GEOSCIENTIST

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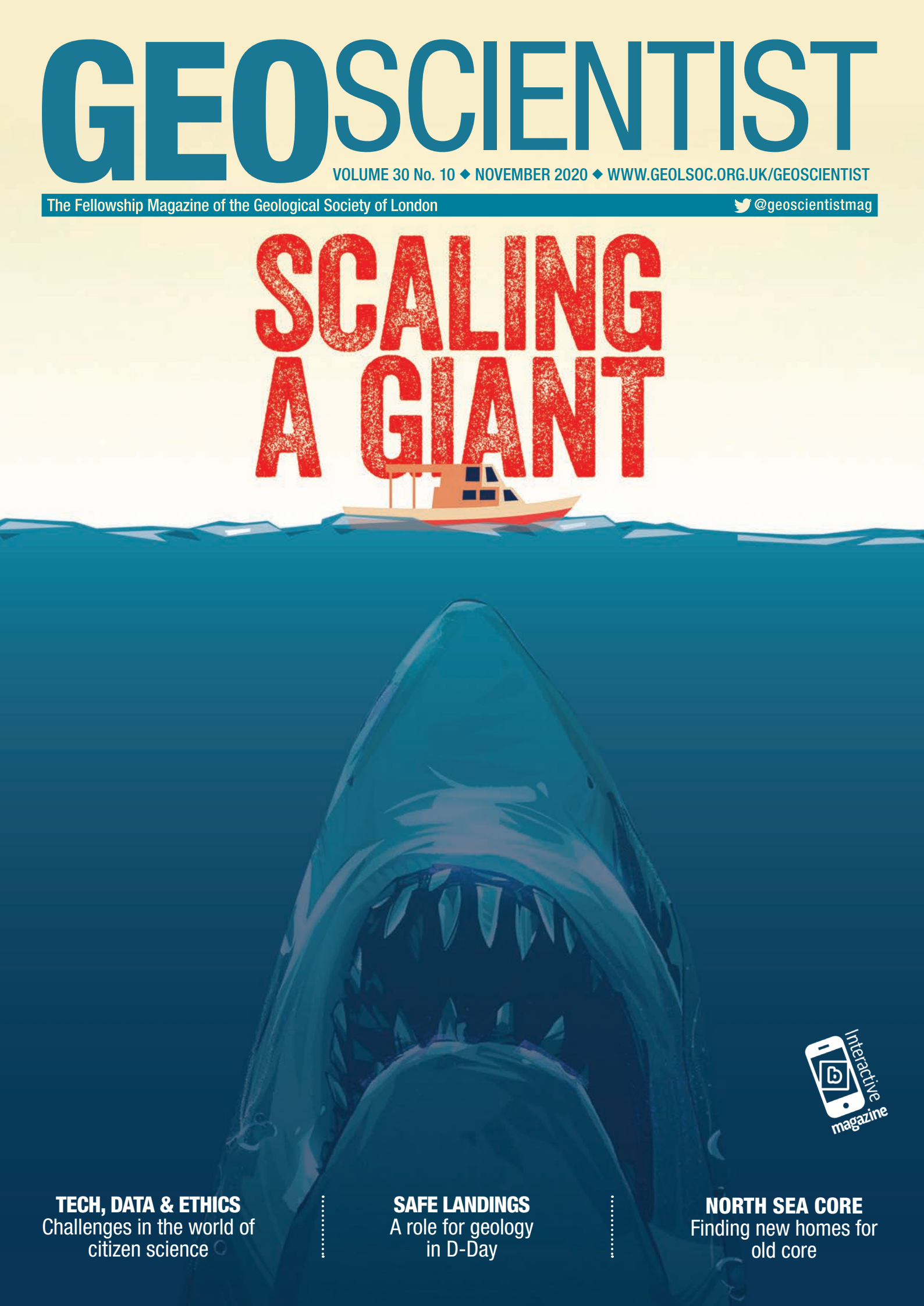
The Fellowship Magazine of the Geological Society of London

@geoscientistmag

SCALING A GIANT



Interactive magazine

TECH, DATA & ETHICS
Challenges in the world of citizen science

SAFE LANDINGS
A role for geology in D-Day

NORTH SEA CORE
Finding new homes for old core

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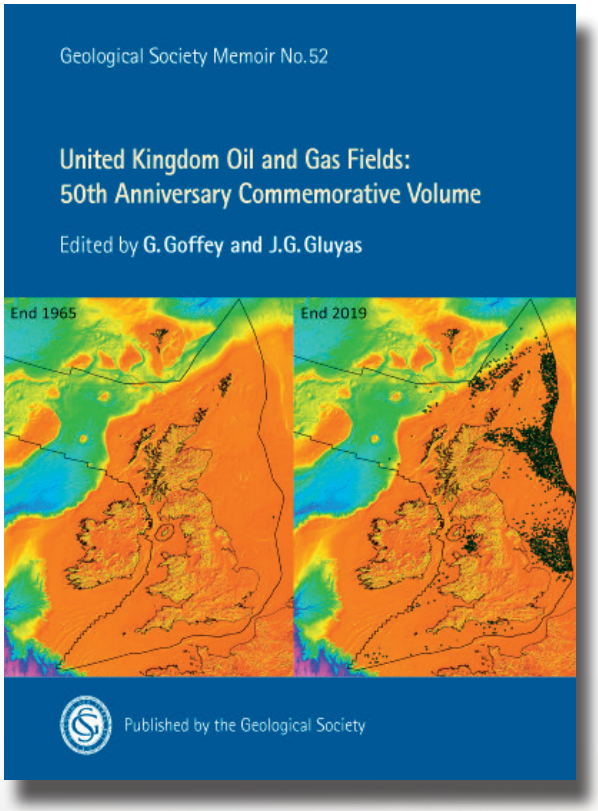
OUT NOW

United Kingdom Oil and Gas Fields: 50th Anniversary Commemorative Volume



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List price: £200
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Other society price: £120

To find out more about the volume please visit:
www.geolsoc.org.uk/M0052

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30 November 2020

16 invited speakers will present talks covering all of the major UK basins and highlight the Memoir's running themes.

All conference attendees will be entitled to a 30% discount off the list price of the publication

To register your interest please visit:
www.geolsoc.org.uk/11-rescheduled-memoir-52-launch-conference-2020

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ON THE COVER:

FEATURES

REGULARS

ES³ Earth Science, Systems and Society

Announcing the Chief Editor of *Earth Science, Systems and Society (ES³)*

Dr Kathryn Goodenough

We are delighted to announce the appointment of Dr Kathryn Goodenough as the Chief Editor for the Society's new open access journal, Earth Science, Systems and Society (ES³).

Kathryn is a Principal Geologist with the British Geological Survey, and Deputy Director of BGS Global. She has developed a knowledge and understanding of peer review and publishing through roles with the Edinburgh Geological Society, Scientific Reports and Geological Magazine, on which she served as an Executive Editor.

Through her continuing role as a member of The Geological Society's Publications and Information Committee, Kathryn actively supports the Society's broader publishing programme and was directly involved in the proposal to launch ES³.

Her research interests include the geology of critical metal deposits, and wider aspects of crustal evolution, magmatism and mineralisation. She also has an interest in sustainable exploration and management of mineral resources, particularly in developing countries. She currently represents the UK on the Executive Committee of the International Continental Drilling Programme.

ES³ is due to open for submissions in January 2021.
For further information, please visit the journal homepage: www.geolsoc.org.uk/escubed

> IT'S BEEN A TOUGH YEAR FOR EVERYONE AND CHANGE INEVITABLY LIES AHEAD

FROM THE EDITOR'S DESK:

CHANGE IN A TIME OF CRISIS

And just like that, another year passes by. My maternity leave is over and I'm back at the helm of *Geoscientist*. It wasn't the year I—or anyone—expected. I have a healthy, cheeky one-year-old daughter, and for that I am deeply grateful, but there were few playdates and grandparental bonds were largely built over Zoom. My daughter hasn't interacted with another baby in 8 months and cries at one glance from a stranger. I can't help but wonder if this will have lasting impacts on her social development—and that of an entire generation of children.

The world has changed irrevocably, for better and worse. Over a million people have died from Covid-19, economies have been floored and millions are jobless. While lockdown led to reduced travel, pollution and carbon emissions, the pandemic has also created a flood of single-use plastic waste in the form of discarded Personal Protective Equipment, PPE, that now chokes our environment. In thousands of years' time (if humankind still exists), will future geologists use the lithified remnants of PPE as a chronological marker of this pandemic? Or are our current struggles with the virus simply too brief in the grand scheme of geological time to leave an indelible mark? Though not considered as life themselves, viruses are such an important companion to life that they must surely leave some sort of fingerprint in the geological record—a question explored by Michael A. Rosen on page 8.

The pandemic has expedited the digital transition, as many adapt to working and studying from home, while attending conferences and even field trips virtually. But living our lives online brings with it a host of ethical concerns. As Estelle Clements discusses on page 16, the geoscience community could benefit from technological advances by using citizen scientists to collect environmental and landscape data on a vast scale. But, for such an endeavour to succeed, we must first ensure that an ethical framework for data use is in place. The need for track-and-trace systems during the pandemic has led to the formalisation of such frameworks, which could come in handy to the data-collecting geoscientist.

In response to the accelerated digital transition, and the increasing appetite for access to information online, I have been working with the editorial team on proposals for Council's consideration on how to greatly improve and expand the magazine's digital presence. How this is best done is still under discussion, but it is likely to involve a transition to decreased print frequency in 2021. These changes will also save the Society money at a time of financial strain, and reduce our environmental impact. I appreciate that the monthly magazine is cherished by many Fellows and I am sorry that I cannot provide more information on the possible changes at present. We're working hard to finalise the details and we will provide another update in the next issue.

In other news, I'm happy to report that Sarah Day will stay on at the magazine one day per week. If you need to contact either of us, you can do so by emailing geoscientist@geolsoc.org.uk. The magazine will only be staffed Monday to Thursday, so please bear with us. I must offer my sincere thanks to Sarah, as well as to Chief Editors Andy Fleet and David Shilston for their hard work during what has been a remarkably difficult year. In the face of adversity, they've kept the magazine in great shape—and we promise that it will continue to thrive, in one form or another, in the years to come.

DR AMY WHITCHURCH, EDITOR - geoscientist@geolsoc.org.uk @geoscientistmag

SOCIETY *NEWS*

SOCIETY BUSINESS

HONORARY FELLOWSHIP

Following a proposal from the External Relations Committee, Council recommends the following candidate for election to Honorary Fellowship at a future Ordinary General Meeting.

Dr Kathryn Dwyer Sullivan

Dr Kathryn Dwyer Sullivan is the only person to have flown missions into space and to have dived to the deepest part of the oceans, the Mariana Trench. She is the first American woman to walk in space, a veteran of three shuttle missions and a 2004 inductee to the Astronaut Hall of Fame. She is the United States Co-chair of the Group on Earth Observations (GEO), an intergovernmental body that is building a Global Earth Observation System of Systems (GEOSS) to provide environmental intelligence relevant to societal needs.

Dr Sullivan has a B.Sc. in Geology from University of California and a PhD in Geology and Oceanography from University of Dalhousie. Following her doctorate, she pursued a career in NASA as an astronaut, and as an administrator in NASA, NOAA and the Obama government.

In 2014, Sullivan was honoured in the Time Magazine's list of the 100 most influential people in the world. In 2017 she was named the 2017 Charles A. Lindbergh Chair of Aerospace History during which time she focussed her work on the Hubble Space Telescope, resulting in the publication of her latest book.

Dr Sullivan is a member of the President's Council of the Resources for the Future whose aim is to improve 'environmental, energy, and natural resource decisions through impartial economic research and policy engagement'. She is also a Senior Fellow of the Potomac Institute, a science and technology policy research institute in Arlington, Virginia.

