


GEOSCIENTIST

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The Fellowship Magazine of the Geological Society of London

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CORE SURPRISE

Lucy McKay on remarkable
discoveries made within the core
of an ancient plate boundary

PLASTIC PROBLEM

We need a long term vision of
sustainability, says John Heathcote

DIPLOMACY AND SCIENCE

A report from the Antarctic
Parliamentarians Assembly

A UNIQUE ORGANISATION

Sarah Day interviews BGS
Director Karen Hanghøj

Year of Life Collection

The evolution of life on Earth has been intrinsically linked to the planet's climatic and biogeochemical state for several billion years. From microbes living deep in the crust to Himalayan tardigrades, and from the search for life's origins to predicting the future climate, life has occupied, adapted to and shaped virtually every environment with impacts across the breadth of the geosciences. This collection, part of the Society's Year of Life 2020, aims to collate recent and seminal papers that cover the breadth of geoscience research into the impacts, or the effects of, life on Earth and beyond. Reconstructing ecosystems from the Archaean to the Anthropocene, mass extinctions to the actions of microbes, and from deep sea vents to astrobiology.



Collection Guest Editors

Heda Agić, University of California Santa Barbara, United States of America

William Foster, University College Dublin, Ireland

Sophie Nixon, University of Manchester, United Kingdom

Sean McMahon, University of Edinburgh, United Kingdom

Duncan Murdock, Oxford University Museum of Natural History, United Kingdom

View the collection at
www.lyellcollection.org/cc/year-of-life-collection

Find out more about the Year of Life
www.geolsoc.org.uk/life20

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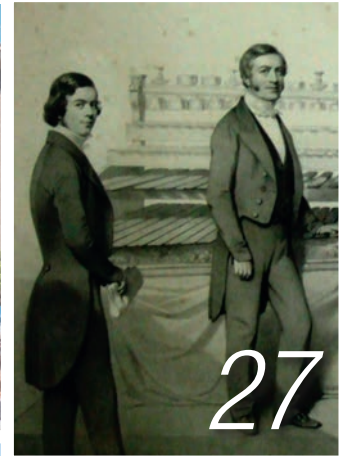
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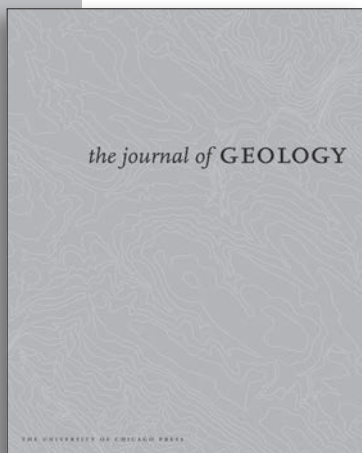
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“ WE NEED TO BE VOCAL IN OUR REJECTION OF RACISM, BIAS AND DISCRIMINATION, AND IN OUR AFFIRMATION THAT BLACK LIVES MATTER ”

FROM THE EDITOR'S DESK:

SILENCE IS NOT AN OPTION

I've been doing a lot of reading over the past few days. As protests against police brutality and racial injustice have swept across the world, so many of us have been wondering what we can do. It's felt more important than ever to listen, to educate ourselves and try to understand. Reading isn't nearly enough – it's barely a beginning – but it's where I've started.

I've been reading about Marguerite Thomas Williams, the first African American geologist to gain a PhD in the United States. After completing her dissertation, 'A History of Erosion in the Anacostia Drainage Basin', in 1942, she was appointed a full professor at Miner Teacher's College – an institution of learning and training for young African American women. Alongside, she taught night classes at Howard University, an institute whose students regularly protested at local cafeterias that refused to serve them due to their race.

I've been reading about the appalling racism, prejudice and links to slavery in the biographies of some of geology's most famous figures – Louis Agassiz, who commissioned humiliating photographs of Black slaves to support his belief in their inferior biology. Henry De la Beche, a slave owner vocally opposed to abolition. And I've been reading about how our science has profited from slavery and colonialism, supporting White scientists, collections and institutions whilst Black lives suffered. Many people have asked what we do about this; how we reconcile these aspects of our science's history, and honestly, I don't know. I just know we can't ignore it.

I've been reading people's testimony of their own experiences of racism in academia, industry and society. #BlackintheIvory, which documents the experience of being Black in academia. #BlackinNature; accounts of Black people feeling unsafe and unwelcome in outside spaces. #BlackinSTEM; people all over the world sharing their stories and offering support. I've been reading statistics which paint a bleak picture of diversity in our science and in academia more widely: 10% of UK geology undergraduates are from a Black, Asian or minority ethnic background. Just 2% of

UK geology undergraduates are Black, and 1.2% of UKRI studentships are awarded to Black students.

I've been reading the numerous messages of support and a commitment to change from universities, institutions and employers and wondering how they will translate into action, hoping that this isn't both the beginning and the end of the conversation. Others have also been researching and learning: on 10 June, thousands of academics and many organisations stopped work as part of #ShutDownSTEM, a global stand against racism in science designed to give time for reflection and planning. It will be interesting to see what changes emerge in the coming days and months as a result.

Reading is a silent process. It's not enough, unless we use it to make noise. We need to be loud and unafraid in our outrage. We need to be vocal in our rejection of racism, bias and discrimination, and in our affirmation that Black Lives Matter.

This magazine should be a part of that. If you have thoughts and ideas you'd like to share, we're listening – whether you want to contribute an article, tell us what you'd like to see more of, or simply share your frustration and your anger.

We stand in solidarity with our Black authors, readers and colleagues. Geoscientist magazine is for everyone, and we know we have a lot of work to do.

FURTHER READING

You can read more on Marguerite Thomas Williams at <https://trowelblazers.com/marguerite-thomas-williams/> For more on Louis Agassiz's daguerreotypes, and a subsequent lawsuit over their ownership: <https://www.nytimes.com/2019/03/20/us/slave-photographs-harvard.html> For more on Henry De la Beche's links to slavery: <https://www.ucl.ac.uk/lbs/person/view/2146633718>

Data on Higher Education student enrolment by subject and ethnicity is available at <https://www.hesa.ac.uk/data-and-analysis/students/table-8>

UKRI studentship statistics taken from Leading Routes' report, 'The Broken Pipeline', available at <https://leadingroutes.org/launch-the-broken-pipeline-report>

Black Lives Matter protesters in Washington D.C., June 7 2020 © Shutterstock (Eli Wilson 1751638400)



SOCIETY NEWS

SOCIETY BUSINESS

SOCIETY AWARDS 2021



Fellows of the Society are invited to submit nominations for the Society's awards for 2021.

We are committed to seeing the diversity of our awardees increase, by broadening the demographics of those put forward for our medals and funds. We are also particularly keen to receive nominations for the funds which recognise excellent contributions by early career geoscientists.

Please visit: <https://www.geolsoc.org.uk/About/Awards-Grants-and-Bursaries/Society-Awards> where there is one standard nomination form for all of our awards, with the exception of the President's Award which has its own form.

The guidance documents and pdf booklet give the criteria and explain how to go about nominating a person you feel is deserving of a Society award.

Please send nominations to the Awards Secretary no later than **noon on Wednesday, 30 September 2020.**

TRUSTEES 2020-2021

Every year following elections, the Trustees list of the Society changes. Trustees give a great deal of their time and effort in representing the Fellowship, and we would like to extend to them a warm vote of thanks.

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LIBRARY NEWS

CALL FOR ENGINEERING GEOLOGIST VOLUNTEER

The Library Users Group (LUG) is looking for a new volunteer working in the engineering geology sector.

This is a great opportunity for Fellows wishing to contribute to the Library's development, particularly to the consolidation of its e-resources collection and public engagement activities, and in the context of the Library Review (see *Geoscientist* 30 (3), April 2020). LUG meetings are valuable for CPD, and current members enjoy being able to serve their profession by helping to conserve and grow one of the UK's most important collections.

LUG members are appointed by the Publications and Information Committee for 3 years. There are three meetings per year. More information is available on our website.

Interested? Please get in touch: library@geolsoc.org.uk

NEW PICTURE LIBRARY GALLERIES

We have recently added two new galleries to our Picture Library of images from our historical collections. The *Visions of Lost Worlds* gallery presents a unique view of the primeval past as envisaged in the 19th Century, while *Buildings* contains photographs of geologically significant buildings including the GSL Library and Charles Darwin's home at Down House. View the galleries at www.gslpicturelibrary.org.uk



"Great Sea Dragons" by John Martin (1789-1854), frontispiece to Thomas Hawkins The book of the great sea-dragons, Ichthyosauri and Plesiosauri

What your society is doing
at home and abroad



PUBLISHING HOUSE

THE GEOLOGICAL SOCIETY PUBLISHING HOUSE CELEBRATES THE RELEASE OF ITS 500TH SPECIAL PUBLICATION!

SP500, co-published with the International Union of Geological Sciences (IUGS) and titled 'Subaqueous Mass Movements and their Consequences: Advances in Process Understanding, Monitoring and Hazard Assessments', offers important and timely contributions and places a strong emphasis on the societal impacts of subaqueous landslides and risks for inhabited areas (fjords, lakes, deltas, touristic islands). The 500th volume in this prestigious series was published in June 2020, in the Lyell Collection. Hard copy volumes will be on sale as soon as our warehouse is able to re-open but please keep an eye on the website for further details on its availability at www.geolsoc.org.uk/SP500.

The Special Publications series covers over 40 geological disciplines and was first published in 1964 as a supplement to the *Quarterly Journal of the Geological Society* (the precursor to the *Journal of the Geological Society*). These early volumes were retrospectively numbered as Special Publications and the series gained its current clear identity in 1981. The frequency of publication has steadily increased, and we are currently publishing around 20 new volumes every year.

Special Publications are renowned throughout the global geoscience community for their high quality of science and production.



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They represent a state-of-the-art treatment of their subject matter. The Society has high standards of quality control for Special Publications and the volume editors undertake peer review of all papers to the standards expected for our journals.

Congratulations to the Editors and authors of Special Publication 500!

CHARTERSHIP NEWS

CHARTERSHIP VIA VIDEO CONFERENCING

Mohammed Jahangir, Head of Fellowship Services, provides an update on the Chartership interview process.

With the current difficulties of holding face-to-face meetings for Chartership, we are now conducting interviews via video conferencing. Over 40 such interviews were successfully held in May (including those postponed in March due to the sudden lockdown requirements).

Feedback from both candidates and scrutineers has been very positive, which gives us confidence to continue developing this part of the application process so that it becomes a permanent feature in the future. Doing so will give both candidates and scrutineers more flexibility, and better accommodate overseas candidates.

Some candidates and scrutineers have preferred to wait until face-to-face interviews can resume, so going forward it is likely that both options may be offered for prospective chartership interviews.

Most interviews have been held using Zoom, Microsoft Teams and Skype, depending on the preference of candidates and scrutineers. For interviews being held within the UK using Zoom, the Geological Society can organise meetings for participants using dedicated licenses and password protected links.

With Government advice changing on a regular basis, we will

continue to conduct all Chartership interviews in September 2020 using video conference. This will potentially be extended to November interviews. As such, all prospective candidates should apply in the normal way before the deadlines published on our website. The Chartership Team will commence the process of matching suitable scrutineers to candidates as soon as all required application documentation has been submitted.

