquet)*

Lundin sells 'world-first' carbon-neutral certified oil

ENVIRONMENT
by Bojan Lepic
27 April 2021

Oil and gas company Lundin Energy has sold the world's first-ever certified carbon neutrally produced oil to Saras S.p.A from its Edvard Grieg field offshore Norway.

Lundin Energy said on Monday that the Edvard Grieg field was the first oil field in the world to be independently certified by Intertek Group, under its CarbonClear certification.

The field is certified as low-carbon at 3.8 kg of CO_2 per barrel of oil equivalent (boe) for the full life of field emissions, including exploration, development, and production – this is considered as five times less than the world average.

Lundin added that to supply a full carbon-neutral barrel to Saras, residual emissions of 2,302 tonnes of CO_2 were compensated through a high-quality, nature-based carbon capture project, certified by the Verified Carbon Standard.

Also, the entire trade was independently certified as carbon neutral by Intertek under its CarbonZero standard. As a result, there were no net emissions released during the production of each barrel delivered to Saras.

The **first-ever carbon neutrally produced crude oil** Saras bought was delivered to a refinery in Sarroch, Sardinia. The Edvard Grieg field supplied 600,000 barrels.

It is worth noting that, all barrels produced by Lundin Energy will be carbon neutral in their production from 2025. Lundin added that, as the energy transition continues to accelerate, providing certified, low emission produced barrels to customers ensures that they can continue the decarbonisation pathway, delivering a differentiated product to their end-users.

Nick Walker, president and CEO of Lundin Energy, said: "We were the first company to have one of its field's carbon emissions independently certified as low carbon, and this certified carbon neutral transaction with Saras, is the next stage in what we believe will become a key value differentiator for Lundin Energy.

"The provenance of a barrel and how it is produced is increasingly important, as society and industry require lower carbon feedstocks to achieve emission reduction targets and meet the goals of the Paris Agreement.

"This trade has been enabled by our […] decarbonisation strategy and offers a proof point of where the crude market is heading and the potential value that can be realised through efficient, industry-leading emissions reductions.

"I am very pleased to have been able to do this industry first with Saras in Italy. Their progressive low-carbon strategy is aligned with ours and through this first certified sale of crude they will be able to clearly differentiate the refined product to their own customer base".

Dario Scaffardi, CEO and general manager of Saras, added: "We are very proud to be one of the first refining companies in taking this innovative opportunity.

"The purchase from Lundin of certified carbon neutral produced crude oil demonstrates the continuous and increasing attention that our group gives to the environmental sustainability of its activities and goes along with various other projects that we have implemented to support our low-carbon strategy.

"[…] most of our efforts have been aimed at reducing and offsetting the direct carbon footprint of the refinery with a number of projects, from scaling up on biofuels production to energy efficiency initiatives, the development of renewable power production and also green hydrogen".

As for the Edvard Grieg field, it is located in the Utsira High area of the North Sea some 180 kms west of Stavanger. It was discovered in 2007 with Lundin's first exploration well and production started in late 2015.

Reference:

https://www.offshore-energy.biz/lundin-sells-world-first-carbon-neutral-certified-oil/?utm_source=offshoreenergytoday&utm_medium=email&utm_campaign=newsletter_2021-04-28

Terrestrial plants flourished after the Cretaceous–Paleogene extinction

Compounds in ancient plant leaves tell the story of how an extinction event shaped our planet's ecosystems.

By Hannah Thomasy
26 January 2021

At first glance, Chambery Coulee might look like any other valley in the vast prairies of southern Saskatchewan. But for Robert Bourque and his colleagues at McGill University in Quebec, Chambery Coulee is a window into the deep past, a place that holds the secrets of the mass extinction that ended the age of the dinosaurs 66 Ma ago.

Their recent study uses compounds in plant waxes to shed new light on how plant communities, the water cycle, and the carbon cycle changed after the dinosaur-killing Chicxulub asteroid impact, which marked the end of the Cretaceous period and the beginning of the Paleogene. Bourque, who received his master of science degree from McGill and is now a Ph.D. student at Rensselaer Polytechnic Institute in New York, said, "Plant waxes provide a unique opportunity in looking through certain lenses at the global ecosystem at the time, since plant waxes record atmospheric [carbon dioxide] as well as the hydrogen derived from rainfall. So, we're able to use them as proxies for looking at these environmental signatures."