GEOLOGICAL SOCIETY AND UNIVERSITY GEOSCIENCE UK RELEASE STRATEGY FOR INCREASING STUDENT ENROLMENT IN GEOLOGY

The number of UK students studying geology at university has declined year-on-year since 2014, with a total drop of 43%.

Without action, the decline in skilled graduates will pose a serious and economically damaging skills shortage in the UK, particularly at a critical time of transition for many industries and businesses that rely on geological expertise.

On 25 September, UGUK and GSL released a report that identifies five key strategic aims for improving the outlook of student enrolment in geosciences over the next five years. In the coming weeks and months, we will be hosting a number of forums and workshops with the UK geoscience community to define action plans and deliver these strategic objectives.

You can download the report at: www.geolsoc.org.uk/UniversityGeoscienceUKResources

Alicia Newton, Director of Science & Communications, and George Jameson, Diversity and Inclusion Project Lead

PUBLIC LECTURE SERIES

Virtual Public Lecture: Engaging geoscience for diplomacy – Understanding Paektu volcano in North Korea

Speaker: James Hammond, Birkbeck - University of London
Location: Online
Date: 9 November
Time: 6pm BST

Further information

The lecture will be streamed online using Zoom. To book your virtual ticket, and for more information, please visit **www.geolsoc.org.uk/understandingpaektu**

Contact: The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: **+44 (0) 20 7434 9944** E: **conference@geolsoc.org.uk**

What your society is doing at home and abroad

SOCIETY BUSINESS

SUPPORTING EARLY GEOSCIENTISTS TO GAIN PEER REVIEW SKILLS

From 2021, the Geological Society of London will support a process known as co-reviewing across its portfolio of journals and books. This type of peer review involves allowing a reviewer to formally involve a colleague in the review of a book or article, and is often an opportunity for junior or early career researchers to gain experience and training with peer review. Both reviewers will receive an acknowledgement for their work, as well as the opportunity to gain credit for their review on the Publons platform.

By making co-reviewing a formal option, GSL will enable both mentor and mentee peer reviewers to receive appropriate credit, editorial and staff support, and the resources to ensure that all peer reviewers meet the Society's ethical policies.

David Boyt, Head of Editorial Development

A NEW SPECIAL PUBLICATION ON GEOETHICS

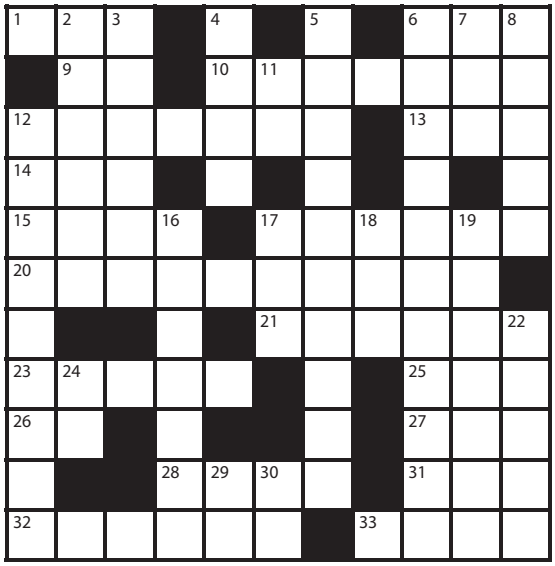
Geoscience has an integral, though often contentious and politically charged, place in the modern world. Issues such as climate change, environmentally destructive mining practices and diversity are complex and important ethical topics that in recent years have become matters at the forefront of discussion within the geoscience community.

There has never been a better time to collate these discussions and ideas into a published volume. The Geological Society of London's Special Publication No. 508, Geoethics: Status and Future Perspectives, will contain chapters on numerous important topics including climate change, water resource management and implications of space exploration that we hope will be of value to the geoscience community and help stimulate further discussions.

The volume is scheduled for publication in early 2021 and the first accepted manuscripts have already been published online at https://sp.lyellcollection.org/online-first/508.

Samuel Lickiss, Production Editor

Crossword



Across

1 All-points bulletin (3)
6 Polychlorinated biphenyl (3)
9 Type of logic circuit (2)
10/12D Canadian potash-rich formation (7,9)
12 An apparatus for emulsifying (7)
13 A room in a harem (3)
14 To examine thoroughly and critically (3)
15 Expression of misfortune (4)
17 Venomous New Zealand spider (6)
20 Sulfate mineral found in the Boulby Potash (10)
21 Beetle's modified forewings (6)
23 Female ruff (5)
25 Global governing body for futsal (3)
26 See 18 Down
27 ___-ora: Maori greeting (3)
28 Alaskan city on Seward Peninsula (4)
31 Organ of hearing (3)
32 German philosopher and revolutionary (6)
33 Messenger ribonucleic acid (4)

Down

2 Largest of the citrus fruit (6)
3 Inhuman or senselessly cruel (6)
4 Nearest or furthest point from the planet of a satellite's orbit (4)
5 Hydrated potassium magnesium chloride mineral (10)
6 Someone who cashes-in when share prices are high (6-5)
7 Criminal Investigation Department (3)
8 Home of Bash Street Kids (5)
11 Domain code for Romania (2)
12 See 10 Across
16 Potassium chloride mineral first recorded on Vesuvius (7)
17 In Scotland, a jackdaw (3)
18/26 A monetary unit of Uzbekistan (0.01 som) (5)
19 Period of the Zechstein Sea (7)
22 Terminalia superba or ivorensis (5)
24 Half an em (2)
29 Suffix indicating the presence of a hydroxy group (2)
30 0.001 seconds (2)

By Bindweed

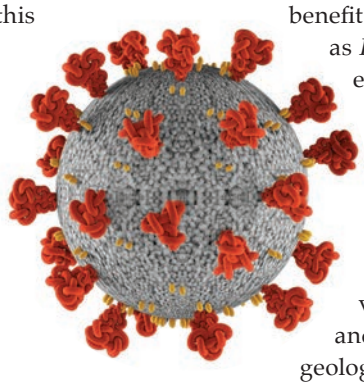
Solutions October | **Across**: **1** rpm **4** alsike **12/10** poikiloblastic **13** Elo **14** vertu **18** IF **19** arbors **21/2/16** demi-plie **24** PDA **25/28A/7** Tanzanite **27/23** inny **29** daring-do **32** ICI **33** ooidal **36** atomisers **39** Merelani **Down**: **1** rivery **3** moptop **4** Ali **6** SS **8** Kilimanjaro **9** Ecofin **11** Bourdin **14** Vanadium **15** Rb **20** sangoma **26** briar **28/37** zoisite **30/22/35** acetals **31** do-in **34/17** deed **38/5** olla

The Year of (What Is?) Life

With life altered irrevocably by the pandemic, **Michael A. Rosen** asks whether viruses might be geological agents.

When our Society designated 2020 the "Year of Life", who could have predicted how life would be transformed by COVID-19? Businesses and institutions closed. Millions became unemployed. The UK economy shrank by a fifth. Confirmed COVID-19 cases have surpassed 30 million globally and over a million people have died. All this from a virus.

Many biologists do not classify viruses as 'life'. Simply composed of nucleic acids enveloped by a protein, viruses cannot metabolise or reproduce without a host cell. Their evolution may lack the "last universal common ancestor" (LUCA) that is theorised for cellular life.



Yet life can appear subordinate to viruses. For example, the sea slug, *Elysia chlorotica* long puzzled scientists. It grazes on algae, from which it incorporates chloroplasts into its tissues, then stops eating to live solely by photosynthesis. How the chloroplasts remain intact within *E. chlorotica* lacking plant cell metabolism was baffling until discovery that the slugs produce essential plant proteins. How did this process evolve?

After laying eggs to propagate the species, a generation of *E. chlorotica* dies, synchronously. But not before a retrovirus blooms inside them. Millions of virus particles are released as the slugs decay. Not only does this explain how photosynthesis evolved in a sea slug (by virus-aided horizontal gene transfer) but the retrovirus may control *E. chlorotica's* full life cycle.

Viruses in the biosphere

Alive or not, viruses arguably are Earth's most successful biological entities. Virus genomic expression and replication vary greatly. Conversely, cellular life has a universal genome, DNA, and only one method of replication. A few genes are common among viruses but missing from cellular organisms. So not all viruses began as genetic material "escaped" from cells. Instead they might be ancient, originating alongside the cellular LUCA.

Every environment harbours viruses. Nearly all cellular organisms host them. They jump between hosts, as we know well from coronaviruses and bats. All viruses are parasitic but not all are pathogens. Some benefit their hosts, as *E. chlorotica's* retrovirus enables photosynthesis.

Viruses outnumber cellular life ten to a hundred-fold. The average litre of seawater contains a billion viral particles, a kilogram of sediment contains a million viruses. With such abundance and influence, do viruses affect geology? Are we overlooking their signature in the geological record?

Viruses in the geosphere?

Photosystems are proven to be transferred among modern cyanobacteria by viruses and recently calcispheres discovered in Neoproterozoic stromatolites are postulated to be virus fossils. Did viruses help oxygenate the atmosphere? They control metabolism, blooms and demise in modern coccoliths. Have viruses affected chalk deposition? Viruses kill 80% of benthic bacteria. What is their influence on ocean productivity? On sedimentation? On source rock accumulation? Viral material is abundant in modern microbial mats. Did they help form fossil lagerstätten? They are documented nucleation sites for iron precipitation in acid mine water. Might viruses play a role in mineralisation?

Our Society designated this "Year of Life" to highlight modern and geological links between the biosphere and geosphere. Will the events of 2020 also trigger the study of viruses as geological agents equal to or in concert with (other) life?

By Michael A. Rosen. Mike is a Director of Windrose Enterprises Ltd, email: geologyrosen@gmail.com

Further Reading list available online.

SOAPBOX CALLING!

Soapbox is open to contributions from all Fellows. You can always write a letter to the Editor, of course, but perhaps you feel you need more space?

If you can write it entertainingly in **500 words**, the Editor would like to hear from you. Email your piece, and a self-portrait, to **geoscientist@geolsoc.org.uk** Copy can only be accepted electronically. No diagrams, tables or other illustrations please.

Pictures should be of print quality – please take photographs on the largest setting on your camera, with a plain background.

Precedence will always be given to more topical contributions. Any one contributor may not appear more often than once per volume (once every 12 months).

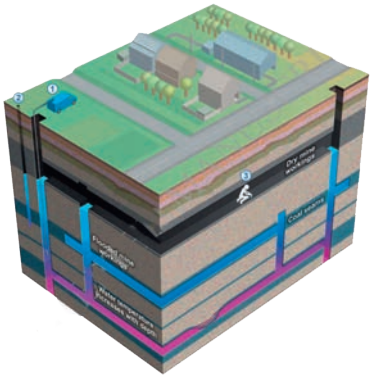
> "ALIVE OR NOT, VIRUSES ARE POWERFUL AGENTS WITHIN THE BIOSPHERE. TO WHAT EXTENT DO VIRUSES ALSO AFFECT THE GEOSPHERE?"

Latest news from the Publishing House

The temperature of Britain's coalfields

By G. Farr, J. Busby, L. Wyatt, J. Crooks, D.I. Schofield and A. Holden

This paper aims to provide the first mapping and synthesis of the temperature of Britain's coalfields to support this emerging technology. Using the best available evidence, a median geothermal gradient of 24.1 °C/km was calculated for the British coalfields. However, geothermal gradients between separate coalfields can vary from 17.3 to 34.3 °C/km.



Read the full paper on the Lyell Collection
qjegh.lyellcollection.org/content/early/2020/09/14/qjegh2020-109

A pioneering geophysicist: Rosemary Hutton

By Bruce A. Hobbs and Alan G. Jones

Violet Rosemary Strachan Hutton ('Rosemary') graduated from St Andrews University in 1948 and a few years thereafter embarked upon a pioneering career in geophysics, a rare and challenging choice for a single woman at that time. Her impressive research career, starting in 1954, was largely devoted to the investigation of how geophysical methods, in particular electromagnetic techniques, could reveal the structure of the Earth's continental crust and upper mantle.