The key difference with proceeding with video conference interviews is that the specific interview dates for September will not apply, and interviews will be held as soon as possible throughout August and early September. Candidates and scrutineers alike should ensure their IT system is capable of video conferencing (via camera and microphone) and that you are able to operate the software.

Fellows wishing to apply for Chartership should continue to do so as normal, using electronic file transfer. For more information about becoming chartered, please visit www.geolsoc.org.uk/chartership.

For Chartered Fellows who have not been able to participate in the scrutineering process in the past due to location or time constraints, this may now present an opportunity to volunteer and help grow the number of Chartered Geologists. For information, please visit www.geolsoc.org.uk/Membership/Chartership-and-Professional/Scrutineers

REGIONAL GROUPS

REGIONAL GROUPS TAKE TO ZOOM

The Society's Regional Groups organise a variety of events throughout the year, and have been adapting to current conditions by moving some of their events online.

In April, the North West Regional Group held a meeting on 'The engineering geology of Florida' via Zoom, and in May the South East Regional Group held 'What is a geological disposal facility?'

Recordings of both events can be viewed on the Society's YouTube channel (www.youtube.com/geologicalsociety/videos). There are lots more remote Regional Group events being organized – visit www.geolsoc.org.uk/events for the latest updates.



CORONAVIRUS UPDATE

At time of writing, due to the ongoing public health risk posed by COVID-19, the Geological Society's offices in London and Bath are closed, and all events and venue hire bookings are postponed or cancelled in line with Government advice. Please check our events page (www.geolsoc.org.uk/events) for the most up to date information. If you have any questions about the Society's response or the services available, please contact us via enquiries@geolsoc.org.uk. For Fellowship/Chartership enquiries, please contact membership@geolsoc.org.uk.



FROM THE LIBRARY

GSL Library staff are here to support our Fellows, Friends, Corporate Patrons and other researchers. For more information about Library services or if you have any enquiries visit www.geolsoc.org.uk/library, email library@geolsoc.org.uk or call us on +44 (0)20 7434 9944 (option 3).

E-journals and e-books

Fellows can access 100+ e-journals and 60+ e-books for free using Athens logins. Find out more and see what's available at www.geolsoc.org.uk/VirtualLibrary

If you've not signed up for an Athens account please download and email us the registration form from www.geolsoc.org.uk/AthensAccess or contact us on library@geolsoc.org.uk

Online Library and Archive catalogues

Search the online catalogue of books, journals and maps held in the Geological Society Library and explore our archive collection: www.geolsoc.org.uk/librarycatalogue geolsocarchives.org.uk

Looking for information? Get in touch

We are able to help with:

- Research/Enquiries - as well as helping with the Library's electronic resources we can advise where to find material. We are able to access some resources in addition to what you might find yourself online
- Inter-Library loans - if you would like to borrow a book or access a paper from a journal we don't subscribe to, please let us know and we will try and source it from elsewhere. Just ask!
- Database searches - we can search the GeoRef and Geofacets databases on your behalf and send you lists of references

Additional online resources during COVID-19 closure

We have created a new page on our Virtual Library bringing together extra online resources which a number of publishers and organisations have made available to support the geoscience community at this time, including e-book collections and the AGI Glossary of Geology. Find out more at www.geolsoc.org.uk/Library-and-Information-Services/Virtual-Library/additional-online-resources-covid-19

Picture Library

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

Library newsletter

Subscribe to our bi-monthly newsletter to keep up-to-date with important Library news, electronic resource updates, online exhibitions, events and more – sign-up at www.geolsoc.org.uk/newslettersignup or email library@geolsoc.org.uk and we will add you to our mailing list.



The problem with plastic

Tackling the plastic problem requires a long term vision of sustainability, argues **John Heathcote**

Geoscientist October 2019 was very much about the evils of plastic. Whilst recognising the problem, we should not forget that the popularity of plastic has grown because it is cheap to make and does a good job. There are many things that are not possible without plastic – I cannot envisage how the computer I used to prepare this could have been manufactured with no plastic at all.

We need to be careful that the popular reaction against plastic does not replace some of it with more harmful alternatives, while not addressing the core problem. Some of the alternatives have their own environmental impacts - paper manufacture or recycling, for example, uses a great deal of energy and water and produces some nasty wastes.

Three options

The real problem with plastic is what to do with it afterwards. Much can be recycled, and should be, but this is not practicable for everything plastic, and in any event some degradation occurs. Allowing it to escape into the ocean is clearly unacceptable, which leaves three options: dispose to landfill, incinerate (with energy recovery), or use as a chemical feed-stock.

Disposal of waste plastic to landfill returns the reduced carbon to the geosphere, whence it came. It might finally produce small pockets of reduced carbon that will be difficult to exploit as a resource, or eventually – presumably when landfills are destroyed by the next glaciation – it may be dispersed to the wider environment.

Incineration returns the carbon to the atmosphere as carbon dioxide. Our planet has dealt with high carbon dioxide levels several times in the geological past, but this process takes

several million years, and while it happens there might be a mass extinction. Our planet recovers from these too, although it may lose in the process the conceited species that calls itself *Homo sapiens*.

Recovery of reduced carbon from mixed waste to use as a chemical feedstock is not yet established technology, and it's not clear that it will ever compete in terms of money or energy with the exploitation of new reduced carbon – hydrocarbons. Oil and gas are abundant and we are unlikely ever use it all – our planet is, albeit over long timescales, recycling carbon dioxide back into hydrocarbons.

New technologies

We can think more widely, and look to new technologies designed to reduce energy use and carbon dioxide production. A number of these use rare elements – gallium, cerium and yttrium for white LEDs, for example – but we don't yet have the means of collecting and recycling these elements on a commercial scale. Moreover, it's not clear to me that our planet has an effective means of recycling these elements from our wastes back into ores.

There is no easy answer to waste, but incineration with energy recovery, and then accumulating the ashes into landfill for future use as a resource, does not seem such a bad idea from a geological viewpoint. Meanwhile, there is a lot that can be done to reduce waste and improve re-usability. Using less in the first place is a good idea too, but that will require some combination of a reduced population and decreased living standards – a politically difficult sell.

Dr John Heathcote CGeol is Director of John Heathcote Consulting Ltd E: jhconsult@outlook.com



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 sarah.day@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).

“ WE NEED TO BE CAREFUL THAT THE POPULAR REACTION AGAINST PLASTIC DOES NOT REPLACE SOME OF IT WITH MORE HARMFUL ALTERNATIVES, WHILE NOT ADDRESSING THE CORE PROBLEM ”

JOHN HEATHCOTE



CORE SURPRISE: WHAT'S INSIDE A PLATE BOUNDARY?

Digging to expose clay 'inside' the Highland Boundary Fault, Lucy McKay, Zoe Shipton and Rebecca Lunn discover a remarkable sequence of clay and microfossils within the core of an ancient plate boundary



Despite the fact that 90% of global seismicity occurs at plate boundary faults, our understanding of their internal structure is lacking.

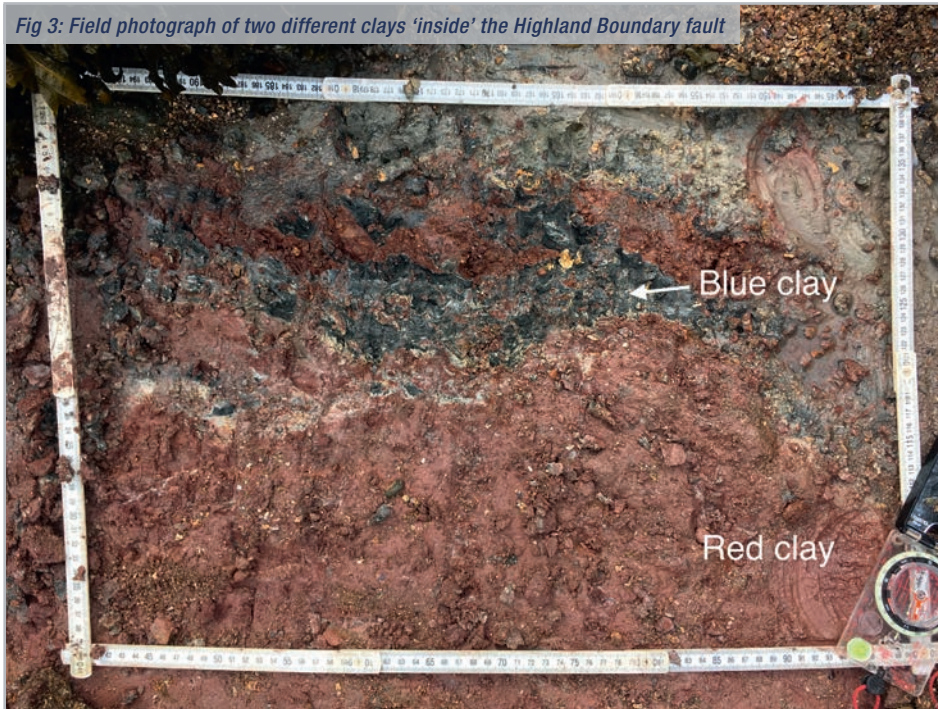
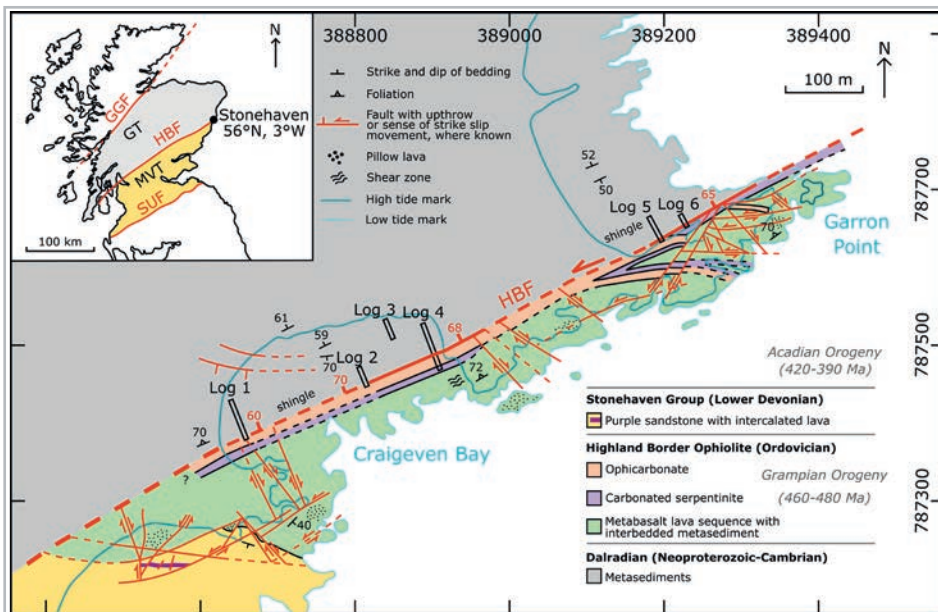
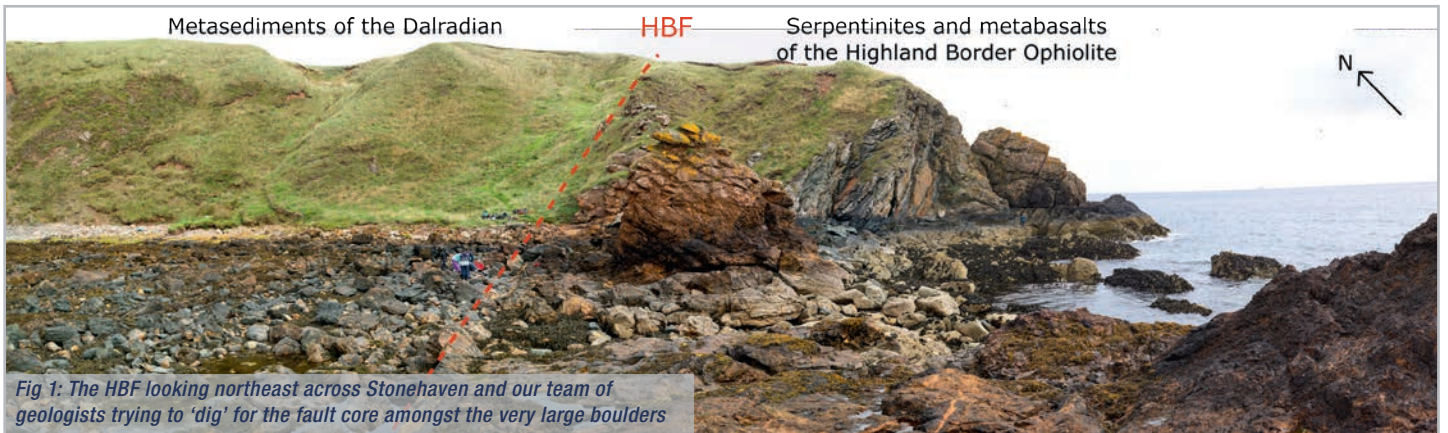
It's not easy to see inside a plate boundary fault – typically composed of a high-strain fault core surrounded by a fractured damage zone – and when we can, it often requires expensive drilling projects that yield limited information on the internal structure of the whole fault.