Even though it is now widely accepted that the asteroid impact was the root cause of the extinction event, the specific mechanism (or mechanisms) by which the impact wiped out the majority of all plant and animal species on Earth is still not fully understood. Studying environmental changes that took place around the time of the impact may help scientists figure out the answer.

Changing Ecosystems

Bourque and his colleagues analysed leaf wax *n*-alkanes (a type of hydrocarbon) that had been preserved in ancient fluvial sediments in Chambery Coulee and another site near Saskatchewan's Highway 37 to learn more about how the world changed. These leaf wax compounds, Bourque said, "come in a variety of…chain lengths, and different types of plants produce different ratios of these chain lengths. Typically, aquatic plants will produce shorter chain lengths, whereas terrestrial plants produce longer ones.… So, we noticed that there's a shift from more shorter-length plant waxes to longer ones going across the boundary." This change implies that terrestrial plants were becoming more abundant compared with aquatic plants after the extinction event.

This finding aligns with previous research on prehistoric pollen samples, which showed an increase in angiosperm (flowering plant) pollen, especially species similar to today's birch and elm trees, in the time following the extinction event.

Researchers also analysed the carbon and hydrogen isotopes in the *n*-alkanes, which allowed them to reconstruct changes in the carbon cycle and the water cycle. In contrast to the long-term changes in plant communities they observed after the extinction event, the team did not find obvious long-term changes in precipitation or the carbon cycle subsequent to the event.

So, what was responsible for the long-lasting changes in plant ecology? Researchers hypothesized that this burst of terrestrial plant abundance was due to another factor: the sudden disappearance of the dinosaurs. With just about every large terrestrial herbivore wiped from the face of Earth, terrestrial plants flourished.

Next Steps

Ken MacLeod, a geology professor at the University of Missouri, said he would like to see the new paper's line of inquiry expanded to include more samples, across both time and geographic space. More samples from the time period would help provide greater resolution of exactly when these environmental changes occurred, whereas more samples from around the world would help determine how widespread this phenomenon was—did it occur only in southern Saskatchewan, across all of North America, or even perhaps around the entire planet?

Bourque had similar thoughts. "Looking at a finer scale across the boundary would be extremely interesting, to try and better estimate what happened over what time period," he said. "And broadening the scope to other sites from the same time period would be incredibly interesting."

MacLeod said there's a lot of interest in improving our understanding of this time period, especially because "the Cretaceous-Paleogene impact is, I think, literally the only event in the Phanerozoic [the past 541 Ma] with global-scale implications that manifest on timescales shorter than anthropogenic changes." Studying how Earth systems responded to perturbations in the past, MacLeod said, might help us understand the response of these systems in the present, which is also a period of rapid change.

Reference:

1. Thomasy, H. (2021), Terrestrial plants flourished after the Cretaceous–Paleogene extinction, Eos, 102, https://doi.org/10.1029/2021EO153785. Published on 26 January 2021.
2. https://eos.org/articles/terrestrial-plants-flourished-after-the-cretaceous-paleogene-extinction&utm_campaign=ealert

The Burgess Shale

High on a mountain ridge in Canada's spectacular Yoho National Park in British Columbia is one of Earth's most important fossil deposits: the Burgess Shale. Preserved with exquisite detail within the rock layers for the last half-billion years are the remains of soft-bodied and often bizarre animals and algae dating from the Cambrian period. These exceptional fossils include some of the oldest members of many animal groups still alive today.

The Burgess Shale has a rich History of discoveries which span more than 125 years. In this website you will discover these extraordinary creatures through images of their remains in the Fossil Gallery and also through reconstructions including digital animations in the Virtual Sea Odyssey. You will learn about the Science, about how fossils are discovered and studied, and about the current research being done — as well as how to learn about, visit, share and help protect the sites today with Parks Canada.

Of global significance for understanding Cambrian life, the Burgess Shale was designated a World Heritage Site in 1980. Today it forms part of the Canadian Rocky Mountain Parks World Heritage Site. World Heritage sites are features of exceptional cultural and natural significance and are considered to be of outstanding universal value to humanity. As part of the Canadian Rocky Mountain Parks World Heritage Site, the Burgess Shale joins locations as unique and diverse as the Taj Mahal in India, the Pyramids of Egypt, and Dinosaur Provincial Park in Canada.

Reference:

https://burgess-shale.rom.on.ca/en/introduction/index.php

Walcott Quarry of the Burgess Shale (Middle Cambrian), British Columbia. The photo shows the Walcott Quarry Shale Member. (Author: Mark A. Wilson, own work (Aug 2009) (Department of Geology, The College of Wooster))