Read the full paper on the Lyell Collection
sp.lyellcollection.org/content/early/2020/09/24/SP506-2019-211

SCALING A GIANT

To date, only the total length of the largest prehistoric shark has been known. Now, **Jack Cooper** reveals the first measurements of the rest of Megalodon's body, including a dorsal fin as large as a human adult

Megalodon. Literally translated, it means "Big Tooth"—and for good reason. At a maximum size of 15 to 18 metres, it is the largest predatory shark known to have ever roamed the oceans. Its teeth have become some of the most iconic fossils in palaeontology and are as big as human hands, reaching sizes of about 160 mm high (Fig. 1). These huge fossil teeth have been found on every continent except Antarctica, suggesting that the species lived worldwide, and are dated to the Miocene and Pliocene epochs (23 to 2.6 million years ago) (Pimiento *et al.*, 2016). As well as its teeth, palaeontologists have found rare vertebrae from this shark which are over 150 mm in diameter, and serrated bite marks on whale bones indicating that whales may have been amongst its prey (Gottfried *et al.*, 1996). The fossil evidence paints a picture of a terrifyingly large shark. But just how big was this animal?

Despite the popularity of this enormous extinct shark, with its huge teeth and its recent starring role in the Hollywood blockbuster The Meg, only its total length has ever been calculated. This was done using the relationship between tooth height and total length in the modern great white shark. But what about the dimensions of the rest of its body? How big was its dorsal fin, slicing through the water as it homed in on prey? What about the tail that powered its swimming, the head that held its enormous jaws, or the gills that allowed it to breathe? Knowing the sizes of these body parts gives a more complete picture of what this huge shark may have looked like, and provides ecological inferences of how it may have lived.

Closest living relatives

Determining Megalodon's size appears daunting at first. Its teeth (Fig. 1) are almost all that remains of the shark, so we have no complete skeletons to start from. This means that scientists have to base their calculations on modern day sharks and, with over 500 species of shark living today, it can seem impossible to know where to start. However, at first glance, Megalodon teeth bear a striking resemblance to those of today's largest ▶

Fig. 1: A Megalodon tooth; the same size as a human hand.

▶ predatory shark—the great white (*Carcharodon carcharias*). Both have large, triangular and serrated teeth; dental traits typical of a shark that feeds on marine mammals (Fig. 2). These teeth have such similar shapes that scientists initially concluded that Megalodon had to be a direct ancestor of the great white shark, leading them to name the giant shark *Carcharodon megalodon*.

A closer examination of the teeth, however, reveals distinct differences. Megalodon's teeth have rounder, finer serrations compared to the triangular, irregular and jagged serrations of the great white. Also, they have a thicker lingual side (the part closest to the tongue) and a dental band that is not present in the teeth of great whites. Further analyses found no overlap in the shape variance of the teeth of both animals and revealed that great white shark teeth are much closer in shape to extinct mako sharks (Nyberg *et al*., 2006). Therefore it has been proposed that the great white did not evolve from Megalodon after all and instead comes from an ancient lineage of mako sharks. Megalodon is now considered part of the extinct Family Otodontidae—also known as the megatoothed clade—and is generally referred to as *Otodus megalodon*.

So where exactly is Megalodon's family

Fig. 2: A Megalodon tooth compared to a great white shark tooth.

on the shark tree of life? That is unclear, but given the similarity in tooth shape to the great white, it is highly likely that Megalodon fits within the order of sharks called Lamniformes, an order more commonly known as mackerel sharks. With 15 living species in this order, including the great white, basking, megamouth and thresher sharks, there are a number of different positions in the family tree that the megatoothed family may be found (Fig. 3). However, there is a way to infer a probable position without the use of fossils, a way that also allows us to deduce which modern sharks could be used to calculate Megalodon's body size. The approach is called extant phylogenetic bracketing (EPB) and it enables the potential phylogenetic positions of extinct taxa to be inferred based on the biological traits that they are known to share with modern taxa.

From Megalodon's fossils, we know that this giant shark had serrated teeth, fed on marine mammals and was most likely able to physiologically control its internal temperature (Ferrón, 2017). Modern lamniform taxa with all of these traits can be narrowed down not only to the great white shark, but also the two species of mako shark, the salmon shark and the porbeagle shark. As such, given the dental, ecological and physiological similarities these species all have with Megalodon, they represent the best available analogues. And, given that Megalodon is not a direct ancestor of the great white, all of these sharks can be considered equally related to the giant. We can therefore regard all five modern sharks as potential analogues, and their body structures that support the traits shared with Megalodon are our best modern insights into the size and appearance of this huge extinct shark.

Body size calculations

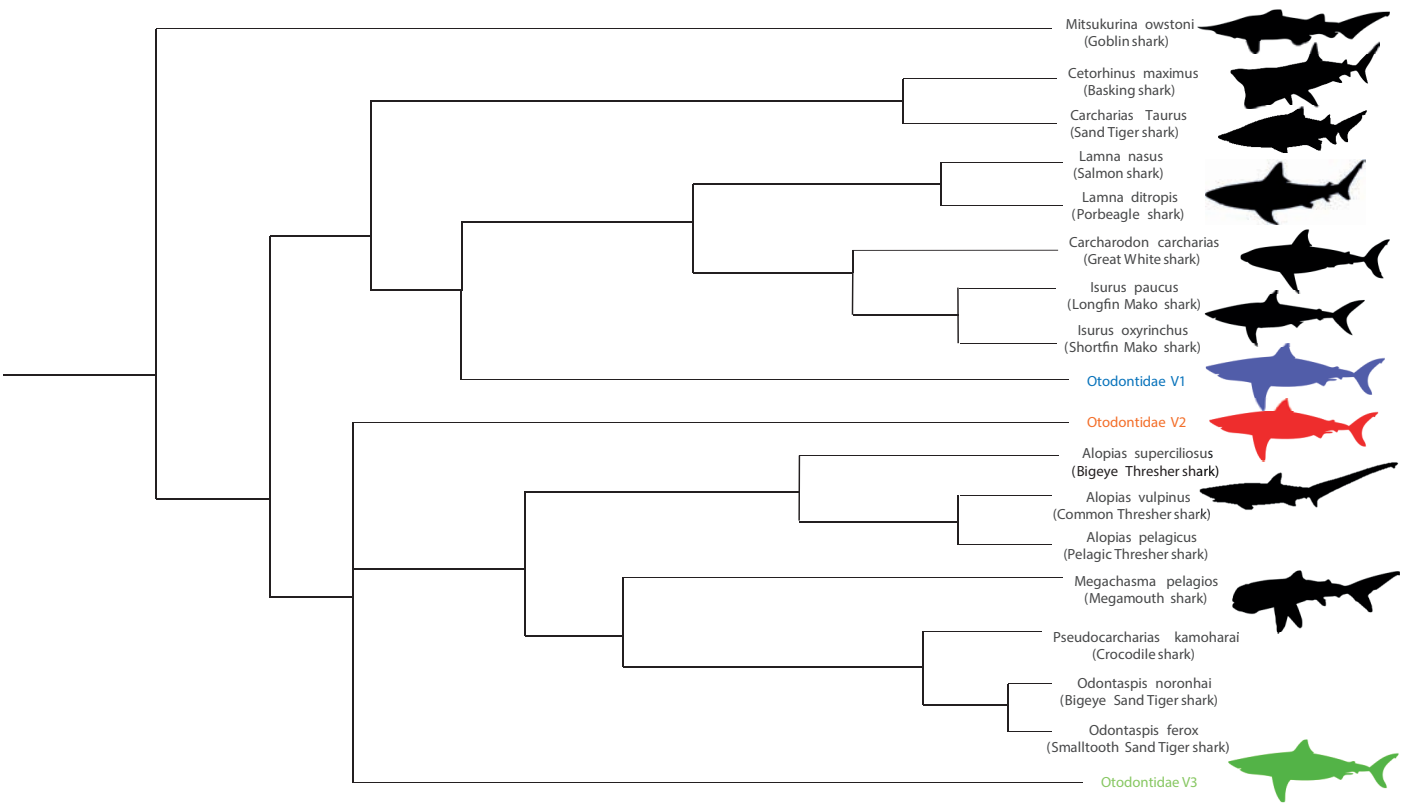
Although the only widely available fossils of Megalodon are their teeth, using these teeth to calculate its total length only requires knowledge of the tooth's position in the jaw and some fairly basic maths. The total length of a shark has a very strong linear relationship with the crown height of its teeth, and is reported as:

$$y = mx + c$$

In this equation, y represents the shark's total length, m is the slope of the relationship between total length and x, the crown height, while c is an intercept that changes depending on the position of the tooth in the jaw (Shimada, 2002).

Such a relationship is found in great whites, shortfin makos and porbeagle sharks among others. To calculate total length from the crown height of Megalodon, we typically extrapolate the same relationship from that of the great white shark. Although the two are not as closely related as originally thought, the great white remains the shark with by far the most similarly shaped tooth to Megalodon. Furthermore, the relationship ▶

Fig. 3: A phylogenetic, or family tree of Order Lamniformes. There are 15 extant species in the Lamniformes order (shown in back). It is unclear where the Otodontidae family, that of Megalodon, sits in relation to these living sharks and 3 separate hypotheses (V1, V2 and V3 – shown in blue, orange and green respectively) are shown as examples. V1 (blue) suggests that the closest living ancestors would be family Lamnidae, the family consisting of the great white, mako, salmon and porbeagle sharks. V2 and V3 suggest that Otodontidae share common ancestors with thresher and sand tiger sharks respectively, theories that have also been proposed. However, given that Megalodon shares numerous traits with the lamnid sharks, including dental and physiological similarities, we suggest that the V1 placement is the most parsimonious. Silhouettes for M. owstoni (by Haplochornis, vectorised by T. Michael Kessey), C. carcharias (by Steven Traver), Isurus species (uncredited), O. megalodon (by Scarlet23, vectorised by T. Michael Kessey) and M. pelagicus (by Jose I. Castro, vectorised by J. Boyle) are found on Phylopic (licence: https://creativecommons.org/licenses/by-sa/3.0/). All other silhouettes created by Jack A. Cooper.



▶ between total length and crown height in these sharks is isometric, meaning that the rate of tooth replacement and growth is near-identical to the rate of body growth. As such, palaeontologists have applied this relationship between crown height and total length to sharks and calculated maximum lengths of 15 to 18 m for Megalodon (Pimiento & Balk, 2015). More recently, it has been found that the middle front teeth of the upper jaw are the teeth that best correlate to total length, and the largest such teeth that are publicly available in museums correspond to lengths of 15 to 16 m. However, there are reports of even larger teeth in private collections that, if confirmed, would represent a maximum (and likely exceptional) length of 18 m (Shimada, 2019).

Although this simple approach is very effective for telling us Megalodon's length, it does not reveal the shark's specific body dimensions, such as the head, gills, tail and individual fins. The next step, therefore, is to apply the same method, but to correlate total length with body parts other than the size of the teeth.

From extant to extinct sharks

While a fully preserved skeleton of Megalodon has never been found, measuring the head, tail or fins of modern sharks and comparing them to total length helps us to understand how long these specific body parts may have been in the giant shark. As stated above, Megalodon shared dental, ecological and physiological traits with the great white shark (Fig. 4), both species of mako shark (shortfin and longfin makos), the salmon shark and the porbeagle shark. Based on EPB, these five species are therefore the five we use to understand the relationship between different body parts and total length. This relationship is the same basic formula as the earlier one, written again as:

$$y = mx + c$$

In this equation, y is a specific body measurement, m is the slope of the relationship, x is total length and c is the intercept.

