GEOSCIENTIST

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The Fellowship Magazine of the Geological Society of London

@geoscientistmag

[SPECIAL ISSUE: 100 YEARS OF FEMALE FELLOWS]

WOMEN IN GEOSCIENCE

Elizabeth Pickett depicts a geoscientist building on foundations laid down by a predecessor

MINE HEAT
The potential in abandoned coalmines

OUTNUMBERED
Malin Kylander on the hurdles still faced by women in science

GIRLS INTO GEOSCIENCE
Jodie Fischer & Sarah Boulton on the growth of this scheme

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Lyell Meeting 2019

Carbon: geochemical and palaeobiological perspectives

28 June 2019 | **The Geological Society, Burlington House**

The fundamental building block of life as we know it, carbon, is critical to the Earth system. Traditionally biological and chemical approaches to understanding carbon dynamics in the geological past have been considered in relative isolation.

For the 2019 Lyell Meeting we will to bring together a broad spectrum of scientists that address the big picture of carbon in the Earth system, drawing on expertise in palaeontology, geochemistry, palaeobotany, atmospheric processes, deep-Earth processes, and anthropogenic impacts.

This meeting seeks to foster conversation between these disparate communities to facilitate a more holistic approach to considering carbon, and how it cycles between Earth's organic and inorganic reservoirs.

Call for Abstracts

We invite oral and poster abstract submissions for the meeting, and these should be sent in a Word document to katherina.steinmetz@geolsoc.org.uk by 30 April 2019. Abstracts should be approximately 250 words and include a title and acknowledgement of authors and their affiliations.

Convenors:

Barry Lomax (Nottingham University)
WT Fraser (Oxford Brookes University)

Further information:

For further information about the conference please contact:

Katherina Steinmetz, Conference Office, The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: 0207 434 9944
E: katherina.steinmetz@geolsoc.org.uk
Web: www.geolsoc.org.uk/lyell19
Follow this event on Twitter #lyell19

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2019 YEAR OF CARBON

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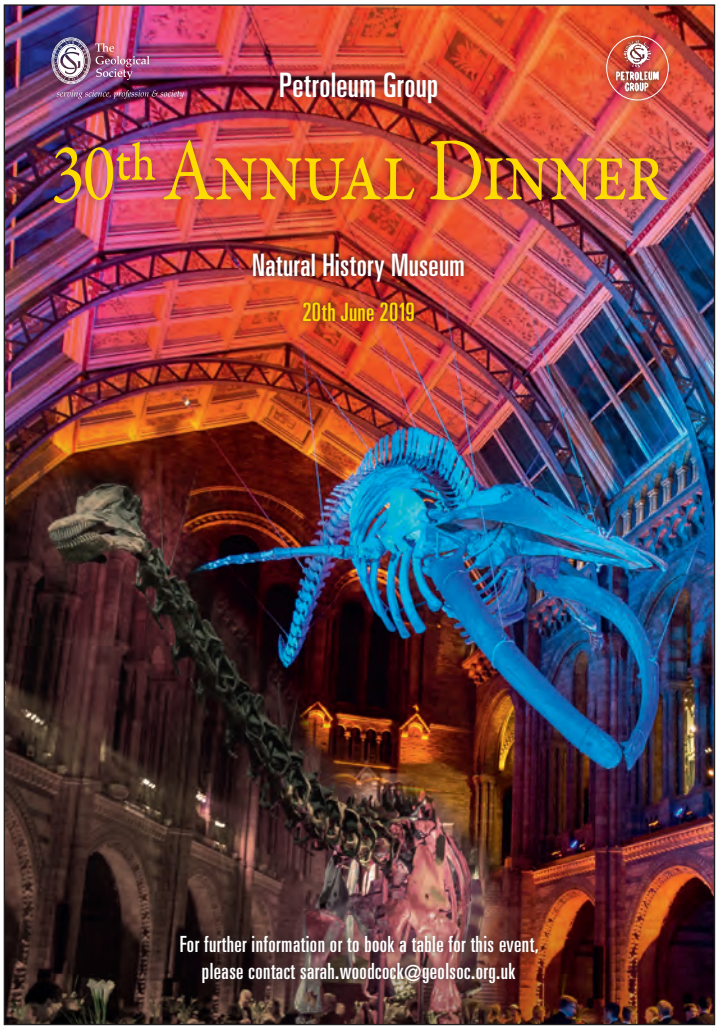
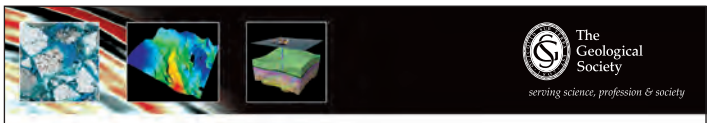
Cover image: An original gouache painting portraying two female field geologists, 100 years apart, in the same (imaginary) field location. By Elizabeth Pickett (© Elizabeth Pickett)