Understanding the internal structure of large faults is crucial, because their chemical and mechanical properties control how and where earthquakes rupture, nucleate and propagate. This in turn limits the size of the earthquake or the amount of radiated seismic energy, and consequently the severity of surface damage. The 1999 magnitude 7.7 earthquake along the Chelungpu plate boundary fault, for example – the second deadliest earthquake in Taiwan's recorded history – saw significant variations in slip and ground motion at different locations along the fault which resulted in large local variations in casualties and damage. Subsequent field investigations related these variations to changes in the fault's structure (i.e., clay width, geometry), which in turn controlled how the fault moved.

Seeing inside

Opportunities to directly study the internal structure of plate boundary faults are few, since they are normally poorly exposed at the surface. One alternative is to drill into the plate boundary to collect geological data. Several drilling projects have recently been undertaken at active plate boundaries in order to explore their internal structure at depth, including at the San Andreas fault in California, the Alpine fault in New Zealand, the Japan Trench, the Nankai Trough offshore Japan and the Chelungpu Thrust in Taiwan.

Such projects, though, are expensive – the bill for the San Andreas Fault Observatory at Depth (SAFOD) project alone was \$25M. They are also limited in what they can tell us, effectively ►



► sampling only spatially limited '1D' transects across a fault, which limits the ability to capture the variability in the internal structure at different locations along the fault.

Luckily, a rare opportunity to study the variability of the internal structure of an ancient plate boundary fault exists closer to home – and without the need for expensive drilling projects – in the form of the Highland Boundary Fault (HBF).

The Highland Boundary Fault

The HBF is an important terrane boundary in UK geology which has been the subject of many regional tectonic studies. It separates the Scottish Highlands from the Midland Valley, extending for over 240 km NE-SW from Stonehaven on the northeast coast to the Isle of Arran in the west. It is also exposed at Comrie, Loch Ard Forest, Loch Lomond and the Cowal and Rosneath peninsulas. We explored several of these locations but found the best exposure along a coastal section ~1km north of Stonehaven.

On a rare, dry, late summer's day in August 2017, our team of geologists from the University of Strathclyde's Faults and Fluid Flow research group travelled from Glasgow to Stonehaven, having applied for and been granted permission from the Scottish Natural Heritage to 'dig' out the fault at several locations at the Stonehaven site.

Tectonic history

The HBF has a long and complex tectonic history. It hasn't always been considered a plate boundary, nor were the rocks on the southern side of the fault, formerly referred to as the Highland Border Complex, considered to be part of an ophiolite sequence (a sequence commonly

associated with plate boundaries.)

These rocks include a diverse assemblage of altered serpentinites, metabasalt, amphibolite, basaltic pillow lava, conglomerate, arenite, black graphitic mudstone, limestone and chert. Recent reappraisal by Tanner & Sutherland (2007) suggests this assemblage belongs to an ophiolite sequence that lies in stratigraphic and structural continuity with the Dalradian, and not an exotic terrane as previously suggested (Bluck 1985). Field observations of the 'Highland Border Ophiolite (HBO)' from the British Geological Survey's Highland Workshop in 2008 (see Leslie et al. 2009 for detail), support Tanner & Sutherland's hypothesis.

Importantly, the orange-brown-weathered carbonated serpentinite (termed ophicarbonates) shows remarkable similarities to rocks from modern Iberia-type ocean-continent transitions and Ligurian-type ophiolites in northern Italy (not the classic Penrose-type ophiolite sequence).

All this suggests that the HBO represents a slice of exhumed serpenitised sub-continental mantle and associated sedimentary rocks, that formed part of the seafloor of an extended Dalradian basin, and was thrust onto the Dalradian block immediately before the start of the Grampian Orogeny and associated metamorphism 490 million years ago (Leslie et al. 2009).

At Stonehaven, as at many plate boundaries, oceanic serpentinite juxtaposes quartz and feldspar-rich crustal rocks of distinct terranes: the now termed Highland Border Ophiolite and Dalradian group, respectively (Fig. 1). We remapped this section of the HBF, focusing on its fault structure (Fig. 2). While the HBF is well-characterised in terms of regional tectonic importance, the only studies discussing mineralisation of the fault focus on the rock walls (on both sides), and do not address the internal fault zone structure.

Exposing the fault core

Using spades and trowels, we scraped back the shingle from below the high tide mark, along as linear a transect as possible. This was easier said than done; in places the shingle layer was very deep, and we had to avoid some very large boulders.

We were surprised to unearth not one



Fig 4: Modelling a fish out of the blue clay

but several distinct clay-rich units. After our initial amazement, we mapped and collected samples, then replaced the shingle to maximize conservation before the tide covered our study area. The site is an important Site of Special Scientific Interest, and it was important to make sure our work left no permanent mark. We returned after six weeks to confirm that the area we had excavated was indistinguishable.

In order to characterize the variability of the internal structure at different locations, with further permission from the Scottish Natural Heritage, we returned to the site and collected a total of five across-fault transects (structural logs) through the fault core (locations given on the geological map; Fig. 2).

What is 'inside' the HBF?

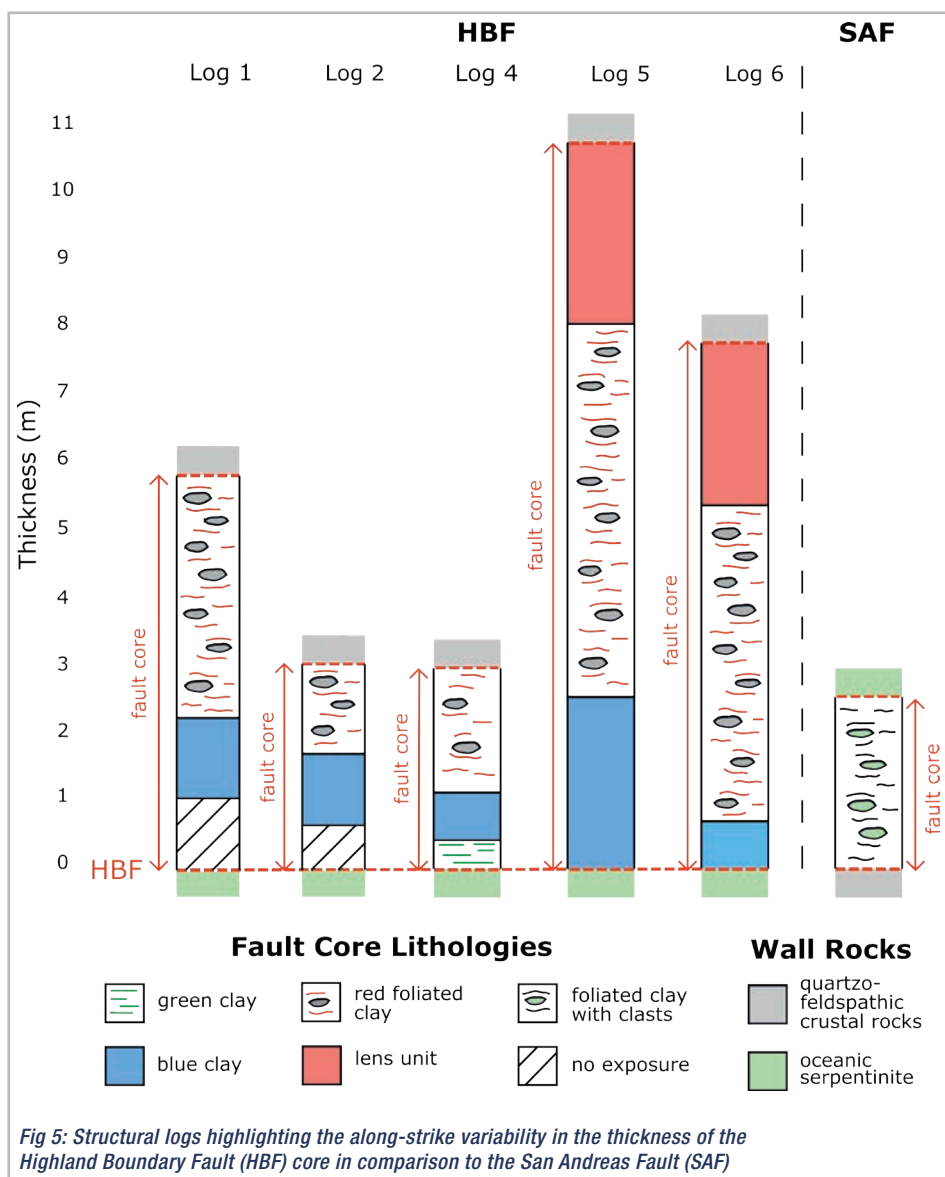
By digging to expose the fault core at five different localities, we are able to deliver a level of detail on the variability of an internal fault core structure of a major plate boundary fault that has rarely been seen before. Each log delivers structural detail equivalent to that revealed via drill core, but with the advantage of being able to trace the variation in fault zone structure through multiple logs hundreds of meters apart.

This work reveals the Stonehaven section of the HBF is composed of a remarkable sequence of fault rocks (Fig. 3). The fault core, which is between 2.95m

(Log 4) and 10.7m (Log 5) wide, is composed of four structurally and chemically distinct units – a localized green clay, a blue clay, a red foliated clay with structural fabrics and a unit consisting of large, lens-shaped clasts broken off the Dalradian wall rock (see McKay et al. 2020).