If isometry is found in these relationships in all species, we can extrapolate them to Megalodon—as was done in the relationship between crown height and total length in the great white shark. Isometry in these new relationships would suggest to us that the specific body part being measured is growing at the around same rate as the total length of the shark in question. Indeed we do see this when we chart each body dimension against total length. We see it when we plot each individual modern shark species, and we even see it when plotting all five species together. As such, these linear body parts do not change in their proportions to total length and thus we can calculate those proportions and apply them to Megalodon to determine how large those body parts would have been in relation to the shark's length.

A more complete profile

When we convert our measurements of body parts into proportions of total length, we find that if we combine our modern day sharks as equal counterparts to Megalodon, head length is ~29% of total length, each of the five gills are ~9% of total length, dorsal fin height and width are ~10% and ~12% of total length respectively, and tail height is ~24% of total length. As we measured 41 total sharks across those five species, we naturally found some variation and thus those percentages represent the mean proportion. To account for this in our results, we also calculated the standard deviation of each measurement. These deviations proved to be very small indeed, suggesting that while there was likely some variation in the size of body parts between individual Megalodon, our results can be considered accurate and reliable.

We also found that isometry held true when we used landmark-based morphometric analyses—an approach that allows the quantification of shapes and shape variation. This approach gave us an indication as to how shape in the head and fins of our sharks change as total length increases. For example, we found that the caudal, or tail fins, were identical between our analogues—supporting previous work that had found four distinct types of caudal fin in Order Lamniformes (Kim *et al*., 2013). Pectoral fins, those on the side, also became proportionately longer and dorsal fins along the back were found to become taller and slightly narrower with increased total length.

So how big were the head, fins and tail of a 16-metre-long Megalodon—a size typically considered amongst its largest? When we apply our proportional findings to the body dimensions, we uncover some extraordinary sizes along Megalodon's body. We find that the head of a 16-metre-long shark would have been approximately 4.65 metres—larger than the average size of an entire great white shark! The dorsal fin,

Fig. 4: A great white shark (Carcharodon carcharias), by far the most commonly used analogue of Megalodon.

the famous icon of a shark stalking its prey from beneath the waves, was at least 1.6 metres tall, the same height as many adult humans. And the tail that powered its swimming through the ancient oceans was around 3.85 metres high. On top of these remarkable numbers, we found gills were about 1.41 metres tall, pectoral fins more than 3 metres long, and a distance of more than 4.5 metres from the tip of the dorsal fin to the bottom of the stomach.

The knowledge of these sizes, combined with our morphometric results of how fins are shaped in larger sharks, allowed us to produce a full 2D reconstruction, providing a complete profile of Megalodon. This reconstruction was finalised in a piece of gorgeous artwork put together by the incredibly talented palaeo-artist Oliver Demuth (Fig. 5). Palaeo-artists provide a key, and often underappreciated, way to engage the public and capture imaginations with illustrations of prehistoric worlds and creatures. There is no better way to express the grand beauty and scale of the Megalodon.

Ecological insights

Now that we have a complete profile of the largest predatory shark to ever exist (Cooper *et al*., 2020), it will inform future model reconstructions of this animal, which are often displayed in museums worldwide. We can also potentially connect some dots about its ecology. For example, how heavy was Megalodon? Estimates exist, but these are mostly based on extrapolations from the great white shark. Megalodon's size may have varied between different habitats (Pimiento & Balk, 2015), perhaps affecting what prey it targeted. Its diet of marine mammals is well documented in the fossil record and suggests that it may have gone after relatively small-bodied whales (Collareta *et al*., 2017). Furthermore, knowledge of Megalodon's full body form could provide insight on how its swimming may have supported such a lifestyle and, by extension, how its lifestyle may have contributed to the shark's eventual extinction in the Pliocene (Boessenecker *et al*., 2019).

I hope to answer some of these questions by combining my results with analyses of Megalodon's vertebrae fossils to construct a 3D model of the shark. As part of a 4-year PhD project, working with Dr Catalina Pimiento at Swansea University, I will examine the functional diversity of sharks through time, to understand which ecological traits of sharks were most affected by past extinctions, which sharks became more favoured as a result, and what might become of today's sharks in the ongoing extinction crisis.

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Acknowledgments: This work formed the basis of my MSc thesis at the University of Bristol. I deeply thank my supervisors, Dr Catalina Pimiento (Swansea University) and Prof Mike Benton (University of Bristol), and our co-author Dr Humberto Ferrón (University of Bristol), as well as my peers at Bristol University. Thanks, too, to Dr Pimiento and Dr John Griffin for their supervision of my PhD, and to Oliver Demuth for his beautiful artistic reconstruction of Megalodon. Finally, I thank the Fisheries Society of the British Isles (FSBI) for their ongoing funding of my PhD.

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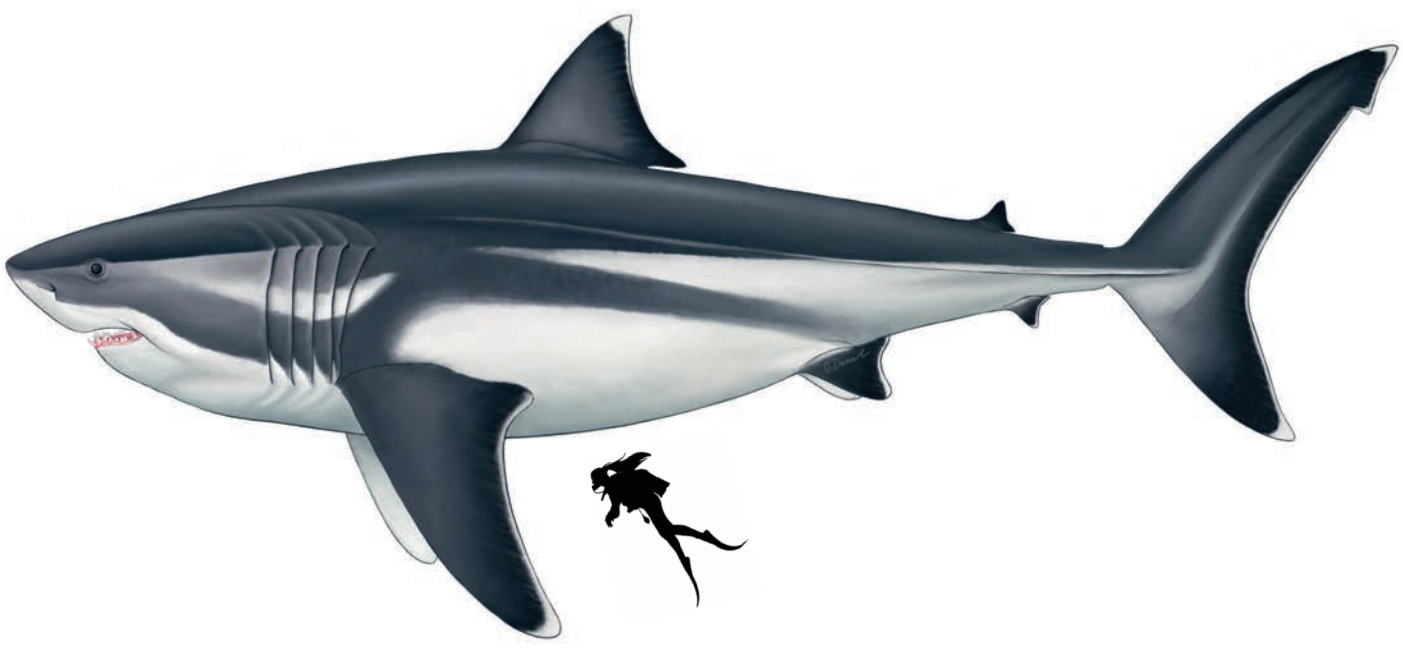

Fig. 5: The final full-body reconstruction of a 16 metre Megalodon created from our work, compared against a 1.6 m diver. Reconstruction by Oliver E. Demuth. Figure from Cooper et al., Sci. Rep. 10, 1-9 (2020). Copyright © 2020, Springer Nature. Creative Commons CC BY license.

TECH, ETHICS AND THE DIGITAL CITIZEN

Cutting-edge tech provides endless possibilities for data collection through digital citizen science projects. But with big opportunities come big ethical challenges, cautions Estelle Clements

An alien-looking landscape stretches out in front of you. Keen to log as much geoscience information about it as possible, you take out a multifunctional handheld tool and start scanning the ground. No, it's not Star Trek; it's current reality—the technology is available now.

One such technology, common to many geoscientists, is LiDAR, or Light Detecting and Ranging, a remote sensing method that uses pulses of light to measure distance. By sending out an array of laser pulses, LiDAR yields rich information on the surfaces it contacts and can be used to build a picture of those surfaces. In the past, the creation of such an image required specialized technology, careful calibrations and maybe a plane or helicopter. Today, LiDAR can be found in household items such as robot vacuum cleaners.

With the company Apple recently announcing that its latest iPad features LiDAR with a 5-metre range, LiDAR stands to become an affordable and commonplace addition to the everyday complement of tools on our digital devices. It also hints at a future where digital citizen scientists can play a key role in contributing to geoscientific data collection and our understanding of the geological world—but only if we can first overcome a number of ethical obstacles.

Technological development

It's not just the presence of LiDAR on a commonplace device that will interest geoscientists. The LiDAR on Apple's iPad (an innovation that doubtless, other companies will reproduce) is integrated with the device's capacity to take photographs. The union of LiDAR with picture data enables photogrammetry, that is, the gauging of distance using photographs—another common technology familiar to many geoscientists.

Thus, enormous volumes of data are stored in the meta-data file associated with an image, such as time, date and location. This mass of information, which can easily be shared, provides incredible opportunities for geological research, including analysis of rock formations and structural features. Acquired over a period of time, such data could also be used to study changes in the Earth, such as ground movements and erosion, aiding geohazard assessments and contributing to land management, emergency planning and building developments.

Citizen science

Emerging technologies could be used by the public to positively impact geoscientific research in many ways. Citizens could build a profile of their local community, scanning and acquiring data that can be compiled for later analysis by geoscientists. Such participation from active digital citizens would be particularly useful in areas that have received little attention, perhaps because they are rural and difficult to reach, or because they are deemed insufficiently critical to receive the limited funding available for such data collection. Such an approach could identify geologically important issues or regions that were previously overlooked, including areas with potential archaeological and geoheritage value.

Programmes could be set up to harness the ability of local populations to contribute to a growing body of knowledge with relative ease. Apps and digital databases would allow citizen scientists to see where data are needed and how they might reliably contribute to longer-term projects, in which data must be collected at regular intervals over specified periods of time.

Such endeavours encourage people to collaborate and contribute to a body of knowledge for public good, foster a closer bond with the natural environment and geological world, and instigate public outreach and education, while inspiring young people to pursue the field of geoscience.

Exploitation potential

Before we rush off to harness new technologies and formulate strategies to broaden the scope of geoscience through input from digital citizen scientists, we also need to consider the potential issues that can arise. Large volumes of location-related data will be readily accessible, and when we grant an app access to our digital devices, they may collect other personal data from our device as well. The access and use of such data present a host of deeply significant ethical issues—particularly when government bodies or private corporations are involved.

For instance, individuals who are recording data from their local environments might travel for personal reasons to certain locations at regular intervals of time. This means their data are not only of scientific value, but also acutely private, and would have to be protected. Readily available data of this quantity and quality could also be commercially exploited and are vulnerable to potentially malign use by private and

third-party companies.

There are plenty of scenarios to consider. Photographs taken of friends on a hike, though not initially intended to assist geoscientists, might prove to be of value later, for example, if images are sought to assess changes in that area over time. Many people won't mind helping out and sharing their images if it means contributing to science, but citizens have to understand what they are giving away—not just photographs or LiDAR data, but personal information as well.

And there are more insidious threats to contemplate. If we upload LiDAR data and photographs to an internet-based cloud storage system, how can we be assured that the data will not be used to map out our homes, personal properties, private lives, time spent with friends, and daily activities?