ON THE COVER:

FEATURES

REGULARS





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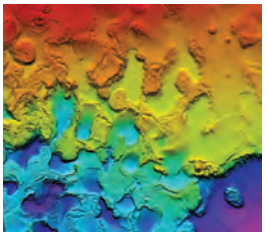
Call for Abstracts – Deadline: 31 May 2019

Salt Tectonics:
Understanding Rocks that Flow

29-31 October 2019

The Geological Society, Burlington House, Piccadilly, London



The complex behavioural and rheological characteristics of salt can strongly influence the structural and stratigraphic evolution of a basin. With many of the largest hydrocarbon provinces existing within salt-related basins understanding of the processes involved in salt tectonics has important scientific and economic implications for geological research and hydrocarbon exploration.

Modern high-resolution 3D seismic data with improved imaging of salt structures in combination with more advanced physical and numerical modelling techniques revolutionises the way we see salt tectonics and the role of salt structures.

This three-day international conference aims to bring together leading academic and industry geoscientists to discuss new techniques and case studies, and to capture an up to date assessment of our understanding of salt tectonic processes including:

- Geographical case studies; e.g. North Sea, Gulf of Mexico, Persian Gulf, Campos Basin
- Salt tectonics in extensional and contractional settings
- Halokinetic sequence stratigraphy
- Analytical methods of interpreting salt in seismic data
- Physical and numerical modelling of salt tectonics
- Implications of salt tectonics for hydrocarbon exploration.

Convenors:

James Hammerstein
Royal Holloway University of London

Jürgen Adam
Royal Holloway University of London

Clare Bond
University of Aberdeen and Tectonic Studies Group

Christina Von Nicolai
BP

Call for Abstracts:

Please submit talk or poster abstract to sarah.woodcock@geolsoc.org.uk by 31 May 2019.

For further information please contact:

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG.
Tel: +44 (0)20 7434 9944

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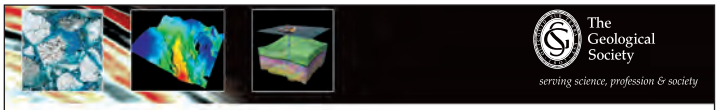

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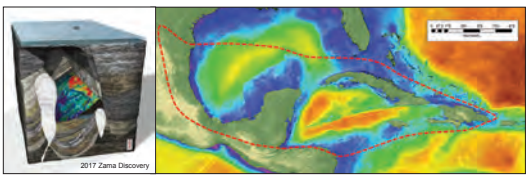
Registration Now Open

Petroleum Geology of Mexico and the Northern Caribbean

14-16 May 2019

The Geological Society, Burlington House, Piccadilly, London



The Gulf of Mexico is a world class prolific hydrocarbon system. As a result of recent energy reform the Mexican sector of this basin has been open to international companies for the first time through a series of competitive licence rounds. The first phase of drilling on these newly awarded permits has resulted in the discovery of giant hydrocarbon accumulations in the Mexican offshore sector. Geologically, the offshore and onshore basins of Mexico offer a diverse range of play types with multiple source / reservoir pairs and are characterised by complex tectonic evolution with associated halokinesis and shale tectonics.

More widely within the Northern Caribbean region, exploration activities are ongoing in several countries targeting both proven and frontier petroleum systems. Some of these play elements are potential extensions of the proven systems in Mexico. While geologically complex, these areas have the potential to emerge as major hydrocarbon basins.