These fault core units are very different to each other and remain surprisingly unmixed, despite having accommodated offsets between 30 to 150 km. For instance, the blue clay is of high plasticity that feels exactly like modelling clay. In fact, one member of our team even managed to model a fish in the field (Fig. 4). The red foliated clay has a grey, silty texture with compositional (colour) foliations that wrap around wall rock clasts elongated parallel to the HBF. Surprisingly, despite the evidence of internal strain, relatively intact clasts of wall rock and ancient microfossils are preserved within the clay.

Similarly to other plate boundary settings where oceanic and crustal wall rocks juxtapose, our field and mineralogical observations (see McKay et al. 2020) suggest the HBF fault core likely formed through shallow, low-temperature, shear-enhanced, chemical reactions between the wall rocks of contrasting chemistry. In other words, the green and blue clay are derived from the HBO wall rocks, whereas the red foliated clay and lens unit are derived from the ►



► Dalradian wall rocks. Our field observations confirm the HBF as dominant sinistral strike-slip, but also reveal that the thickness and composition of the HBF core is variable at different locations i.e. not every unit is continuous, and each unit has variable thickness (Fig. 5).

Fault zone palaeontology!

One of the most surprising (and puzzling) discoveries was the preservation of relatively intact, ancient microfossils within the blue clay (Fig. 6). Initially, and rather disappointedly, we thought these were just modern-day fossils, and hence modern-day clay found on a beach. However, after discussion with Paul Taylor at the Natural History Museum it was confirmed that these fossils were indeed ancient bryozoans, possibly belonging to the order Fenestrata. They were found alongside brachiopods and echinoid spines.

Since we think that the blue clay is derived from the HBO, one hypothesis is that these shallow, marine fossils are derived from the sedimentary cover of the ophiolite sequence. Regardless of their origin, it is impressive that these delicate fossils remain relatively intact within a high-strain fault clay and show no evidence of internal strain (e.g. microfracturing or shear indicators). Strain within the clay must have been highly localized and principally concentrated on the margins of the fault core.

Clay growth must be younger than the fossils which, assuming the bryozoans belong to the order Fenestrata, are Ordovician to Permian in age but reached their largest diversity during the Carboniferous. The presence of these ancient fossils within the clay therefore constrains the age of the clay to younger than Ordovician-Permian. Obviously this does not provide a very tight age constraint, but to the best of our knowledge this is the first time that the age of fossils preserved within a fault clay have been used to constrain the relative age of that fault.

How representative is the HBF of active plate boundary faults?

Our maps are the first time anyone has seen 'inside' this iconic plate boundary fault that is such an important part of UK geology. As well as contributing to the understanding of the sequence of events at the HBF system, our maps show the

HBF has remarkable similarities in thickness and composition with other plate boundary faults.

All plate boundary faults appear to have similar fault core thicknesses. For example, the San Andreas fault (SAF) clay as revealed by the \$25m SAFOD project has a fault thickness of 2.5m (similar in thickness to Log 2 and 4). It is composed of a dark greyish-black to greenish-black, highly-sheared, foliated clay that wraps around wall rock clasts that are elongated parallel to the foliation (similar to the red clay). Structurally foliated fault rocks with clasts derived from the wall rocks are common along many strike-slip plate boundary faults. In both the HBF and SAF, the clay formed as a result of fluid-assisted, shear-enhanced chemical reactions between wall rocks of contrasting chemistry.

What can we learn from the Highland Boundary Fault?

The remarkable similarity between the HBF and other plate boundary faults confirms that our results are applicable to the growing number of studies into how fault structure controls earthquake ruptures. The magnitude and speed of rupture propagation and the frequency content of radiated seismic energy all affect how damaging an earthquake is, so understanding the internal structure of plate boundary faults is crucial if we are to better understand and mitigate damage.

If the thickness and composition of

the fault changes at different locations along the fault, which we have demonstrated they do for the HBF, then models of structural control on earthquakes must take this thickness variation into account. For instance, if the units within the fault core have variable thickness, then the effect of shear heating or lubrication by thermal pressurisation is likely to vary (the thinner the unit the faster the heating). Therefore, it is crucial to understand the controls on the presence and thickness of such units along the length of the fault. Drilling a few boreholes at a particular section of the fault is not enough to fully characterize the internal structure, and hence earthquake properties, of the entire plate boundary – variable fault core thickness and composition have to be accounted for.

What next?

The next stage of this work, which forms part of my PhD, involves detailed microstructural (thin section) analysis and laboratory work on the blue and red clay. Not only will this help to unravel the history of this iconic UK tectonic structure, but it will provide new data on the interplay between fault processes and earthquake mechanics. Look out for a forthcoming publication with these observations!

We have also received funding from the Geological Society to attempt to constrain the timing and nature of fluids responsible for the growth of the blue and red clays. Any suggestions for further

work that will help understand the puzzling fault zone palaeontology will be most welcome...

Lucy McKay is a PhD student at the University of Strathclyde; e-mail: lucy.mckay@strath.ac.uk

ACKNOWLEDGEMENTS

Thanks go to my supervisors at the University of Strathclyde – Zoe Shipton and Rebecca Lunn - and also to Adrian Boyce at SUERC and Tim Raub at the University of St Andrews. Thanks also must go to the Scottish Natural Heritage and local landowners for permission to sample at this Site of Special Scientific Interest. Also, to the team of 'diggers': Billy Andrews, Izabella Otalega, Lisa Millar, Carla Romano, Bruno Thomas and John Helstrip. This work was funded by an Environmental and Physical Science Research Council (EPSRC) Doctoral Training Partnership (DTP) award, and further ongoing laboratory work is funded by the Geological Society through the William Fearnside Fund.

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Fig 6: Fossils in the blue clay



Panorama of a cliff with ancient castle in a bay with blue sky and white clouds in Dunnottar Castle, near Stonehaven, Aberdeenshire

THE MODERN GEOLOGICAL SURVEY

Sarah Day talks to British Geological Survey Director Karen Hanghøj about geoscience, outreach and why we need experts more than ever



‘When I was a student at the University of Copenhagen, we had various clubs – sedimentology, petrology, palaeontology and so on. You’d notice that, for example, the people studying petrology wouldn’t go to a talk about sedimentology because they thought it wasn’t relevant to them. Historically, we’ve closed in on ourselves a little bit.

‘I think the modern Geological Survey is beginning to change this.’

Karen Hanghøj took up her post as Director of the British Geological Survey in October 2019, having previously headed up the Department of Economic Geology and Petrology at the Geological Survey of Denmark and Greenland before managing EIT RawMaterials – a Knowledge and Innovation Community headquartered in Berlin.

‘All the things I’ve done have been a natural continuation, and that’s what attracted me to this role – it’s the culmination of where I’ve been trying to go.’

Academia and industry

Hanghøj took her Masters and PhD at the University of Copenhagen, focusing on east Greenland, the breakup of the Atlantic and the igneous petrology of crustal and mantle rocks. At the same time, she was becoming interested in mineral exploration.

‘The very first year I did my Masters thesis in east Greenland, we were working in a very remote mountainous area, and there was a Canadian exploration company operating in the area, drilling for gold and platinum. They offered me a few weeks’ work, which I did every summer during my Masters and PhD studies. Ever since, I’ve maintained an interest in mineral exploration and industry alongside my academic work.’

Her background, then, makes her ideally suited to leading an organization which combines academic research with industry expertise.

‘The modern Geological Survey is very much about combining the basic

geoscience with an understanding of the societal context. It’s about listening to the needs of society, through engaging with policy makers, industry, NGOs and the public. Coming to a Geological Survey has felt a bit like coming home.’

She wasn’t, she says, always determined to become a geoscientist.

‘My own path to becoming interested in geology is useful in thinking about how we attract others. I was interested in and fairly good at science and maths, and also quite ‘outdoors-y’. I liked things like camping and hiking.

‘When I finished high school, I had to choose a subject to study for the next six years – we had a different system in Denmark then. So it felt like a very big decision. I looked at various degrees in the sciences – medicine, veterinary science, engineering – and then I saw geology.

‘Denmark is more or less a big piece of moraine – there are almost no rocks or mountains – so when I looked at what I would learn about, I realized quickly that to become a geologist I would have to travel. Other than that, I didn’t really know what I was getting into, but very quickly, within the first semester, I knew I had made a perfect choice.

‘That’s perhaps one way to get people into the geosciences – to talk about how it gets you outside, and thinking about something bigger than yourself.’

Many audiences

Hanghøj sees outreach – in its many guises – as key to the work of the Geological Survey, and the future of the geosciences.

‘I’ve always been interested in it. I think it’s important to recognize that there are many different audiences. ‘Pure’ outreach involves communicating with the public through things like open days, popular science articles and social media, so we can demonstrate how important geoscience is. But it’s important not to mistake quantity for quality – some types of communication can’t be judged by the number of people you reach. If only ten people access our data on things like



► ground water, seismicity etc., but they're the right ten people, then we've done our job well.

'Some communication requires asking 'if we don't do this, is anyone else going to do it? And if not, and it's critically important to society, then it's important for us to do.'

Despite the work being done by the British Geological Survey and other organisations to promote the study of geoscience, student numbers are currently in decline. Hanghøj believes this is only partly down to a reputation as being linked with fossil fuel industries.

'Yes, it's partly that the subject's reputation has suffered from links to mining and especially oil in recent years, but I don't think that's the entire story. I think young people today think about things in a different way. They're attracted to new subjects like AI – and perhaps we haven't done enough to show students that the geosciences are part of topics like that too. Young people have to navigate such a huge variety of options now – we need to get better at selling ourselves. I think the BGS definitely has a role to play here.'

Signal value

Hanghøj is the first female Director of the Survey, which was founded in 1835. Unsurprisingly, it's a subject she's asked

about often.

'It means a lot to me to be the director of an incredible geological research organization that's been around for a long time, but it doesn't mean a lot to me personally to be the first woman. I think what's important is what it means to other people and the signal it sends – it's about time!

'I can tell from the reaction to the announcement that my appointment had a tremendous signal value for female geoscientists, and that's incredibly important. I do sometimes wish we could focus on other things though. There's always going to be an element of that – we want women to be visible at the top, but we also don't want the most interesting thing about female directors to be that they're female.

'In the profession as a whole, we're moving very slowly in the right direction but it is too slow. When I was a Masters student, we were probably around 30% women, and when I became a PhD student that cohort was also at least 30%. I'm not part of a 30% cohort any more.

'There is something systemic that makes women leave the career path in geology, and we need to think really hard about it.

'We have to start thinking differently, about the environment scientists work in as a whole. With diversity more widely, particularly ethnic diversity, we're doing very badly. I think we're still only beginning to understand why, and how we can change.'

A unique organisation

Despite the challenges, Hanghøj is happy to be back working at a Geological Survey, combining interests in academic research, societal applications and industry which have been a feature of her career so far.

'It's been a steep learning curve in many ways, but in others, not at all, because I feel so at home. I'm interested in the core research, but also in what society needs from us, and that's what the modern Geological Survey is all about.