Most people are aware that targeted advertising results from our internet searches. But companies don't only track where we go online, they also track where we go in the physical world, since we leave a similar, easy-to-follow data trail behind us. For example, you may allow an app to access the map function on your smart phone or tablet, so that it can direct you. However, the company that owns the app may then sell your information to third-party companies so that they can send you targeted advertising. Our location data could tell a company what our daily commute is like and what time we get home in the evening. The company may see that we're trying to lose weight by going to Weight Watchers, but that our resolve weakens and we head to the local ice cream parlour when we've had a challenging work commute. So, a company may advertise ice cream to us when traffic has been heavy or the trains are delayed, then advertise weight-loss products an hour later, when we feel vulnerable.

By knowing all our favourite private haunts, companies can tell what our religious beliefs are, our political leanings, our sexual orientation, even what our favourite food is. They might see that we rarely go to the gym, or that we're prone to drive instead of walk, and change our health insurance rate. With visual data, a construction company might see our damaged roof and target us with advertising. With technology that can map out what is inside our homes, the possibilities are endless. The decisions made based on the data collected by citizens should improve our lives, but could damage them as well.

Ethical framework

For geoscientists to benefit from technological advances and citizen science projects, they must instil confidence in participants, ensuring that any data offerings will not be exploited or used against them later. Geoscientists must be the guardians of good data use, insisting on an ethical code and demanding moral conduct from the corporations with which they work. Certainly, geoscientists cannot allow some of their most reliable and promising tools to be misused in nefarious ways.

The creation of a formal ethical framework that is specific to geoscientific data would be a major step in helping to ensure the responsible use of LiDAR and other data gathered from digital citizen scientists, and would encourage greater uptake in digital geoscience community projects. Similar frameworks already exist. For example, an unexpected outcome of the Covid-19 outbreak, and the focus on location-tracking apps to help prevent its spread, is the development of a set of ethical guidelines that describe the appropriate use of location data. Formulated by some of the world's best information ethicists, the guidelines include 16 questions to ascertain the ethical design of digital tracking and tracing systems, and provide a valuable starting place to create geoscientific-specific frameworks. We are just beginning to appreciate the challenges posed by cutting edge technologies, and it is essential that we address these challenges to safeguard a healthy scientific future.

The addition of LiDAR technology to Apple's latest products signals a move toward the broader inclusion of such technologies in the consumer marketplace. Significant ethical issues accompany this shift and must be addressed. We need to carefully consider how we understand, manage and apply these technologies in order to harness their full potential. The technologies are young, but the possibilities—both good and bad—are endless. We must consider from the outset how to ensure the outcomes for geoscience and citizen geoscientists are good. A tremendous potential for scientific advances exists, but it requires a positive vision and a well-considered ethical strategy.

Dr. Estelle Clements is an expert in digital civics, and researches ethical and responsible behaviours in the digital realm. She maintains the website digitalcivics.org; estelle@digitalcivics.org

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NEW HOMES FOR OLD CORE

Two years on from its launch, **Kirstie Wright** and **Henk Kombrink** discuss how the North Sea Core initiative is helping to support the future of geoscience

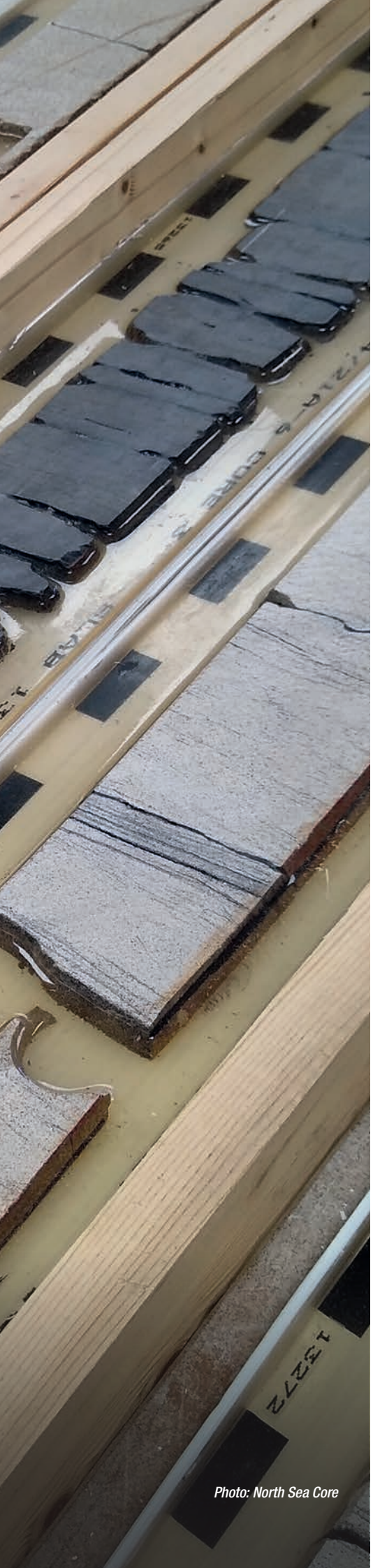
Photo: North Sea Core

Any geoscientist who has trained or worked in the UK is aware that for such a small geographic area, the onshore geological record is remarkably diverse. The same can be said of the offshore geology, which preserves Precambrian basement to Late Cenozoic sediments.

Gaining access to the offshore geology requires a range of tools and techniques that includes everything from dredging the seabed, to remote imaging, to drilling wells. With the UK offshore basins home to the petroleum industry since the 1960s, it is core material retrieved from the wells drilled during this time that have provided a unique window into the subsurface.

Since October 2017, we at North Sea Core Community Interest Company (CIC) have been collecting core material made redundant due to the abandonment and decommissioning of wells on the UK Continental Shelf. In turn, we transform and upcycle core for use by the geoscientific and wider scientific community.

Of core concern

The North Sea Core initiative was founded on the basis that core material provides an invaluable resource for understanding the subsurface. Rather than see this material fall into disuse or be discarded, it should be preserved as part of our geoheritage and as a teaching resource. Therefore, we only collect material that has been sourced from surplus company samples and approved for donation by the Oil and Gas Authority, as documented in the Petroleum Operations Notice 9 (PON 9) guidance, with no material removed from the British Geological Survey collection.

This November marks two years since we started North Sea Core and six months since it became a Community Interest Company. The campaign to save the core material started when Henk was alerted to the disposal of core while serving as the Petroleum Exploration Society of Great Britain (PESGB) Aberdeen Director and began to advertise the fact. He created what is now the basis of North Sea Core, by collecting and upcycling this valuable material into accessible resources. This led to a partnership with Kirstie Wright, who became involved while serving on the committee for the Petroleum Group of the Geological Society of London (now the Energy Group).

North Sea Core officially launched in November 2018, using a dedicated email, website, and a range of social media accounts to centralise our operations and reach a wider audience. We are also assisted by a team of volunteers who donate their time and energy, supporting our aim to collect, transform and distribute core to the wider geological community for education, research, outreach and display.

In May 2020, we formalised our initiative by becoming a Community Interest Company, giving us scope to grow in the future and become a sustainable enterprise, potentially providing employment. Different to a traditional Limited (Ltd) company, as a CIC we have a legal clause known as an "asset lock" that states any profits generated through the sale of core are reinvested into North Sea Core and used to benefit the Geoscience community, rather than divided between directors.

A second life

We believe that long after core material has served its purpose in the petroleum industry, it still has the potential to answer new questions. Core can have a second life in making geology accessible to non-scientists, educating the next generation of geoscientists and aiding in the research for future energy needs.

While most of our core is from the UK North Sea, other samples have come from the East Shetland Platform, Moray Firth Basin and the Irish Sea Basin. The material includes a variety of cut core and resin-impregnated core slabs, ranging from the Carboniferous to the Paleocene. These supplies, at the time of writing, have enabled us to send over 260 national and international packages of core to 21 countries. We have achieved this by collating and creating resources aimed at education and science outreach. The packages can range from small individual half-cut core samples, to much larger bespoke teaching sets, with selected core and associated logs, reports and maps—all chosen depending on the needs of the course or teaching environment. ▶

Selection of core material, as often collated together in teaching sets. Includes Carboniferous fluvial sandstones, Middle Jurassic shallow marine and channel sandstones and Upper Jurassic oolitic limestones. Photo: North Sea Core.

These resources include a range of Exploration Boxes. Each box contains five samples that support the chosen geological theme of the box, together with an explanation sheet. Our first box explored the petroleum geology of the North Sea and was generously sponsored by the Petroleum Exploration Society of Great Britain, the Petroleum Group of the Geological Society of London and the Oil and Gas Authority. Our second box explored the depositional system of the Middle Jurassic delta in the Northern North Sea, which provides the key reservoir for the Brent oil field. Named the BRENT Group, the Broom, Rannoch, Etive, Ness and Tarbert Formations record the progradation, deltaic, coastal plain and transgression of the delta. Future boxes are planned and may explore topics ranging from the depositional environments of the Southern North Sea to Geothermal Energy.

We also cater to interested geologists and the industry from which the core material originated. This varies from

Henk Kombrink in the North Sea Core HQ with a range of core samples, cleaned and prepared, ready to be shipped to their new homes. Photo: Rory Raitt.

individually selected core samples of framed cores that serve to explain a person's work to their friends and family, to larger geological displays that consist of core material, maps, cross sections and explanatory text. These larger displays help communicate the geology of a region, the nature of the subsurface and the type of work companies undertake. Conference gifts and prizes are also popular, with material supplied to recent DEVEX and PETEX conferences, and the Oil and Gas Authority National Data Repository launch.

A future resource

While much of our work may be focused on the geological past, we are also looking to the future. The relinquished core has provided an opportunity for us to support a variety of research projects ranging from digital rock microscopy and fracture mechanics, to unconventional gas and well completion and abandonment. We believe core also has the potential to assist in the research of geothermal resources, as well as carbon capture and storage—with recent requests exploring this.

In addition to the physical core, it is vital to integrate digital data where possible and we utilise open access data from both the Oil and Gas Authority's National Data Repository and the British Geological Survey. Using these data, we can place the core in both a local and regional geological context, combining it with other subsurface information, such as seismic, petrophysical and stratigraphic data. Where possible, we make this integrated material available for use with a Creative Commons licence.

We are extremely grateful to those who have engaged and championed our initiative, helping it become a success. We plan for North Sea Core CIC to be an established resource that serves the geoscience community by providing access to core and offering training. We will continue to seek funding, form collaborations and work with partners to maximise use of this important geological resource.

Dr Kirstie Wright and Dr Henk Kombrink, Directors of North Sea Core CIC

FURTHER READING

North Sea Core Website: https://www.northseacore.co.uk/

Oil and Gas Authority PON 9 guidance: https://www.ogauthority.co.uk/exploration-production/petroleum-operations-notices/pon-9/

Kirstie Wright in the North Sea Core store with material, ranging from the Permian to the Jurassic. Photo: Rory Raitt.

The Geological Society

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The role of subsurface research labs in delivering net zero:

realising the potential of UKGEOS

3-4 February 2021

Virtual Event

Main Convenor:

Mike Stephenson (British Geological Survey)

Co-convenors:

Mike Spence (British Geological Survey)
Zoe Shipton (University of Strathclyde)
David Manning (University of Newcastle)
Linda Stalker (CSIRO, Australia)

Further information:

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The Geological Society
serving science, profession & society
2021 YEAR OF SPACE

A range of energy resources, infrastructures and technologies are likely to be required as part of the transition to a low carbon energy system and net zero. Many of these resources are likely to have impacts on or implications for, the subsurface. Against this background, the purpose of the new £31 million UK Geo-energy Observatories (UKGEOS) is to facilitate research that improves understanding of subsurface energy developments, mass and energy transfer in coupled systems, and their impacts on the subsurface and surface and consequently their interactions with the wider energy system. The conference will bring together scientists from the UK and internationally, to talk about their experience with subsurface facilities, to examine the capacity of the UKGEOS facilities, to develop and stimulate research directions, to link these to decarbonisation policy and regulation, and to stimulate international collaboration in geo-energy.