An excellent series of abstracts have been submitted for the conference which have been arranged into the following themed sessions – Mexico Regional Tectonics, Mexican Basins - Sureste, Campeche, Burgos, Perdido Basins, Onshore Basins, Northern Caribbean Regional Tectonics, Northern Caribbean Basins Reservoir Distribution, Petroleum Systems and Salt Tectonics with the following Keynote Presenters:

- *Elisa Fitz-Diaz, Instituto de Geología, Universidad Nacional Autónoma de México*
- *Iain MacEwen, Premier Oil*
- *Chris Matchette Downes, CaribX Limited*
- *Jim Pindell, Tectonic Analysis Ltd*
- *Mark Rowan, Mark Rowan Consulting*
- *John Snedden, The University of Texas*

Registration is now open and the full conference program is available on the Geological Society Website: https://www.geolsoc.org.uk/petroleum

Poster submissions are still being accepted until 15th March 2019 and the committee would encourage further submissions for this category.

Convenors:

Jonathan Hull
Ophir Energy – Chair

Matthew Bowyer
Cairn Energy

Ian Davison
Earthmoves

Mike Hohbein
Ophir Energy

Aruna Mannie
Premier Oil

Chris Matchette Downes
CaribX

Adrian Neal
Badley Ashton

Mark Shann
Sierra Oil & Gas

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caribx
DEA
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ERCE
ophir
PremierOil

For further information please contact:

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG.
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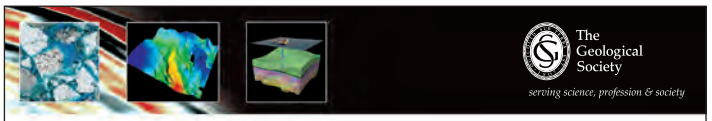

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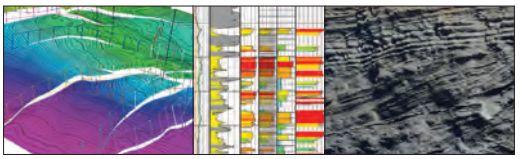
Registration Now Open

Capturing Geoscience in Geomodels

26-27 June 2019

Robert Gordon University, Aberdeen



Over recent years the construction of 3D static and dynamic reservoir models has become increasingly complex. With the availability of extensive tools and technology it is important not to forget the objective of the modelling process.

As we develop our hydrocarbon fields it is essential that 3D Static Models be built with fit-for-purpose geological models, honouring the geological, geophysical and petrophysical data that they are created from.

This two-day conference will explore how geoscience information should be used to best effect, and how to identify when geoscience data may no longer add value. Sessions will include the following themes:

- Data integration: seismic, well log, sedimentological, core dynamic data and beyond
- Capturing conceptual geology in reservoir modelling for different settings and depositional environments
- Scale: geology vs model vs data
- Uncertainty: dealing with geological uncertainty in modelling and understanding its benefits and limitations
- Embracing new modelling technology and approaches.

Convenors:

Matt Jameson
Glencore

Gwilym Lynn
Shell

Leigh Truelove
Schlumberger

Ingrid Demaerschalk
Tullow

Alun Griffiths
Rockhopper

Catherine Tonge
Shell

David Hulme
Equinor

Tom Marsh
Rock Flow Dynamics

James Aguas
Halliburton

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> AS WE CELEBRATE THE CONTRIBUTIONS OF FEMALE GEOSCIENTISTS, WE ARE REMINDED THAT THERE IS STILL SOME WAY TO GO

FROM THE EDITOR'S DESK:

Make your voice heard

Although founded in 1807, it wasn't until 1919 that women could be elected as Fellows of the Geological Society of London. Women were making important contributions in geological science, yet they weren't allowed to attend Society meetings—even to read their own papers or receive their awards. So, to mark the centenary of this major turning point for the Society, this issue is devoted to women in geoscience.

Fronted by an arresting cover painted by Elizabeth Pickett, the winner of our cover competition (see page 7), this issue is packed full of interesting science, analysis, reviews and advice, largely authored by brilliant female scientists. But, you'll notice that Soapbox (page 9)—our main outlet for opinion—is not authored by a woman. Not that author gender has any bearing on the significance of the message. In his piece, Phil Heron makes the important argument that we should broaden our views of outreach and impact, in the process highlighting a disadvantaged minority group in society—an apt point for an issue that celebrates the contributions of the under-represented.