'To be able to provide credible advice, we need to be experts. The great advantage of a Survey is you have a lot of different people who have similar experience and overlapping expertise. So if a new problem shows up in society, industry or government, we have the critical mass to respond and contribute to finding new solutions. That's something pretty unique to an organisation like ours.' ●



All images: Karen Hanghøj in Greenland

Mineral Resource Estimation: Recent Advances and Current Best Practice

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

19 October 2020

In an era of rapid technological innovation, opportunities exist to improve efficiency and quality of resource estimates, both developing trust and encouraging investment in mining projects. This conference aims to provide a forum for resource estimate practitioners to meet and discuss new developments and advances in mineral resource estimation and reporting.

As part of the conference, we will explore topics from the following broad areas:

- **Exploratory data analysis:** analysis of geoscience data prior to use in a MRE including databasing, data quality analysis, utilising 'big data', and methods of critical evaluation.
- **Geological modelling:** methods and processes used for generating 3D models of geological features, including software advances and comparisons, how to integrate 'big data' and busting commonly encountered myths.
- **Geostatistics and grade estimation:** methods for estimating tonnage and grade/quality of a mineral deposit, including recent software advances, new techniques and comparisons of techniques in different mineralization types. Reconciliation between estimates and production, to ground truth models.
- **Resource reporting:** methods used for generating Mineral Resource statements, including methods for demonstrating 'reasonable prospects for eventual economic extraction' (as defined in international reporting codes), including updates/comparisons of CRIRSCO standards, new ESG requirements and participating committees.

Convenors

Ben Lepley Senior Resource Geologist

Lucy Roberts Principal Resource Geologist

James Catley Resource Geologist

Further information


For further information please contact:

Conference Office,
The Geological Society,
Burlington House, Piccadilly,
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T: 0207 434 9944

E: conference@geolsoc.org.uk

Web: www.geolsoc.org.uk/events

 Follow this event on Twitter:
[#gslminerals20](https://twitter.com/gslminerals20)

Call for papers

We invite oral abstract submissions for the meeting, and these should be sent in a Word document to conference@geolsoc.org.uk by Friday 21st August 2020. Abstracts should be approximately 250-350 words and include a title and acknowledgement of authors and their affiliations.

Due to the ongoing situation with Covid-19 and acting on advice from the UK Government, the Society's offices in London and Bath are closed at time of writing. Unfortunately, this is impacting some of our upcoming events – we are rescheduling and adapting to virtual events where possible.

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.

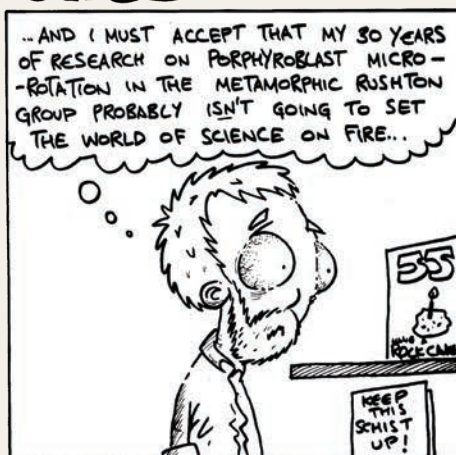
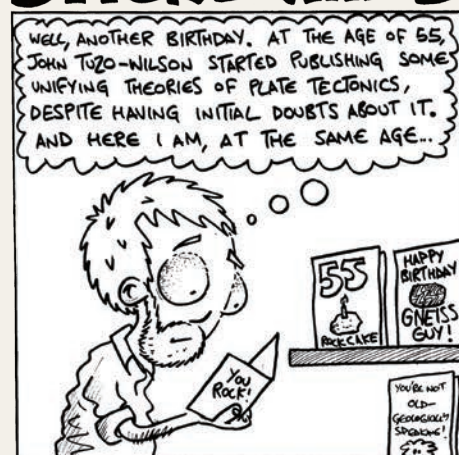
VIRTUAL EVENTS

MEETING	DATE	VENUE AND DETAILS
West Midlands Regional Group: Charter-ship Evening	14 July	Evening meeting Venue: Taking place remotely W: https://www.geolsoc.org.uk/07-wmrg-chartership-evening-2020
West Midlands Regional Group: September meeting, 'Cold supraglacial volcanic deposits and their effects on glacial ablation'	8 September	Lecture Venue: Taking place remotely W: https://www.geolsoc.org.uk/09-wmrg-sep-meeting-2020
Mineral resources estimation: recent advances and current best practice	19 October	Conference Venue: Taking place remotely W: www.geolsoc.org.uk/10-gsl-mineral-resource-estimation-2020

RESCHEDULED EVENTS

MEETING	NEW DATE	VENUE AND DETAILS
Marine Reptile Conference 2020	29 Sept – 1 Oct	Conference Venue: The Etches Collection, Kimmeridge, Dorset W: www.geolsoc.org.uk/09-rescheduled-marine-reptile-conference-2020
Plastics in the Environment	15 March 2021	Conference Venue: Burlington House, London W: www.geolsoc.org.uk/plastics2021
Core Values: the role of core in 21st century reservoir characterisation	5-7 May 2021	Conference Venue: Burlington House, London W: www.geolsoc.org.uk/05-rescheduled-pg-core-values-2021
Engineering Group Annual Field Meeting: The engineering geology of canals, Somerset – the William Smith legacy	2-4 July 2021	Field trip Venue: Swan Hotel, Wells, Somerset W: https://www.geolsoc.org.uk/07-rescheduled-eg-field-meeting-2021

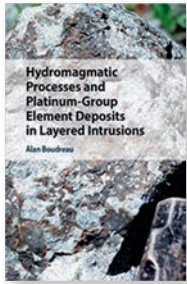
STICKS AND STONES



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BOOK REVIEWS

Hydromagmatic Processes and Platinum-Group Element Deposits in Layered Intrusions



This is a welcome book with a case to make that volatiles have key roles in the development of PGE deposits in layered intrusions. Alan Boudreau has argued for the role of volatiles for a number of years and it reflects the tenor of this book that he addresses the concerns of skeptics head-on in a final chapter on 'Some Objections Considered'.

Volatiles strongly influence the generation and evolution of magmas, melt migration and the concentration of metals. An introduction to layered intrusions is followed by a discussion of magmatic volatiles and fluids before considering the behavior of the PGE and evidence for the role of volatiles in layered intrusions. Evidence is summarised from different layered intrusions, in particular from the Bushveld, Skaergaard and Stillwater complexes, discussing melt and fluid inclusions and pegmatoids, and the effects of volatiles on mineral stability and volatile fluxing. There is little doubt that the host magmas contain significant volatile abundances, and the questions are mostly over the role of those volatiles in the development of mineralization.

The Bushveld, for example, is the world's largest layered continental intrusion, and contains more than half of the known PGE reserves. Its distinctive features include a strong lithospheric signature, the marked changes in Sr isotope ratios with stratigraphy indicating open system behavior, the associated volcanic and intrusive rocks, and evidence for movement of magma and crystal mushes subsequent to the formation of the distinctive planar layered fabrics. The Bushveld has elevated volatile contents (Cl, and >1% H₂O), and parental magmas with elevated PGE contents, and it is of interest both in terms of what happens sub-volcanically in mafic magmatic systems and for the processes involved in ore formation.

Models for sulphide saturation include

crustal contamination, magma mixing and fractional crystallization, and whereas volatiles influence phase relations, their role in the formation of ore bodies is less clear. There is compelling evidence for volatiles in the PGE-bearing pipes and pegmatoids in the Bushveld, and more widely in the presence of hydrous minerals and fluid inclusions. Thus volatiles were present, and much of the debate is over the extent to which the reefs were the product of fluid/volatile saturation and sulphur and PGE were concentrated by vapour refining processes, as vapour is exsolved from crystallizing interstitial liquid.

The jury is still out, but this timely book brings together evidence for the presence and the possible roles of volatiles in continental ore-bearing magmatic systems. It is well written and it deserves to be widely read given the current interest in the roles of volatiles for continental magmatic systems, and in the formation of PGE-bearing ore bodies.

Reviewed by *Chris Hawkesworth*

HYDROMAGMATIC PROCESSES AND PLATINUM-GROUP ELEMENT DEPOSITS IN LAYERED INTRUSIONS by Alan Boudreau. Cambridge University Press 2019, ISBN 978-1-108-41600-9 Hardback, 270pp W: www.cambridge.org

River to Reservoir: Geoscience to Engineering



This book explores some of the cross-disciplinary area(s) involved in studying rivers and their sediments, and thus between the geosciences and engineering. That it is

successful in doing so is a credit to the editors as much as the authors of the various papers.

The book operates, in effect, at three rather different scales in the four principal dimensions. It starts with what the editors call 'architecture and properties', moving from discussion of river basins and their changing structure(s) across periods and at continental scale, to methods of characterisation and detailed assessment of

deposits from fluvial systems. The potential value and sense in using multi-source data to gain a fuller understanding of depositional structures etc should be obvious – nature has no reason to observe 'our' notional boundaries between the sciences, or science and engineering. Combining them in valid ways can be difficult, however, despite that. Here, in various papers and combinations, data from outcrop observation, drilling cores, gamma ray logs, mineralogy, aerial photographs, satellite images etc are brought together successfully to provide clearer pictures than might be achieved with one or more less complex datasets.

The papers covering modelling and simulation are generally good to very good. The authors of one fall into the old trap of expecting modelling outcomes to be perfect. While models are often complex they are, essentially, simplifications intended to enable better understanding and forecasting of processes. The explanations and examples of what can be achieved with modern modelling techniques, including statistical processes, are useful as well as interesting.

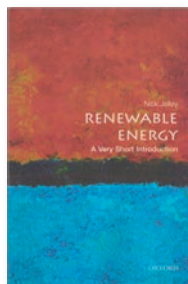
The final group of papers, on management, are again generally good to very good. The techniques discussed are potentially useful quite widely, in part at least because the examples are well chosen. One paper is rather weaker because a considerable proportion of it consists of detailed cost information extending over a couple of decades and across a large country. The information is not supported by a map showing the locations of the areas and regions concerned, however, and no account seems to be taken of inflation during the period covered.

This is a good book, and the cross- and multi-disciplinary aims and aspects built into it work well. The boundaries (pseudo-boundaries?) induced by human thought modes, both between and within disciplines – i.e., between geology and engineering, and between the geosciences within geology – remain, of course, but are weakened by this publication, which is a useful move forward.

Reviewed by *Jeremy Joseph*

RIVER TO RESERVOIR: GEOSCIENCE TO ENGINEERING Ed P W M Corbett et al, 2019. Published by: The Geological Society, London, UK. ISBN: 978-1-78620-431-8. Hardback. 295 pp. List Price: £120. Fellows' Price: £60 W: www.geolsoc.org.uk/SP488

Renewable Energy: A Very Short Introduction



The publisher of the Very Short Introduction series, OUP, claim such books (they list over 600 titles) are the perfect way to quickly get ahead in a new subject. But clearly such books are a real challenge to write. To paraphrase Mark Twain, short stories are harder to write than novels, because in a short story every word has to count, while the narrative in a novel can meander. Nick Jelley, an emeritus professor of physics, has taken this challenge to heart by writing a book of 131 pages, 'Renewable Energy: A Very Short Introduction', small enough to fit into my jacket pocket.