Call for Abstracts

We invite oral and poster abstract submissions for the meeting, and these should be sent in a Word document to conference@geolsoc.org.uk by Wednesday 15th December 2020. Abstracts should be approximately 250-350 words and include a title and acknowledgement of authors and their affiliations.

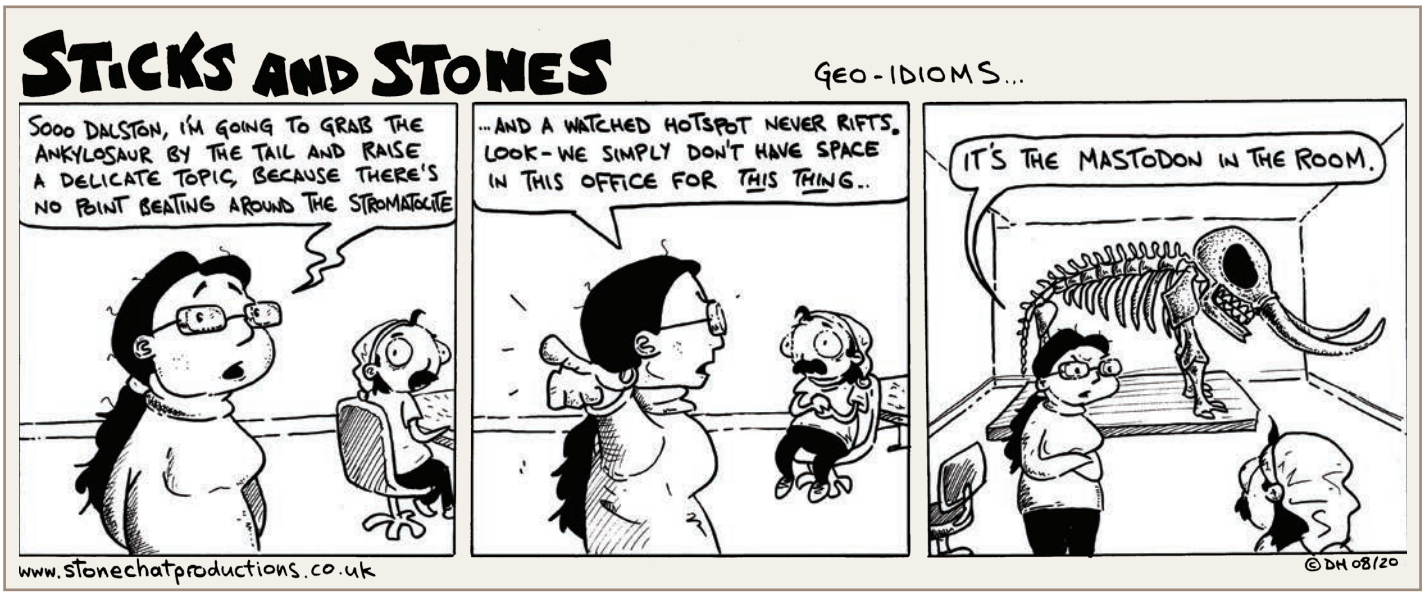
CALENDAR

Due to the ongoing public health risk posed by COVID-19, all GSL events and venue hire bookings at time of writing are being held virtually, in line with Government advice.

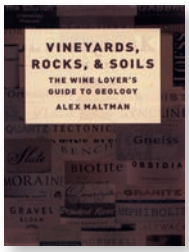
Please visit www.geolsoc.org.uk/events for the latest updates. If you have any questions about upcoming events, please contact conference@geolsoc.org.uk.

VIRTUAL EVENTS

MEETING	DATE	VENUE AND DETAILS
Energy Group: Operations geology in 2020 and beyond: traditional and modern approaches	4-5 November	Conference **Venue:** Taking place remotely **W:** www.geolsoc.org.uk/pg-ops-geology
GSL Public Lecture: Engaging geoscience for diplomacy-understanding Paektu volcano in North Korea	9 November	Lecture **Venue:** Taking place remotely **W:** www.geolsoc.org.uk/understandingpaektu
WMRG: Early Careers Award launch event	10 November	Evening meeting **Venue:** Taking place remotely **W:** www.geolsoc.org.uk/wmrg-early-careers-award-launch-event
GSL online training: Publishing in GSL journals	11 November	Webinar **Venue:** Taking place remotely **W:** www.geolsoc.org.uk/publishing-in-gsl-journals
Sulfur in the Earth system: From microbes to global cycles through Earth history	16-17 November	Conference **Venue:** Taking place remotely **W:** https://www.geolsoc.org.uk/sulfur
Memoir 52 launch conference: UK oil and gas fields 50th anniversary commemorative memoir	30 November	Conference **Venue:** Taking place remotely **W:** www.geolsoc.org.uk/rescheduled-memoir-52-launch-conference
Brownfield Development Festival 2020	21 October - 19 November	Conference **Venue:** Taking place remotely **W:** https://www.geolsoc.org.uk/brownfield-development-festival-2020



Vineyards, Rocks, and Soils – The Wine Lover's Guide to Geology



The important link between geology and wine is, on one level, rather obvious: geologists drink a lot of it. It is also generally accepted that while geology is 'everything to the grower', in reality it is very little to the drinker. As Alex Maltman points out in this jolly and enthusiastic book, appreciation of geology can add as much to vinous enjoyment as history enhances one's enjoyment of a mediaeval cathedral. But lately, back-ticket labels—even some wine names—increasingly reference geology. The dustjacket, showing a collage of labels from wines called 'Amphibole', 'Moraine' and 'Biotite', makes this clear. As with certain perpetrators of so-called 'new nature-writing', in much wine writing we see a stringing together of (often obsolete) geological vocabulary like beads on a string, just to be pretty and not to convey any meaning.

Geologists should rejoice, because this trend evinces warm feelings towards their subject in the heart of the oenophile public. But often they wince. They know it's impossible to taste the slate or the flint, simply because rocks are insoluble. They know the 'iodine', which certain pundits pretend to detect in Chablis, can only be a metaphor, and certainly cannot derive from fossil molluscs. But unfounded belief in geological taste descriptors as 'actual' rather than 'metaphorical' seems to be tenacious.

Revulsion at this sort of thing turns some geologists into tiresome 'anti-terroiristes' who suspect that 'terroir' as a concept is all magical nonsense, and that everything is vinification. The truth probably lies somewhere in between and thankfully, Maltman is not so reductionist. But he is at great pains to explain how—and why—the wine-geology pudding is so often over-egged in popular wine literature.

PR is about warm feelings; education about conveyancing knowledge, which often (indeed, usually) has the reverse effect. If I have reservations about this book—apart from its anaemic index—it is wondering who should buy it. The first 140 pages are a good and comprehensive textbook of geology—from cation exchange to plate tectonics—seen through a glass, with occasional references to wine regions worldwide. Only when geomorphology makes an appearance (chapter 8) does it get into its stride; and the best passages come at the end, when relationships between rocks, geology, wine and wine terminology are truly discussed. But I found this a little unbalanced, like a joke whose punchline doesn't quite justify the laborious build-up.

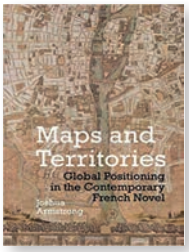
There is far more science in here than any normally arranged person can be expected to stomach; and being education, it has to begin at the beginning, which is to say, very far indeed from the matter in hand. That's education for you. It assumes the audience is captive, which is why its storyboarding is really rubbish. Most geologists will not learn much geology, but most non-geologists will find it all a bit too much.

Nevertheless I would recommend it as a fantastic and improving Christmas present for any vinous rockhound, who will find much to savour throughout.

Reviewed by ***Ted Nield***

VINEYARDS, ROCKS, AND SOILS – THE WINE LOVER'S GUIDE TO GEOLOGY by ALEX MALTMAN
2018 Oxford University Press ISBN: 978-0190863289)
List Price: £26.99 234pp, hbk.
W: https://global.oup.com/

Maps and Territories: Global Positioning in the Contemporary French Novel



Over the last decades the internet, urbanisation, technological advances and the global movement of people, information and ideas have wrought profound changes to how we perceive the concepts of location and human relations. The author of this book of literary criticism has selected eight recent novels by eight leading French novelists and analyses how the authors engage with this.

The book is divided into four parts, excluding the introduction and conclusion. Each section examines how the protagonists of the novels analysed deal with a specific aspect of globalisation by focussing on two books by two authors. I particularly enjoyed the first part, which is about the effect 24/7 media dominated by neo-liberal moguls affects both individuals and society. The bird's eye view detaches the viewer from the events portrayed and turns them into passive spectators. In the second part, novels where the protagonists find themselves transplanted to unfamiliar, fast-moving international environments are analysed. I also really enjoyed the third part in which protagonists who have lost their place in society develop new lives in the boundaries between the public and private spheres.

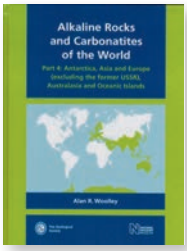
Maps do not show reality as such but are edited to convey a message. In the example in the book, the 1652 map of Paris ostensibly shows a realistic view of the city, but is full of symbolism emphasising the power of the Sun-King. Meanwhile, blank spaces in the present street-map of Paris are not empty at all, but actually contain large industrial estates or undeveloped areas that corporations and developers do not want the public to be aware of. In the fourth part, novels where protagonists find ways to counter their alienation are analysed.

That does not mean the other two parts were not interesting; far from it. The entire book is a challenging but thought-provoking and enjoyable read. I have one minor issue, and that is the quotes in French that break up the text. The big issue I have is that I now want to read the novels analysed, but the only ones that seem to be translated into English are Michel Houellebecq's The *Map and the Territory* and Virginie Despentes's *Vernon Subutex* trilogy. To me, this limits the impact of the book as readers unfamiliar with French cannot partake of the analysed novels.

By ***Lars Backstrom***

MAPS AND TERRITORIES: GLOBAL POSITIONING IN THE CONTEMPORARY FRENCH NOVEL
by JOSHUA ARMSTRONG, 2019. Published by: Liverpool University Press 238pp (hbk) ISBN: 9781786942012
List Price: £90.00. W: https://www.liverpooluniversitypress.co.uk/books/id/51707

Alkaline Rocks and Carbonatites of the World, Part 4: Antarctica, Asia and Europe (excluding the former USSR), Australasia and Oceanic Islands



The last part of a four-volume set on the distribution of alkaline rocks and carbonatites has recently been published by the Geological Society of London. As with the other volumes, the work is authored by a true authority of the subject, Dr Alan Woolley.

Woolley's knowledge and enthusiasm for these rocks is reflected in this highly professional publication. Alkaline igneous rocks are an important source of mineral commodities including niobium, rare earth elements and phosphates. In addition, the study of alkaline rocks and carbonatites has greatly contributed to our understanding of crustal scale and mantle processes based on field, petrographic, mineralogical and geochemical studies. Despite this, clearly identifying these rocks can be challenging, particularly in the areas covered within this volume, where such rocks were mis-identified in historical studies.

Consistent with the other volumes, the book is divided on the basis of geography and country. For each of these, a locality map and a cross-referenced list of occurrences is given. Each alkaline and carbonatite complex is accompanied by a detailed geological map, geographical co-ordinates, details of the general geology, petrography, ages and, where relevant, economic aspects. An index at the end of the book provides easy access to sections on individual localities.

This is a unique reference source for alkaline igneous rocks that can be found outside of the generally recognised areas for these rocks. As with all previous volumes, it is well presented and will, I am sure, along with its companion volumes be the focal reference for generations to come on these enigmatic rocks.