I approached several women to ask if they might want to contribute to our Soapbox section, but they declined due to over-commitments elsewhere, or a lack of time to really delve into the details that they felt would be required to make a compelling argument. This got me thinking about the scarcity of women's voices in the opinion pages of our magazine and I decided to dig into the stats.

It turns out that since 2007 (the limit of our digital archives), women have authored just 6.7% of Soapbox articles in *Geoscientist* magazine (compared to a male-to-female split of 71% to 29% for the Fellowship). The statistic for Letters is similarly depressing at just 6%. There are several years where no female voices have featured on the opinion pages in any issue (see the raw data online).

This lack of female voices is disappointing, but not surprising. The dearth of female-authored opinion pieces published in major newspapers, including the New York Times, the Guardian and the Telegraph, is widely documented (see further reading online). Reasons often cited for this disparity are that women are overloaded with 'soft' work, such as childcare, teaching or mentoring and so don't have time to write, or that many women remove themselves from the discussion because they discount their knowledge, essentially due to a crisis of confidence that stems from ingrained and implicit societal bias. These reasons resonate with some of the responses I received from the women I approached, at least anecdotally.

To remedy these disparities in our pages, I work hard to commission content and publish diverse views, but I need your help: we cannot publish what we do not receive, so I encourage all members of our community to get in touch. Our opinion pages provide an opportunity to make your voice heard, as well as an additional avenue for outreach—please feel free to use them.

Historically, women's contributions have been undervalued and it was a long wait before women could participate in Geological Society debates. In line with the Society's policy on diversity, equality and inclusion, it's important to see their voices, and those of other under-represented groups, reflected in the pages of this magazine.

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

SOCIETY NEWS

President's Day

President's Day at Burlington House on Thursday, 6 June will begin with the Annual General Meeting at 11.00am followed by a buffet lunch with the award winners (members with ticket only—£28.00 per head). As in previous years, the recipients of the major medals have been invited to give a short talk on their subject, and the Awards Ceremony will be followed by presentations by the Lyell, Murchison, William Smith and Wollaston medallists (details on the website: **www.geolsoc.org.uk/GSL-Presidents-Day-2019**). The timetable for President's Day and the agenda for the AGM are below. To obtain luncheon tickets please send cheques (payable to the Geological Society) to Stephanie Jones at Burlington House or email **stephanie.jones@geolsoc.org.uk**. Please also contact Stephanie if you wish to attend the afternoon events for which there is no charge.

Timetable

11.00	Annual General Meeting (members only)
12.30	Lunch with the Award winners (members with tickets only)
14.00	Awards Ceremony
15.15	Talks by Lyell, Murchison and William Smith medallists
16.30	Tea
17.00	Talk by Wollaston Medallist
17.30	President's closing remarks
17.40-19.30	Drinks reception

AGM Agenda

Apologies
Minutes of the Annual General Meeting held on 6 June 2018
Appointment of Scrutineers for the ballots for Council and Officers
Ballot for Council Annual Report and Accounts for 2018
- President's Report
- Secretaries' Reports
- Treasurer's Report

Comments from Fellows
Report of Scrutineers on the ballot for Council
Ballot for Officers
Fellowship subscriptions for 2020
Deaths
Appointment of Auditors
Report of Scrutineers on the ballot for Officers
Any other business
Provisional date of next Annual General Meeting – 4 June 2020

Future meeting dates

OGMs: 19 June 2019, 17 September 2019, 20 November 2019, 5 February 2020, 8 April 2020

Council: 19 June 2019, 17 & 18 September 2019 (residential), 20 November 2019, 5 February 2020, 8 April 2020

Election results

The advisory ballot for Council, conducted by Electoral Reform Services, closed on 31 March. The turnout was 18.1%.

A total of 2,055 valid votes were cast for President-designate. The results were as follows:

Dr Michael Daly – 1,196 votes (58.2%)
Prof Jonathan Craig – 859 votes (41.8%)

Dr Michael Daly will go forward to the Annual General Meeting on 6 June 2019 for election as President-designate.

A total of 2,040 valid votes were cast for the remaining five vacancies on Council. The results were as follows:

Dr Kathryn Goodenough	1,544 (75.7%)
Ms Gemma Sherwood	1,495 (73.3%)
Mrs Sarah Scott	1,326 (65.0%)
Dr Joel Gill	1,186 (58.1%)
Mr Andrew Moore	1,088 (53.3%)
Prof Quentin Crowley	863 (42.3%)
Dr Stephen Laubach	570 (27.9%)

The five candidates receiving the most votes will go forward to the Annual General Meeting on 6 June 2019 for election as Council members.