Jelley covers all the essentials needed for anybody to get up-to-speed on all aspects of renewable energy; why they are needed (CO₂ excesses, greenhouse effects, climate change, pollution), what processes there are, how these different processes work, the economics and the controversies and, of course, what developments are in the pipeline. Thus we learn about the main renewable sources of energy (mostly derived from the sun, p2), solar photo-voltaics, wind then biomass, hydropower, tidal and wave and from the earth, geothermal. Wind and solar farms can now provide the cheapest electricity in many parts of the world and maybe could provide all of the world's energy needs without contributing to climate change or pollution. Jelley even tells us how huge the turbine blades are, how silicon wafers are made, about energy mining and the innovative developing low carbon technologies, hydrogen, electric vehicles, batteries, heat pumps, energy storage technologies and more. Market forces are fast helping the transition from traditional fossil fuels to renewable energy at country, regional and local levels, but there are strong opposing pressures (particularly political and global power companies) which are outlined. Everything is lucidly discussed.

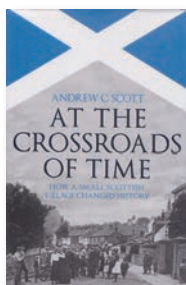
Throughout this readable text, Jelley emphasises how renewable energy can tackle climate change. Admittedly, some of the illustrations would benefit by being in colour (but this might add to the cost) and I would have liked the list of abbreviations to

have been expanded to include some explanations e.g. GDP, fuller definitions of power and energy, the significance of the size of kilo-, mega-, giga- terra-watts with more examples. Such items may be known to the science-based readers but may not be to those beginning their journey in understanding renewable energy. Nevertheless, Jelley has presented a good grounding on all the essential facts for anybody wanting to understand state-of-the-art renewable energy and its benefits to climate change. Clearly, Nick Jelley has successfully risen to the Very Short Introduction philosophy by writing this easy-to-understand pocket-sized volume.

Reviewed by **Richard Dawe**

RENEWABLE ENERGY: A VERY SHORT INTRODUCTION by Nick Jelley, 2020. Published by Oxford University Press, Oxford, OX2 6DP, UK 168 pp (pbk). ISBN: 978-0-19-882540-1
List price £8.99 W: global.oup.

At the Crossroads of Time: How a small Scottish village changed history



Written by Andrew C. Scott, Emeritus Professor of Geology in the Department of Earth Sciences at Royal Holloway, University of London, this is a fascinating book, studying as it does the

position and influence of a small Scottish village. Is Leshmahagow a village that changed the world? Judging from the book, it and some of its residents have certainly influenced things much more than one might have expected.

The village and surrounding area certainly has an excellent geological heritage. To the author's immense credit, this is explained in such a way that the interested layman could pick the book up and not be put off by overly technical descriptions. The geology is set out in a logical manner and holds sufficient interest for the knowledgeable geologist, with an excellent bibliography allowing further research if required.

But this is so much more than a geological book, exploring as it does the social development of a village and the opportunities that became available to many of its inhabitants. The story of Leshmahagow's place in the development of the pedal bike, in its own right, makes fascinating reading. But it is the wide societal context raised by Scott that make this such a worthy tome. In all honesty, I thought I would study the geology and then skim read the remainder – but due to an easy reading style, I have not been able to put the book down!

There is a section of plates in the book, with sufficient images to illustrate many of the points of interest raised. Reading about how education evolved in the village, how communication was established with the coming of the railway, and the rise and inevitable decline of the coal industry has been fascinating. The section looking at significant people from the village was illuminating and is testament to the inspiration of the teachers involved in the village at the time.

All in all, this has been a superb read, one that once started, I found difficult to put down. It has been a book that has sought to make me look at the things that have influenced me, and the author is to be commended on the quality of his writing and the fascinating story contained within. A book to relax with, with a fascinating story to tell – what more could you want?

Reviewed by **Gordon Neighbour**

AT THE CROSSROADS OF TIME – HOW A SMALL SCOTTISH VILLAGE CHANGED HISTORY by Andrew C. Scott. Amberley Publishing 2020. ISBN: 978-1-445-69832-8. 256pp (hbk). List price £16.00
W: <https://www.amberley-books.com/>

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 sarah.day@geolsoc.org.uk if you would like to supply a review. See a full, up-to-date list at www.geolsoc.org.uk/reviews

- ◆ **NEW! Introducing Hydrogeology**, by Nicholas Robins, Dunedin Academic Press 2020, 150pp, pbk.
- ◆ **NEW! Scotland's Mountain Landscapes: A Geomorphological Perspective**, by Colin K. Ballantyne, Dunedin Academic Press 2019, 183pp, hbk.
- ◆ **NEW! The Western Highlands of Scotland** by Con Gillen, Dunedin Academic Press 2019, 284pp.

The Antarctic Parliamentarians Assembly – Diplomacy and science

Peter Dolan (FGS) and Martyn Millwood Hargrave report on the inaugural Antarctic Parliamentarians Assembly, held in Westminster in December 2019

The inaugural Antarctic Parliamentarians Assembly was hosted by the UK government in London on 2 and 3 December 2019 to mark the 60th anniversary of the signing of the Antarctic Treaty and to discuss the future of the ‘White Continent’.

Parliamentarians from 13 signatory countries, including most of the seven who claim sectors of Antarctica and other interested parties such as China, issued a final conference statement and press release, available at <https://www.antarcticparliamentarians.com/download>

The meeting featured presentations on climate change, natural resources (primarily fishing), scientific research, geopolitics and tourism. (Since first drafting this report, COVID-19 is, of course, likely to severely limit tourism in the short to medium term.) But what were the ‘takeaways’?

Global impact

Despite its remote location, Antarctica has a global impact. This is partly because circum-Antarctic deep sea currents are connected to those in other oceans, affecting their path and nature. Changes

in circulation in the south are, for example, predicted by fisheries experts to have a very negative impact on fish stocks in northern polar areas in years to come.

Antarctica is both a victim and engine of change. These ocean currents contribute to climate change which in turn is driving the anomalous and rapid temperature increases being witnessed in West Antarctica. The melting of huge glacier systems (e.g. Thwaites and Pine island) and calving of ice shelves as a result of currently escalating CO₂ emissions and global temperature increases are virtually certain to lead to global sea level rise of 30cm to 50cm over the next few decades. But here, Antarctica’s influence on the rest of the world arises again: whatever the sea level rise, it will be greatest in northern latitudes due to the gravitational pull of northern hemisphere landmasses. Coastal cities such as London, New York and Shanghai, beware.

So what to do? The parliamentarians and their advisors had no ‘silver bullets’ to offer. Their final statement “*Noted with concern ... the profound effects of climate change on Antarctica’s ecosystems and the potentially catastrophic effects of Antarctic ice loss on*

global sea level.” They agreed to:

- Uphold the Antarctic Treaty System.
- Establish the Assembly as a biennial gathering.
- Protect and conserve the Antarctic environment.
- Promote and support international scientific collaboration
- Ensure effective management of activities in Antarctica.

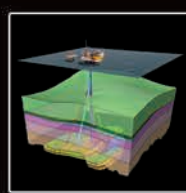
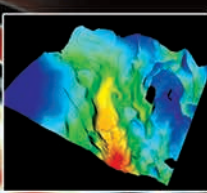
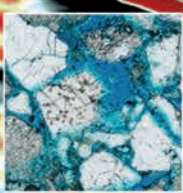
Enthusiasm and concern

We left enriched by the enthusiasm of the participants and the science but concerned at the inevitability of severe impacts from global sea level rise over our children’s lifetimes.

There are many geoscience contributions we can make to mitigate the underlying drivers of climate change, and our profession and community should work hard to push these areas: carbon capture, utilisation and storage (CCUS), geothermal, facilitating efficiencies in the necessary harvesting of natural resources, etc. In the meantime, the buzzword from the environmental engineers was on increasing coastal resilience. It looks like we will all need it.



First year ice off the Royal Society Range, Scott Coast, Antarctica c. Martyn Millwood Hargrave



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Registration Open

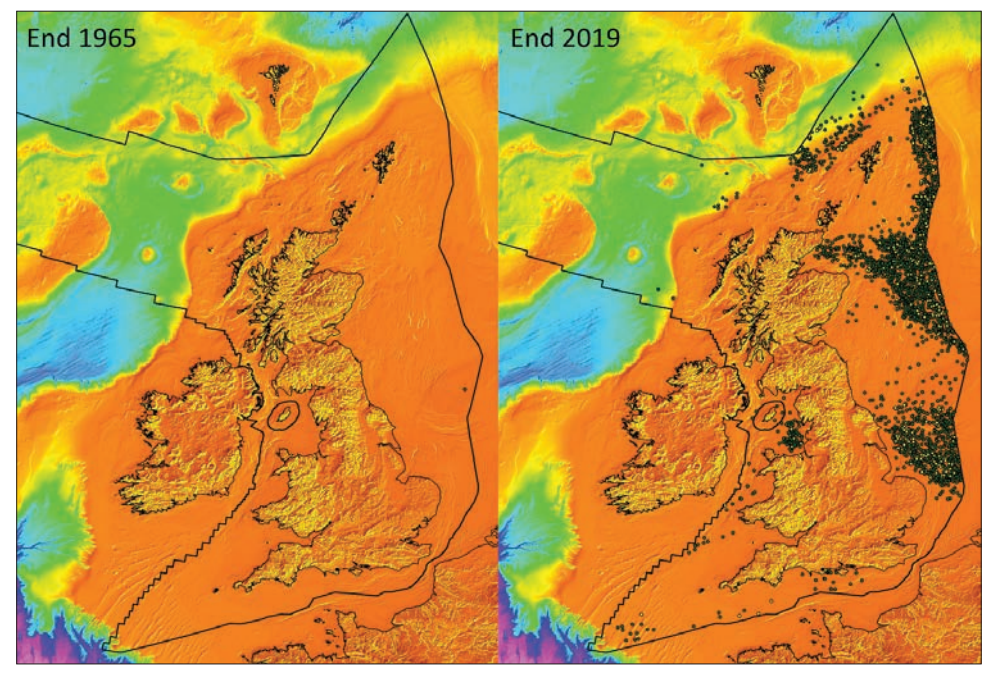
LAUNCH CONFERENCE – MEMOIR 52

UK Oil and Gas Fields

50th Anniversary Commemorative Memoir

30 November 2020

Virtual Conference



Geological Society Memoir 52 records the extraordinary 50+ year journey that has led to the development of some 458 oil and gas fields on the UKCS. It follows the 1991 and 2003 Memoirs and is the largest of the series, containing papers on around 150 fields both on and offshore. Memoir 52 is a major, landmark volume that will be an enduring data source for those exploring for, developing, producing hydrocarbons and sequestering CO2 on the UKCS in the coming decades.

This conference marks the planned publication of Memoir 52 in Q2 2020. Sixteen invited speakers will discuss fields which are contained in the Memoir. These talks will cover all of the major UK basins and will highlight themes which run through the Memoir. These themes include the utility of seismic data across the value chain, evolution in drilling and completion technologies, recent and near term field developments, and new exploration targets in less common reservoirs and subtle traps. As such it will be of benefit to all geoscientists working the UKCS.