Reviewed by ***Rob Bowell***

ALKALINE ROCKS AND CARBONATITES OF THE WORLD, PART 4: ANTARCTICA, ASIA AND EUROPE (EXCLUDING THE USSR), AUSTRALIANA AND OCEANIC ISLANDSS by Woolley, A.R. (2019) The Geological Society of London. 562 pp. (hbk)
List Price: £120.00 Fellow's price: £ 60.00
W: https://www.geolsoc.org.uk/MPAR4

BOOKS FOR REVIEW

Please note, there may be a delay in supplying review copies whilst our offices are closed due to COVID-19. Please contact **geoscientist@geolsoc.org.uk** if you would like to supply a review. See a full, up-to-date list at **www.geolsoc.org.uk/reviews**

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- **NEW! Integrated Fault Sea Analysis** by S. Ogilvie et al (eds), Geological Society of London SP296, 288pp, hbk.
- **NEW! Subaqueous Mass Movements and their Consequences: Advances in Process Understanding, Monitoring and Hazard Assessments** by A. Georgipoulou et al. (eds), Geological Society of London SP500, hbk.
- **Rivers in the Landscape** by Ellen Wohl, Wiley Blackwell 2020, 500pp, pbk
- **Paleozoic Plays of NW Europe** by A.A. Monaghan et al. (eds), Geological Society of London SP 471 2019, 398 pp. hbk.
- **Development of Volcanic Gas Reservoirs: The Theory, Key Technologies and Practice of Hydrocarbon Development** by Qiquan Ran, Dong Ren & Yongjun Wang, Elsevier (Petroleum Industry Press, Gulf Professional Publishing) 2019, 1066 pp. Pbk
- **Plant Flow Measurement and Control Handbook: Fluid, Solid, Slurry and Multiphase Flow** by Swapan Basu, Elsevier Academic Press 2018, 1288 pp. hbk.

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- Database searches - we can search the GeoRef and Geofacets databases on your behalf and send you lists of references

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Discover hundreds of images from our historical collections on our Picture Library. Whether it's the fossils discoveries of Mary Anning, beautiful geological maps, or even the world's largest pearl, there is something for everyone! www.gslpicturelibrary.org.uk

Online exhibitions

The Library's online exhibitions highlight various treasures from the Geological Society's special collections, and shed light on some of the most important figures in the history of geology. Our new exhibition, The First Women, celebrates just a few of the firsts achieved by women in both the science of geology and at the Geological Society. www.geolsoc.org.uk/Library-and-Information-Services/Exhibitions

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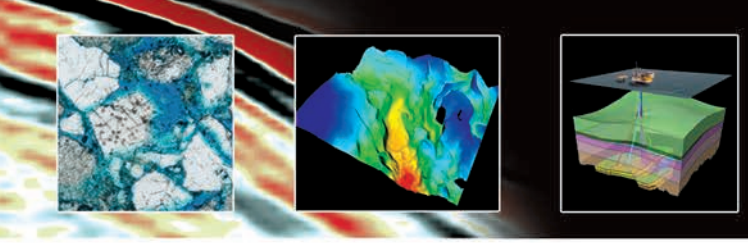

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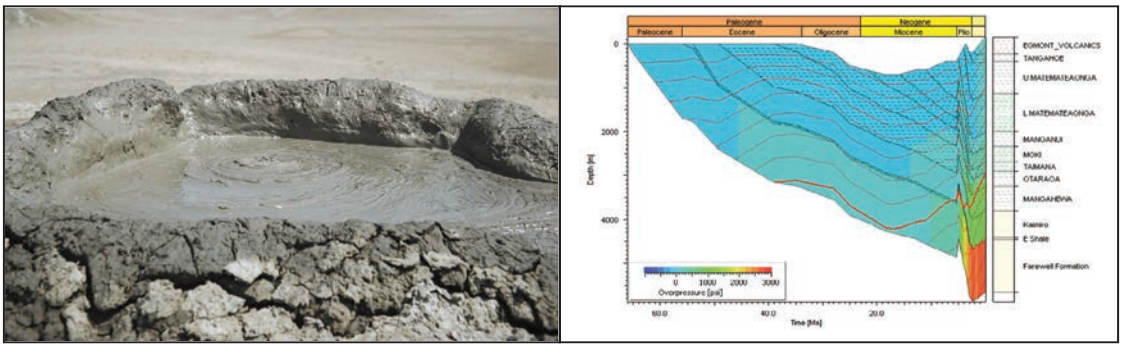
Managing Uncertainty in Geopressure by Integrating Geoscience and Engineering

23-26 March 2021

Virtual Conference and Masterclass



The organisers invite contributions within any aspect of geopressure but are particularly interested in the various phases of pore fluid pressure prediction, modelling and overpressure evaluation to manage uncertainty during the life cycle of a well. Suggested themes and sessions include:

- Pore Pressure and stress, especially complex stress regimes
- Impact of machine learning on PPFG
- Well engineering and PPFG
- Injecting fluids underground (including CO2)
- Coupling of Pore Pressure and FG including depletion and closing the drilling window
- Seal capacity and relationship with PPFG
- PPFG issues in mature basins (including abandonment/decommissioning)
- Classic case studies, including Macondo and LUSI mud volcano
- Pore pressure as an exploration and prospectivity tool.
- Geopressure in mature basins – lessons learnt
- Pore pressure in active tectonic basins
- Unconventional stress regimes

Event Details:

23-25 March 2021: Conferece

26 March 2021: Best practice for PP and FG - Mastery Class - Led by Richard Swarbick

Further Information:

For more information please contact sarah.woodcock@geolsoc.org.uk or visit the event website: https://www.geolsoc.org.uk/03-rescheduled-pg-geopressure-2021

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Geoscientists in the news and on the move in the UK, Europe and worldwide

DISTANT THUNDER

Safe landings

Geologist and science writer Nina Morgan discovers the key role geology played in the D-Day landings

During World War I, geologists such as W.B.R. King [1889-1963] and T.W. Edgeworth David [1858-1934] opened the eyes of military planners to the value of geological expertise. So when World War II broke out, geologists, including King, were once again recruited into service.

Another who joined the ranks was Fred Shotton [1906-1990]. Shotton, who served as Lapworth Professor of Geology at the University of Birmingham from 1949 until 1974, is best known for his pioneering work on the Pleistocene geology of the English Midlands. But perhaps not so well known is his work as a military geologist during the Second World War.

Top secret

As Captain Fred Shotton of the Royal Engineers, he spent the early war years from 1941 until 1943 based in Egypt, drawing on his knowledge of hydrogeology to provide potable water supplies for the 8th Army in the Western Desert. In October 1943, he was promoted to Major and recalled to the UK to carry out work classified as 'top secret'. It later emerged that Shotton's geological expertise played a key role in identifying suitable beaches in Normandy where heavy vehicles wouldn't become bogged down. In the run-up to D-Day, he also identified British beaches with similar conditions where landings could be practised.

Initially based at the Geological Survey in London, Shotton took advantage of information available from existing aerial photographs, historical French publications and postcards with images of the French coasts supplied by the British public. But needing more information, his daughter, Anne Black (née Shotton) recalled how: "My dad was flown over the beaches at great risk to try and make out the nature of the ground and take photos, but this didn't show enough detail and commandos had to make forays on to the beaches to get samples". These low-altitude flights were carried out using a modified Mosquito aircraft with a glass bottom on the fuselage.

Fooling the enemy

To conceal their activity, for every flight flown over Normandy beaches, 20 flights were flown over other French beaches. To gather further information, midget submarines were used to carry out near-shore hydrographic surveys at night, and crafts such as low-profile motor boats were used to allow volunteers to swim ashore to collect samples of stone and soft sediments and make observations on obstacles that could make movements difficult.

To confuse the enemy, the volunteers took samples from beaches they intended to use, as well as from beaches they didn't. On one of these missions they accidently left an auger drill bit behind. To conceal the Allied activities, the military planners toyed with the idea flying aircraft along the coast of much of western Europe and dropping augers on other beaches to obscure the preferred choice. Alas, this ingenious proposal was eventually abandoned due to an acute shortage of augers in the UK.

The information gathered enabled Shotton to physically look at the surface of the beaches and identify features that were not shown on the existing maps. As a result, he was able to estimate the load-bearing properties of beach areas by noting the depth of the wheel marks left by cars used to transport German defence stores. The data Shotton collected were used to create maps at 1:5000 scale to highlight treacherous conditions.

I told you so!

As Major-General Sir Drummond Inglis wrote in an article published in 1946, "We [the British] had, fortunately, long appreciated the importance of geology in modern war." However, as Shotton's daughter recalled, this view was apparently not shared by the Americans, who were sceptical about the need for all the detailed planning carried out for the Normandy landings. But, she reveals, her father had an answer to that. One of the photos Shotton retained shows an American truck bogged down "with dad's writing underneath saying 'I told you so!'"

End Notes: Sources for this vignette include: Rose, EPF & Clatworthy, J.C, *QJEngGeol and Hydrogeology*, **41**, 2008, 171-188; material available at www.birmingham.ac.uk/facilities/lapworth-museum/about/object-shotton-map.aspx and www.birmingham.ac.uk/accessibility/transcripts/les/lapworth-object-shotton-map.aspx; Black, Anne, My Father's D-Day Geologist Role, BBC WW2 People's War website www.bbc.co.uk/history/ww2peopleswar/stories/54/a4101454.shtml. I also thank Ted Rose and Eric Robinson for sharing personal memories of Fred Shotton.

*** Nina Morgan** is a geologist and science writer based near Oxford. Her latest book, *The Geology of Oxford Gravestones*, is available via www.gravestonegeology.uk

The Scottish Geology Trust

Melvyn Giles issues a call to arms for Scotland's geoheritage

From a geological point of view, Scotland is something of a superstar. Whether you view it from the development of the science, the range of rocks and processes preserved, the stunning scenery, the quality of the universities or its contribution to the economy and history, Scotland's geology is fundamentally important.

Scotland's past, present and future are intimately linked to geology. The beauty of the country stems from its long geological history, which includes continental collisions raising mountain chains of Himalayan proportions, meteor impacts, rifting, volcanism and glaciation. It is truly a land of ice and fire. The country's prosperity—past and present—is largely or partly derived from its geology. Today most of Scotland's primary industries, including the renewable energy, agricultural, life sciences, oil and gas, mining, forestry, tourism, environmental protection and even the whisky industries, all rely on an understanding of the physical processes operating on our planet.

Geological malaise

In the land of Hutton, Lyell, Hugh Miller and many other famous geologists, it is surprising that so little is generally known about the importance of the Earth sciences. Few of the many visitors to the Highlands who marvel at the landscape know much of the reasons why it exists or how it came about. Within the pre-university education system, mention of geology by name is rare, and our young people don't aspire to work as geologists. The future impacts of this on our workforce are concerning.

Rather than being celebrated for its value to landscape, industry and culture, geology has become tainted in many people's minds by its connection to the extractive industries. The importance of geology for securing the resources needed for renewables such as geothermal power and technologies that require lithium and other rare metals is overlooked. Crucially, knowledge of the physical processes that make our planet work are fundamental to understanding issues of climate change and to the management of geohazards.

Key conservation sites are woefully substandard. For example, Fossil Grove in Glasgow is an outstanding yet seriously neglected geological site of national and international importance. Siccar Point (Hutton's Unconformity) is an internationally regarded iconic geological site, and yet you wouldn't even know it was there. The ice age Parallel Roads of Glen Roy is an excellent example of the malaise hanging over Scottish geology. Although a site of international importance, its visitor centre, which is supported by Lochaber Geopark, closed for lack of funding.

Scotland's flagship Geoparks receive no core funding from the public purse, despite being an international model of best practice for geoscience communication and sustainable development, recognised by the United Nations. The four Scottish Geoparks (Northwest Highlands, Lochaber, Arran and Shetland) face a huge challenge to make themselves "self sufficient". With over 50,000 visitors to their visitor centres per year and at least 400,000 visits to their landscapes, they are very much where geology meets the general public.