Notification of Officers 2019/2020

At the AGM, Fellows will be asked to elect the following members of Council as Officers for 2019/20:

President:	Prof Nicholas Rogers
Vice-Presidents:	Mr John Booth
	Mr Nicholas Reynolds
	Miss Jessica Smith
	Mr John Talbot
Secretaries:	Prof Katherine Royse
	Prof Robin Strachan
	Dr Alexander Whittaker
Secretary, Foreign & External Affairs:	Dr Sarah Gordon
Treasurer:	Mr Graham Goffey

President's Awards for 2019

The President's Awards for 2019 are made to Oliver Dabson for the quality of his work with Jacobs and his academic publication record; and Nicole Duffin for the quality of her work with Shell and her work with the Society on the Science Committee and last year's Janet Watson Conference. Congratulations to both.

What your society is doing
at home and abroad

Annual Fellowship subscriptions

Since 2015, the annual increase in Fellowship fees has been set with reference to the prevailing annual rate of Consumer Price Index (CPI) inflation when proposals are considered for the following year in March and April. The rate of CPI for January 2019 was 1.8%. Inflation has recently been on a downward trend and in recent months has been fairly static. It is forecast to rise slightly in the coming months and though the effects of an exit from the EU is unknown, it is projected to be in the 2.0% - 2.2% range during 2020. It is an established principle that the fellowship fees should be set at a level commensurate with the cost of providing the fellowship services provided, therefore an increase in line with CPI has been recommended.

At its meeting on 17 April, Council will discuss the subscription rates for 2020 shown below. An increase of 1.8% has been recommended. Due to rounding, not all categories are adjusted and the maximum fee payable will be £214, up by £4 on the equivalent 2019 rate. Once ratified by Council, these rates will be recommend to the Fellowship for approval at the Annual General Meeting.

	2019 £	2020 £
Junior Candidate Fellow	10.00	10.00
Candidate Fellow	15.00	15.00
27 and under	74.00	75.00
28-33	138.00	140.00
34-59	210.00	214.00
34-59 (Overseas)	161.00	164.00
60-64	138.00	140.00
65-69	105.00	107.00
70+	72.00	73.00
Concessions	74.00	75.00
Full time postgraduate MSc	30.00	31.00
Full time postgraduate PhD	43.00	44.00
RAS 25% discount	158.00	161.00
Supplement (to payer) for Joint Fellowship	60.00	–
Joint Fellow discount	–	35%
CGeol supplement payers	50.00	50.00

Cover competition

The results are in and we're thrilled to announce that the winner of our cover competition is Elizabeth Pickett. Congratulations!

To mark the 100th anniversary of female Fellowship of the Society, we asked you to send us an image that celebrates women in geoscience, whether past or present. We received many fantastic entries—a big thank you to all those who contributed.

It was a tough choice and we eventually whittled the entries down to three wonderfully creative and striking submissions. But, there could only be one winner, and so the top prize goes to Elizabeth Pickett for her stunningly detailed, original gouache painting portraying two female field geologists, 100 years apart, in the same (imaginary) field location. Elizabeth writes:

"Although knowledge, understanding and technology have developed enormously since 1919, the rocks are still fundamentally the same, as are many aspects of geological fieldwork. Today's geologist is building on foundations, both geological and societal, laid down by her pioneering 1919 predecessor. Despite the differences in their situations, they can still reach across the time gap to discuss the geology of an area and share observations and ideas—I like to think they'd have lots to discuss!"

Eye-catching and beautiful illustrations from Lauren Moore, depicting the diversity of female geoscientists through time, and Nicola Dakin, depicting Mary Anning, one of the first recognised female palaeontologists of the 19th Century, came in as close runners up.

You can read more about the competition winners and see the entries in more detail on our website here: **www.geolsoc.org.uk/covercompetition**

© Elizabeth Pickett

© Lauren Moore

© Nicola Dakin

Earth Science Week 2019

This year's Earth Science Week is taking place on 12-20 October, with a theme of 'Geoscience is for everyone.' An annual celebration of the geology all around us, Earth Science Week is coordinated by the American Geoscience Institute in the US, and the Geological Society in the UK & Ireland. The week also takes place in an increasing number of countries around the world.