For further information please contact:

Sarah Woodcock, sarah.woodcock@geolsoc.org.uk
 Web: <https://www.geolsoc.org.uk/11-rescheduled-memoir-52-launch-conference-2020>

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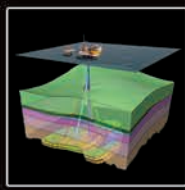
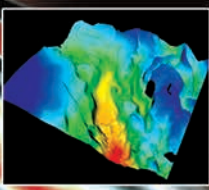
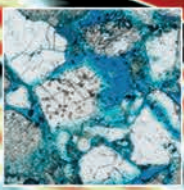
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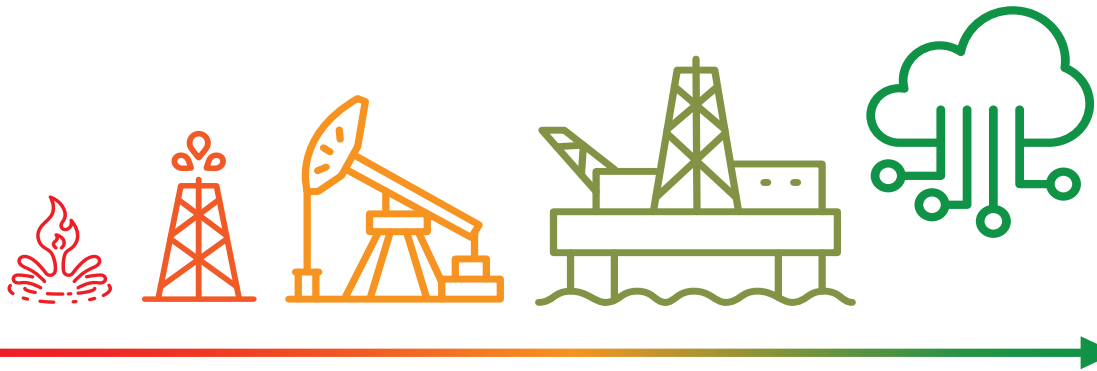
Call for Abstracts – Deadline Extended: 4 September 2020

Operations Geology in 2020 and Beyond:

Traditional and modern approaches

4-5 November 2020

Virtual Conference



The key theme of the 5th Operations Geoscience conference is how the role of the Operations Geologist will evolve as the Oil & Gas industry embraces the digital transformation. **Operations Geologists will be at the heart of this transformation** by bringing together digitalisation and geological expertise to improve operational efficiency and promote success.

The organisers invite contributions within **all aspects of Operations Geoscience** with a preferred **focus on emerging technologies and advances in the digital oilfield**.

Suggested themes include:

- **Machine learning and artificial intelligence** applied to planning and drilling a well
- **Digitalisation and “disrupting” current work flows** – can digitalisation and data mining generate additional information that will change the role of the operations geoscientist?
- **New analytical technologies and technological advances** – case studies of e.g. LWD, wireline or modelling solutions as applied during operations
- **PPFG, Geomechanics & surface logging** showcasing innovative approaches and surprising outcomes
- **Managing risks and improving safety**

Keynote speakers to be announced soon. **A parallel poster session** will take place in the library during the breaks.

For further information and abstract submission please contact:

Abstract Guidelines available on the conference website www.geolsoc.org.uk/11-pg-ops-geology-2020

Sarah Woodcock, sarah.woodcock@geolsoc.org.uk



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#PGOpsGeo20



DISTANT THUNDER

Rock Bands

Geologist, science writer and music lover Nina Morgan relishes the sounds of stone

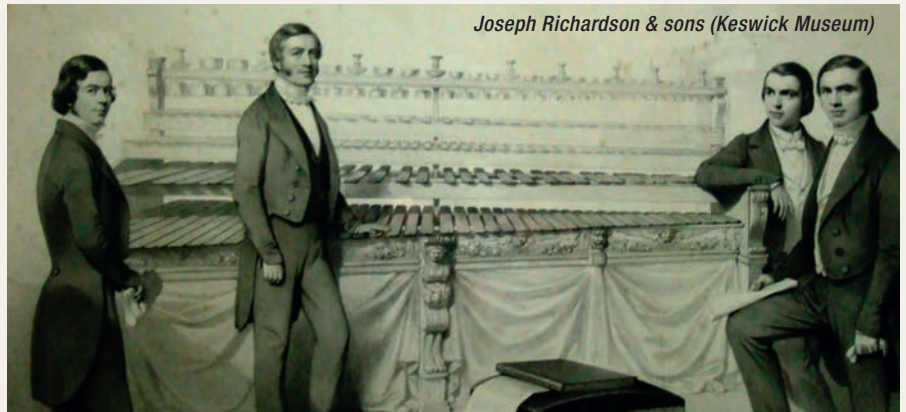
From early times, stone workers have tested blocks of stone with a sharp tap, listening for ringing sounds to check for cracks or flaws. Geologists, too, often take advantage of this trick to map subtle changes in lithology, porosity and permeability in the field. But these days even the most *avant garde* Hard Rock bands don't seem to look to geology to create their sounds. Perhaps they're missing a trick.

The musical properties of rocks have been exploited from ancient times in many parts of the world. But arguably it was a stonemason Joseph Richardson [1790 – 1855], born in Keswick, Cumbria, who brought the musical possibilities of stones to international attention in the form of a lithophone – a xylophone made up of tuned stone keys. He named his creation the 'Richardson and Sons Rock, Bell and Steel Band'.

Early inspiration

Richardson must have been inspired to build his lithophone by tales of the musical stones around Skiddaw collected by Peter Crosthwaite [1735-1808], founder of the Keswick Museum. In 1785, Crosthwaite recorded the discovery of his '6 first music stones at the Tip end or North end of long tongue'. The stones, composed of a coarse-grained hornfels created when the Ordovician mudstones and siltstones of the Skiddaw group were affected by low-grade regional metamorphism and deformation associated with the Acadian Orogeny in the Devonian, were, he claimed, in perfect tune. The discovery inspired him to shape more stones to produce other notes to create a set of Musical Stones.

Later the musically-inclined Richardson further explored the sound properties of Lake District rocks. In 1827, while building houses at Thornthwaite, he struck musical gold with the hornfels around Skiddaw, and started work to create a lithophone



Joseph Richardson & sons (Keswick Museum)

capable of playing every musical note. Finding, testing and shaping suitable stones to assemble into an instrument took nearly 13 years, and nearly drove his family into poverty.

In 1840 Richardson enlisted the help of his three sons to play his new lithophone. They built up an impressive repertoire, including selections from Handel, Beethoven, Mozart and arrangements of waltzes, quadrilles, gallops and polkas. Their concerts were very popular and received rave reviews. "The richness as well as the sweetness of the tones produced seemed to excite the astonishment of all who heard them" noted one commentator.

In the mid-1840s Richardson updated the instrument, adding octaves of steel bars, Swiss bells, drums and various percussion instruments, and the group became known as the Richardson & Sons, Rock, Bell and Steel band. They gave over sixty concerts in London, toured all over Britain, performed in France, Germany and Italy and on 23 February 1848 played at Buckingham Palace by command of Queen Victoria. But their career was cut short by the death of their star player shortly before they were due to leave for a tour in America. The mighty instrument was packed away, and eventually given to the Keswick Museum in 1917, where it is still on display.

New music

Although other performers on Musical Stones followed during the 19th century,

including the Till Family Rock Band, who played at the Crystal Palace in 1881 and toured in America, all went quiet on the lithophone front for many years. But now interest in musical stones seems to be growing. A team of musicians, scientists and geologists at the University of Leeds have created a 21st century version with each stone wired up to a battery of computers to create a wider range of musical sounds. The percussionist Evelyn Glennie gave the updated instrument its premier outing in 2010.

It was an impressive performance. But so far, the new lithophone doesn't seem to have taken off. Perhaps the fact that it weighs 100 kg has something to do with it.

End notes: Sources for this vignette include: Julian WS Litten and Jamie Barnes, Richardson & Sons Rock, Bell & Steel Band, *Magazine of the Friends of Kensal Green Cemetery*, March 2006, pp 4-6; The Musical Stones of Skiddaw, published online by Allerdale Borough Council and the Keswick Museum; Martin Wainwright, Evelyn Glennie's Stone xylophone, *The Guardian* 18 August 2010; the website <https://ruskinrocks.leeds.ac.uk/>, includes a demonstration of the modern version of musical stones being played.

* **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

Society welcomes new President



Following the AGM in June, the Society has a new President, Dr Michael Daly. With a background in industry and academia, he is currently a Visiting Professor at Oxford University researching continental tectonics and resource systems, and holds director positions at Tullow Oil and CGG Geoscience.

Prior to election, he listed his three priorities as 'developing the Society's future by responding to the changing context of geology in the natural sciences; bringing my industrial experience and connections to the Society's significant financial challenges, and supporting and challenging the Executive Secretary and team.'

Marie Cowan elected a Member of the Royal Irish Academy



Marie Cowan, Director of the British Geological Survey of Northern Ireland at the British Geological Survey (BGS), has been elected a Member of the Royal Irish Academy 2020.

Dr Cowan was awarded the accolade for her contribution to society on the island of Ireland, including her creation of a multi-lingual communications campaign for OneGeology, a flagship BGS project for UNESCO's International Year of Planet Earth. Reaching a global audience of 107 million, the project aimed to improve the accessibility of global geoscience data to address societal issues including climate change.

'I am absolutely honoured' Dr Cowan said on her election. 'Geoscience impacts on all our lives, accounting for 34,000 jobs and 6150 businesses in Northern Ireland alone putting it on a par with agriculture.

'Looking ahead, geoscientists will play an integral part in society as we work towards a zero-carbon economy and greater environmental protections.'

Established in 1785, the Royal Irish Academy honours Ireland's leading contributors to the world of learning, with past Members including Seamus Heaney, Dame Nuala O'loan and former Presidents of Ireland Mary McAleese and Mary Robinson.



The Society notes with sadness the passing of:

Brooks, John*
Bennison, George
Cambray, Frank W*
Donovan, Desmond
Douglas, Tom*
Greenleaves, Keith
Holland, Charles
James, Ella*
King, Cuchlaine*
Morey, Colin Robert*
Pascall, Carolyn*
Reading, Harold
Rhodes, Frank
Snelling, Norman John
Walton, Derek*
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 sarah.day@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.

Staff matters

Two longstanding staff members, who will be known to many Fellows, are moving on.