Initiatives

There have been education initiatives, such as the founding of Geobus by the University of St Andrews–a project that goes into classrooms to deliver practical and career focussed workshops, and

inspires school pupils by teaching field skills at geological sites. GeoBus has visited 70,000 pupils over 8 years, but has struggled with a rocky funding history. Geoparks have also been running their own outreach initiatives. Lochaber, for instance, runs an annual primary schools STEM prize, provided talks to schools and a kids STEM club.

Unfortunately, many of these outreach activities have been curtailed as funds ran short. Ultimately, young Earth scientists come up through the education system and are often inspired by the scenery around them. With no governmental support, little or no interest from industry, it is up to us, the community of Earth scientists, to put right this sorry situation.

There are four regional geological societies in Scotland—Edinburgh, Glasgow, Aberdeen and Highland. Together with the Geological Society of London, they represent most geologists not working in the petroleum industry. The universities of Aberdeen, Edinburgh, Glasgow and St Andrew's have significant undergraduate and research programmes in the Earth sciences. The British Geological Survey, Dundee, Heriot Watt, the University of the Highlands and Islands, Stirling and Strathclyde also contribute to geosciences training and research. Scotland is also an exciting laboratory for international research. Despite the range of bodies covering the science, at a pan-Scotland level there is a failure to get the message about the value of geology to society across to its people, its politicians, and visitors.

Unified body

Until now there has not been a body to bring people from across the different geological communities to work together. To fill this gap, starting in 2019 a group of enthusiastic geologists have been working to establish the Scottish Geology Trust. This exciting development provides the only national organisation in Scotland that can act as a focal point for chronically under-resourced activities such as geoconservation and education. In November 2019, the Trust formally came into existence and in June this year superseded the Scottish Geodiversity Forum and took responsibility for the Scottish Geodiversity charter.

The Trust aspires to be the voice of Earth science in Scotland, with key themes covering:

Promoting Scotland's geology. Improving access to and information about Scotland's Geology by holding an annual geology festival and raising funds to develop public outreach in the geosciences.

Education. Supporting projects like Geobus, and promoting and resourcing the geosciences content of Curriculum for Excellence.

Supporting Scotland's Geoparks. Building support for the network of Scottish geoparks.

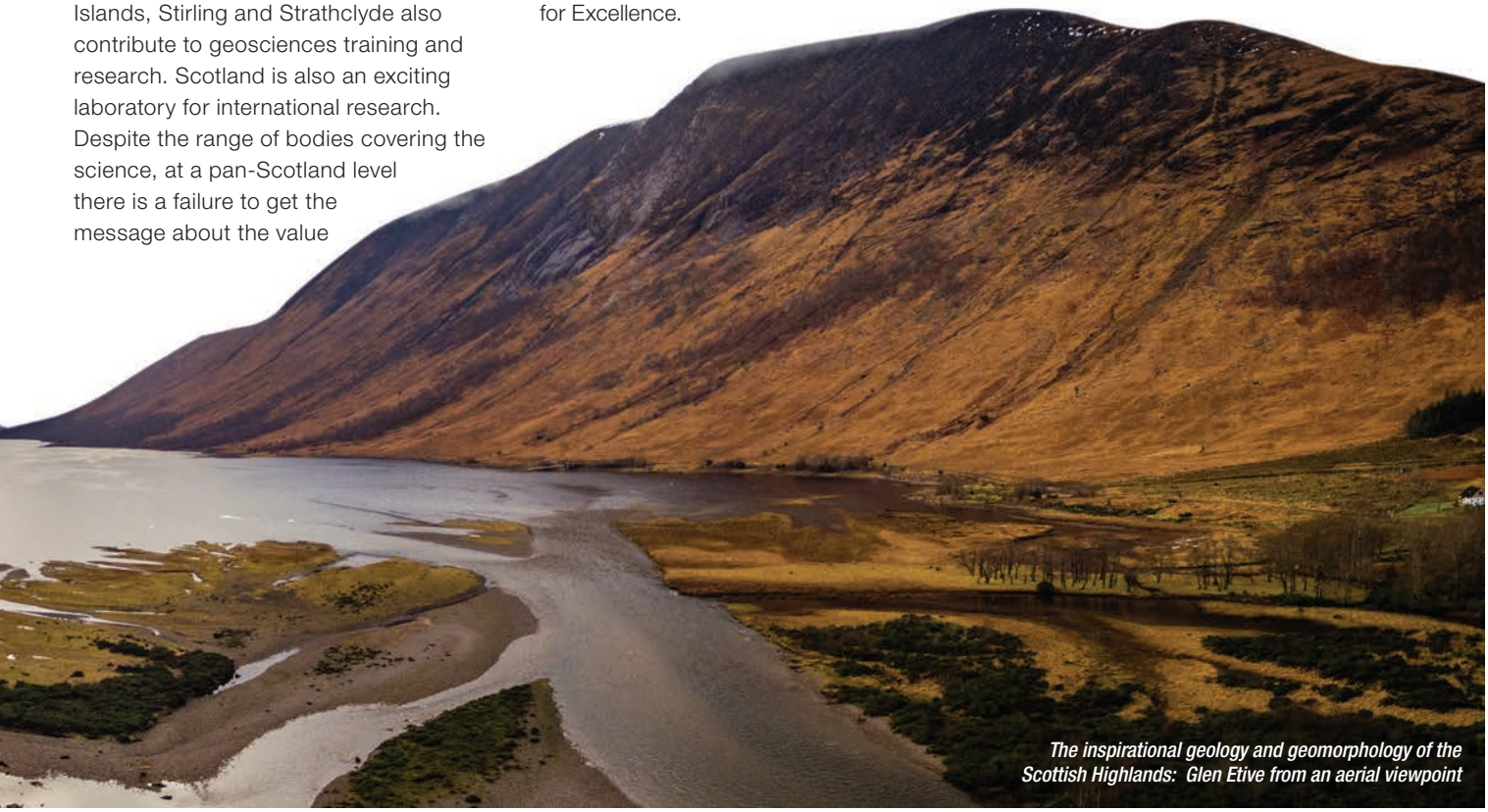
Campaigning for Scotland's geology. Taking forward the Scottish Geodiversity charter and its programme, building multi-disciplinary links, promoting geoscience research, geotourism, and getting the message to policy makers and government.

Get involved

In each of these four areas we are currently consulting with our members and other bodies, including the Geological Society of London, on short, medium and long-term action plans. We plan to build strategic partnerships to support our aims and provide a unified agenda on the key issues.

If you would like to assist us in this endeavour please take a look at: www.scottishgeologytrust.org and consider joining the group of Founding Members at: www.scottishgeologytrust.org/join-us/. The Trust launches its first Crowdfunding Campaign in late October. If you can, please donate.

Melvyn Giles is Chairman of the Scottish Geology Trust



The inspirational geology and geomorphology of the Scottish Highlands: Glen Etive from an aerial viewpoint

OBITUARY Kenneth W. Glennie (1926-2019)

Renowned sedimentologist with a sharp intellect and passion for geology

Ken left a positive footprint wherever he trod and his enthusiasm for the science of geology will not be forgotten. A modest, friendly man, Ken was easy company and his characteristically relaxed manner belied his sharp intellect and passion for geology.

'The father of Oman's geology'

Professor Kenneth W. Glennie D.Sc, ex-Shell Chief Geologist and latterly Honorary Professor at the University of Aberdeen, was arguably best known for expanding the science of desert sedimentary systems that became instrumental in a strategy of wealth creation in the exploration and production of gas from the UK Southern North Sea from the 1960s onward.

He gained global recognition for his seminal 1970 book "Desert Sedimentary Environments". Equally significant was his renown as the 'father of Oman's geology.' His pioneering work studying the Oman Mountains earned him the enduring respect of the Omani Royal Family and citizens alike.

Retirement provided Ken with opportunity to expand his geological activities, taking the leading role in producing 'Petroleum Geology of the North Sea' (1986), and being pivotal in the revival of the Geology Department at the University of Aberdeen. His productive academic career included definitive publications on Arabian geology.

Ken Glennie in a wadi in the Oman Mountains with Lynda Armstrong OBE, formerly MD of Petroleum Development Oman (PDO).

Awards

Ken received the Major John Coke Medal (1986), the Silver Medal of the Petroleum Group (2000) and the William Smith Medal (2001), all from the Geological Society of London. He was also a recipient of the Van Waterschoot van der Gracht Medal (1999) from the Royal Geological and Mining Society of the Netherlands, the Alfred Wegener Medal (2000) from the European Association of Geoscientists and Engineers, and the American Association of Petroleum Geologists' Sidney Powers Award (2005), the first time the award was ever made to a non-US citizen living outside USA.

Infectious curiosity

Ken delighted in the beauty of diverse natural environments and extolled the virtue of creating and maintaining balance between wealth creation and the sanctity of the natural environment. His infectious curiosity for geology and much more will last beyond his passing within the minds of those he taught and befriended; a great but humble global ambassador for geology and science.

By Caroline Hern, Andrew Hurst and Brian Williams

The Society notes with sadness the passing of:

Bennison, George
Copponex, Jean-Pierre *
De Wit, Maarten*
Dickins, Dennis*
Douglas, Tom*
Fookes, Peter
Greenleaves, Keith*
Hawkins, Kevin*
Jackson, David Ian *
Max, Michael David
Mudge, David Charles *
Naldrett, Anthony James
Rostron, Brian*
Ralph, William Thomas*
Symes, Douglas Kean *
Thomas, Michael
Weeks, Alan*
Woodland, Bertram George
Worthington, Paul F

In the interests of recording its Fellows' work for posterity, the Society publishes obituaries online, and in Geoscientist. Bold, recent additions to the list; * Fellows for whom no obituarist has been commissioned; § biographical material lodged with the Society.

If you would like to contribute an obituary, please email geoscientist@geolsoc.org.uk to be commissioned. You can read the guidance for authors at www.geolsoc.org.uk/obituaries. To save yourself unnecessary work, please do not write anything until you have received a commissioning letter.

Deceased Fellows for whom no obituary is forthcoming have their names and dates recorded in a Roll of Honour at www.geolsoc.org.uk/obituaries.

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Sulfur in the Earth system:

From microbes to global cycles through Earth history

V I R T U A L C O N F E R E N C E

16-17 November 2020

The cycling of sulfur has been important in controlling the chemistry of Earth's surface environments for billions of years at scales from the microscopic to the whole globe. It plays fundamental roles in many microbial metabolisms, in the transition to the oxygenated atmosphere and oceans of the Phanerozoic, and is a key volatile in volcanic systems. Studies of various aspects of the sulfur cycle have been accelerating in recent years but are spread across a range of scientific communities.

During this meeting, The Earth System Science Group will aim to bring these diverse studies together to foster a holistic understanding of the role of sulfur in the Earth system. We welcome the studies of microbiological and experimental systems, the sulfur chemistry of terrestrial environments and the atmosphere, the marine sulfur cycle including hydrothermal and vent systems, sulfur in the deep Earth and volcanic systems, and records and models of sulfur cycling across Earth history.

Registration:

Registration for this event is now open. To register please visit the conference website: https://www.geolsoc.org.uk/11-gsl-sulfur-2020 or contact the conference office.

Main Convenor:

Dr. Robert Newton (University of Leeds)

Convenors:

Dr. Andrea Burke (St. Andrews) Geochemistry SG
Prof. Graham Shields (UCL) Chair, Earth System Science SG
Dr. Sasha Turchyn (Cambridge) Chair, Marine Studies SG

Keynote Speakers:

Tamsin Mather (University of Oxford) **Ben Mills** (University of Leeds)
Itay Halevy (Weizmann Institute of Science)
Emma Liu (University College London)
Aubrey Zerkle (University of St Andrews)

Further information:

For further information about the conference please contact: Conference Office, The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: 020 7434 9944 **E:** conference@geolsoc.org.uk
Web: www.geolsoc.org.uk/events

Follow this event on Twitter: #gslsulfur2020

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