Events include lectures, geology walks, family activity days and workshops, organised by institutions and individuals around the country. Last year, a number of our Regional Groups got involved, alongside Dynamic Earth in Edinburgh, the North West Highlands Geopark, National Museums Scotland and many more.

Find out more about Earth Science Week on our website at **www.geolsoc.org.uk/earthscienceweek**. A number of small grants are available from the Geological Society to help with running your event—details on how to apply will be available on our website soon. If you would like to organise an event, find out more or discuss your ideas, please get in touch with us via **outreach@geolsoc.org.uk**.

100 years of female Fellows

Sarah Day calls on female Fellows to recount their stories.

2019 marks the 100th anniversary of female Fellowship of the Geological Society. Throughout the year we will be highlighting the work of our pioneering early members, as well as celebrating the contributions women have made to the geosciences before and since. Find out more about the anniversary at **www.geolsoc.org.uk/100years**.

As part of this project, we're embarking on an oral history project in partnership with our History of Geology Group to capture the memories of female Fellows; particularly those who have been members for a long period of time. In doing so, we hope to both enhance our oral history archives, and provide a more balanced and accurate representation of the Society's heritage.

If you have memories you would like to share with us, whether via interview or more informally, we would love to hear from you. Please contact **outreach@geolsoc.org.uk**, or write to us at:

Oral History Project
The Geological Society of London
Burlington House
Piccadilly, London
W1J0BG

Chartership news

CGeol: Massimo Antonelli, Dario Avagliano, Jessica Charles, Thomas David Desmond Curran, Nicola Daniele, Hywel Gwrthefyr Davies, Payal Debroy, Stephen Joseph Dixon, Timothy John Downes, Katherine Alexandra Elizabeth Edwards, Robert David Fordham, Lyndsey Fletcher, Ruth Leala Jacobs, Rigilia Lau Chu Leh, Pak Wing Leung, George Lawrence Lloyd Mitchell, Nicholas Charles Peters, Robert Colin Pugh, Silvia Terzuoli, John Wilton

CSci: Fiona Waldron, Anthony Windsor

Mentoring

An update on mentoring from Bill Gaskarth

The Mentoring Workshop scheduled for 26th March was cancelled because there were too few registrants to make it viable.

The Society is committed to the provision of mentoring support for Chartership Applicants. At present, companies with Accredited Training Schemes are required to provide their trainees with a mentor to guide their professional development. Trainees in these companies therefore get the necessary support and many companies have sent people to the GSL workshops or have organised 'in house' mentor training.

The Society maintains a list of Chartered Fellows who have offered to help any early career Fellow looking towards Chartership. This support is largely in the form of coaching/advising in the late stages of an application. Such help has been useful to a number of people who work in companies where a mentor is not available, usually due to the size of the company. We wish to continue to offer this service, but the numbers offering help have shrunk to a low level following the introduction of GDPR, when many former Mentors did not sign up again.

Experienced CGeols who are willing to be contacted for help by early career geologists are asked to contact the Chartership Officer (**Chartership@geolsoc.org.uk**) with their details. In the meantime, the Regional Groups are encouraged to see if they have members who could help develop 'self-help' groups for aspiring applicants. The Chartership Officer is always available to visit and advise groups or companies.

Those that attended greatly appreciated the workshops run by the Society. We intend to offer more in the future, along the lines of previous workshops that give attendees an appreciation of what mentoring entails and how to avoid pitfalls. The Chartership and Professional Committees is also considering the possibility of developing Webinars covering this introductory area and perhaps others that offer training beyond the preliminary level.

A form for reporting annual professional development and training is available on the Society's web site **www.geolsoc.org.uk/Membership/Chartership-and-Professional/Applicants**.

PUBLIC LECTURE SERIES

Recipes for Making the Earth

Speaker: Tim Elliot, University of Bristol
Location: Burlington House, London
Date: 30 May

Programme

- **Afternoon talk:** 14:30 Tea & Coffee; 15:00 Lecture begins; 16:00 Event ends
- **Evening talk:** 17:30 Tea & Coffee; 18:00 Lecture begins; 19:00 Reception

Further Information

Please visit **www.geolsoc.org.uk/gsllondonlectures18**.
Entry by ticket only (contact the Society about four weeks before the talk). Both lectures will be available to watch live streamed.