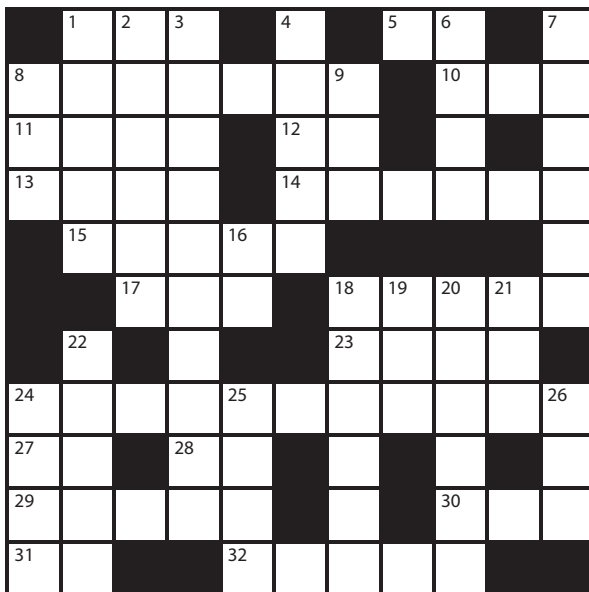


Judi Lakin, Head of Education, left the Society at the end of May. Over 23 years she has worked in various roles, including Conference Organiser and Membership Manager. In her latter role she has been responsible for a number of high profile projects, including the Society's Plate Tectonics online education module and the Geology Career Pathways web resource. We thank Judi for her valuable contribution to the Society in many areas over the years, and wish her every success in her new role.



Stephanie Jones, Administrative Secretary, will be retiring at the end of August after 12 years with the Society. Steph will be known to many readers, having organized President's Day, and administered Council and a number of committees, the Society's awards and research grants, Council elections and much more. We wish her all the very best for her retirement, and thank her for everything that she has done for the Society over the years.

Fellows wishing to send best wishes or make a contribution may contact sarah.day@geolsoc.org.uk.

**Across**

- 1** Body of water mostly surrounded by land (3)
5/6 Committee acquires new member without election (2-4)
8 Gypsum and opal are examples of this type of mineral (7)
10 A receptacle for hemp? (3)
11 Surface dwellers in *The Time Machine* (4)
12 See 16 Down
13/28/22 Tectonically active Gujarati salt marsh (4,2,5)
14 Palaeobotanist who conjectured on the thrill and hum of Devonian woods (6)
15 Amusing (5)
17 On BGS maps, code for Shaftesbury Sandstone Member (3)
18 The Western ones are a UNESCO World Heritage Site (5)
23 River on which Peterborough stands (4)
24/18D According to Murchison: the oldest stratified rock in Scotland (11,6)
27 Pronoun (third person singular) (2)
28 See 13
29 An operatic scene (5)

- 30** Type of crude, handstruck coin (3)

- 31** A very hard pencil (2)
32/20 Purple porphyry quarried in Egypt (5,6)

Down

- 1** Regulation made by a local authority (2-3)
2 ----- Blue. Butterfly of chalk downlands (6)
3 See 26
4 1 ac with the world's largest tidal range (5)
6 See 5 Across
7 Imperial measurement based on rocks (6)
8 Pronoun (female possessive) (3)
9 Often, part of an ocean (3)
16/12 River on which Gateshead stands (4)
18 See 24 across
19 In the Cretaceous it would probably have had teeth (3)
20 See 32 Across
21 According to Andrews, it goes with jam and bread (3)
22 See 13 Across
24 The Devonian was the age of these (4)
25 Triangular depression and triple rift junction (4)
26/3 Name proposed by Owen for a Triassic maze-toothed amphibian (13)

Solutions June | **Across:** 7/5 yo-yo 8/6/1A/9 Cote de Buttertubs 10 gynocelia 12 nick 13 nibs 14 chela 15 BY 17 floc 19/14D birch 21 lithomarge 22 monte 23 ola 24 Sugar 25 wood 26 gr 27 Flymo **Down:** 1/4/8 Big Rock Candy 2 tunnelling 3 eye-catcher 11 oil 15 bomb 16 bread 17 flour 18 ottar 19 Broom 20 igloo 22 MSG 25 WY

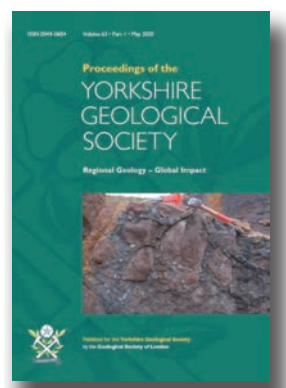
By Bindweed

Latest news from the Publishing House

Call for Chief Editor: Proceedings of the Yorkshire Geological Society

The *Proceedings of the Yorkshire Geological Society* (PYGS), one of the UK's oldest and best-known geoscience journals is seeking a new Chief Editor

The new Chief Editor will lead development of the journal from 2021 onwards and will shape future editorial priorities and policy. The role offers an exciting opportunity to provide strategic leadership at a time of rapid and radical change in scientific publishing.



For more information and how to apply please visit: www.lyellcollection.org.uk/PYGS

Deadline for applications: **31 July 2020**

A rare and unusual trace fossil from the Lower Jurassic (Lias Group) of Ketton, East Midlands, UK

By Stephen K. Donovan, Peter del Strother and Timothy A. M. Ewin

The top of the Whitby Mudstone Formation (Lias Group, Toarcian, Bifrons ammonite Zone) is exposed low in the geological Site of Special Scientific Interest at Ketton Quarry, East Midlands. A rare burrow of *Fustiglyphus annulatus* Vialov from this part of the succession, not reported from the Whitby Mudstone Formation hitherto, was collected from float. In the dull brown mudrock, the burrow has a contrasting fill of grey sandstone.



Read the full paper free for a limited time on the Lyell Collection
pygs.lyellcollection.org/content/63/1/43

OBITUARY**Kenneth John Chew (1945-2019)**

Kenneth (Ken) John Chew was born in August 1945 in Edinburgh, Scotland. He obtained a first-class honours in Geology from the University of Aberdeen in 1968, before starting a PhD in Aberdeen on the 'The Origin of Certain Base Metal Sulphide Deposits at Manitouwadge, Ontario'. While at Aberdeen he was active in student politics, serving on the Student Representative Council as Full-time Secretary (1969-1970) and President (1970-1971), and was the first student on the University Court.

Petroleum exploration

The petroleum exploration industry was now starting up in Aberdeen and Ken joined BP Petroleum Development in 1974, working as a rig geologist in the 'Operations Geology' unit: one of the wells he 'sat' was a renowned stratigraphic test drilled in a syncline in the Celtic Sea. In 1976, he joined the Geology Department of University College Galway, where he lectured principally on applied aspects of geology. His PhD thesis was awarded in 1977.

1978 saw a return to the petroleum industry at the new office of Petroconsultants Ltd. in Dublin. He became the assistant manager and head of research, with overall responsibility for the company's petroleum exploration database.

Geneva

In 1987 Ken transferred to Petroconsultants' (later IHS)

Influential petroleum geologist with an enthusiasm for the history of geology and tourism development initiatives



“KEN WAS CENTRALLY INVOLVED IN CREATING THIS DIGITAL RESERVES DATABASE... THE ONLY SOURCE OF COMPREHENSIVE, RELIABLE INFORMATION ON THE OIL AND GAS FIELDS OF THE WORLD”

Geneva headquarters where he held a number of appointments including Head of the E&P Database, VP - Computerized Services Division, VP - Geological Information Division and VP

- Database Support & Client Services Division. Petroconsultants' worldwide products included their 'Well Records' and 'Field Records', which were initially paper-based but were progressively incorporated into a digital database (Iris21).

Ken was centrally involved in creating this database and expanding it to include 'Basin Monitors' (for each of the 1800 worldwide basins he outlined!) This digital reserves database was the only source of comprehensive, reliable information on the oil and gas fields of the world. All the major companies relied

on it, as did the International Energy Agency in Vienna. Ken's access to this wealth of data on petroleum reserves and resources provided the opportunity for a series of articles on the hydrocarbon reserves of the North Sea, Norway and western Europe.

Retirement and further research

Early in 2006 Ken left the IHS Geneva office, but continued to work for IHS out of his home in the Scottish Highlands, officially 'retiring' in 2010. He maintained an interest in many aspects of geology, including the history of geology and the geology of Scotland, while continuing to work as an independent analyst of Unconventional Oil & Gas E&P Activity.

In recent years, Ken was active in the fieldwork team investigating the Port Askaig Tillite on the Garvellachs and Islay and used his knowledge of analysing worldwide sedimentary basins and their columns to compare the stratigraphic record of the Port Askaig Tillite with other Neoproterozoic glacial successions.

He was also heavily involved in the community of his adopted home village of Killin in Perthshire, where he led many tourism development initiatives up until his sudden death from a brain haemorrhage in July 2019. He is deeply missed by his family, partner and friends.

By David Chew and Anthony Spencer

HELP YOUR OBITUARIST The Society operates a scheme for Fellows to deposit biographical material. The object is to assist obituarists by providing contacts, dates and other information, and thus ensure that Fellows' lives are accorded appropriate and accurate commemoration. Please send your CV and a photograph to Sarah Day at the Society.

Sulfur in the Earth system:

From microbes to global cycles through Earth history



16-17 November 2020

The Geological Society, Burlington House, London

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.

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 Friday 11th September 2020. Abstracts should be approximately 250-350 words and include a title and acknowledgement of authors and their affiliations.

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)

Further information:

For further information about the conference please contact:
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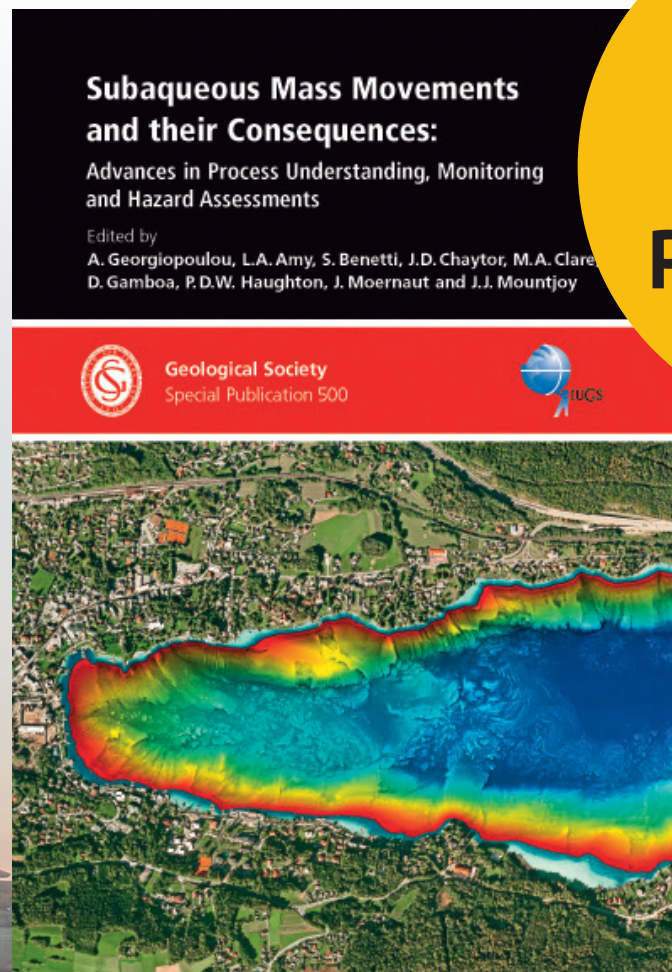
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Geological Society publications online



Subaqueous Mass Movements and their Consequences: Advances in Process Understanding, Monitoring and Hazard Assessments

Edited by A. Georgiopolou, L.A. Amy, S. Benetti, J.D. Chaytor, M.A. Clare, D. Gamboa,
P.D.W. Haughton, J. Moernaut and J.J. Mountjoy



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