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

The 'impact' factor: Can we be more useful?

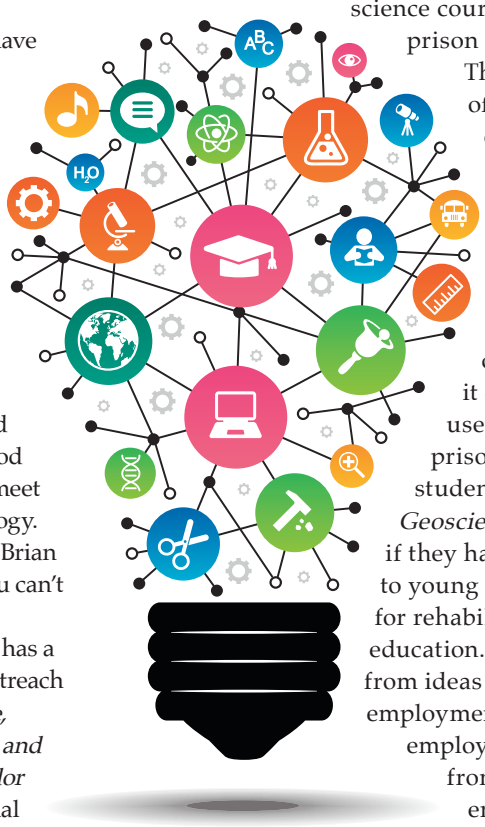
Expanding our portfolios. **Phil Heron** reaches out on outreach

Impact. The section on the grant application that is becomingly increasingly important to funding bodies. How is your project going to benefit people? And by 'people' I mean real people. Not those twelve souls in your precise area of expertise that are genuinely interested (some may even say keen) to hear about your new research. Or the scattering of other geologists in different fields that might find your work useful. Actual people.

Schools

For a number of years, I have been going into high schools and primary schools armed with a bag of rocks, spaghetti and marshmallows, and some chat about plate tectonics. I love it. I don't even do it because I said I would in a grant—I just like presenting things I find interesting to people. And it is impactful. I find a good percentage of students I meet love the exposure to geology. Some would rather I was Brian Cox or Tim Peake, but you can't please everyone.

The Geological Society has a comprehensive school outreach programme—the *Science, Technology, Engineering and Maths (STEM) Ambassador Programme* is phenomenal in getting positive role models into classrooms to enthuse students about science. There are a number of national initiatives, like Earth Science Week, to focus student's attention on our dear subject, as well as a wealth of online material for teachers to peruse for lessons. With that in mind, is it time to start exploring other avenues outside the traditional classroom setting for our required outreach programme?



Other avenues

I live and work in Durham, a city that has, broadly speaking, a university, a cathedral and a few prisons. As part of my outreach activity, I thought I could try and combine one of the non-university institutes. Going in and talking to prison leaders (sidestepping the cathedral), it became clear that there is a real lack of science education on the inside due to a lack of funding and personnel. To try to bridge this gap, I've set up what appears to be England's first science course to be taught inside the prison system.

The work within a young offenders institution has enabled the students to gain access to information on STEM apprenticeships, and mentor them in 'thinking like a scientist'. As the course continues to gather pace, it could be genuinely useful and impactful to the prison system and to the students. I'm encouraging *Geoscientist* readers to reach out if they have guidance of any sort to young offenders who are keen for rehabilitation through science education. This may be anything from ideas for routes into science employment, to qualities that employers would need to see from non-graduate employees.

Grants demand academics to be impactful with our science and our outreach programmes—is it time to expand our portfolio of classrooms and science fairs?

Philip J. Heron is a Marie Skłodowska Curie Research Fellow at Durham University; e-mail: philip.j.heron@durham.ac.uk (Phil's science course is called 'Think Like A Scientist'; https://philheron.com/think-like-a-scientist/)

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 **amy.whitchurch@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).

> "IS IT TIME TO START EXPLORING OTHER AVENUES OUTSIDE THE TRADITIONAL CLASSROOM?"
> PHIL HERON

MINING FOR HEAT

Many UK towns were built on coal. **Charlotte Adams**, **Alison Monaghan** and **Jon Gluyas** highlight the vast potential to repurpose our abandoned mining infrastructure as a low-carbon heat source

Deep coal mining in the UK has left a legacy of flooded former mines. Water within these mines can provide a source of heat energy. Durham University is researching the potential of this resource and the British Geological Survey (BGS), commissioned by the Natural Environment Research Council (NERC), are constructing and operating a research site in Glasgow to further understanding of mine energy systems.

When coal was king

Over the past century, vast quantities of coal were mined from the UK subsurface as it fuelled our industrial and economic growth. The 15 billion tonnes mined are equivalent to a 5-cm-deep layer of coal spread over the entire UK land surface. Despite the wealth generated by the UK's coal deposits, coal is now regarded as a "dirty" fuel because of the associated CO_2 and other pollutant emissions, and is being phased out of our energy mix. UK government demonstrated its commitment to reducing coal use by joining 27 other national governments that have signed up to the "powering past coal alliance" and there are now days when coal is not being burned to produce electricity in the UK.

The UK has made good progress in decarbonising its electricity supplies over the past decade, with around half of UK electricity demand supplied from low-carbon sources (DBEIS, 2018). However, electricity provision is only part of the story and half of the UK's total energy demand is used to produce heat, most of which is consumed by the domestic sector. Heat is predominantly produced from

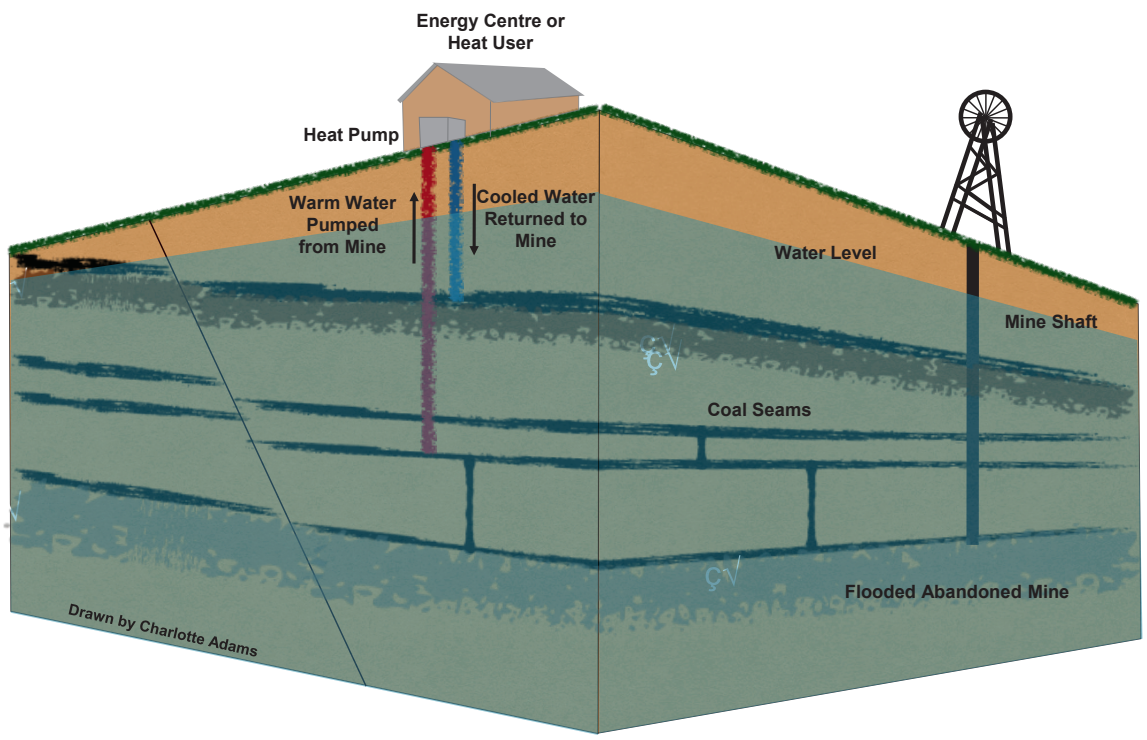


Fig 1: Schematic Diagram of a mine water heat pump system (Drawn by Charlotte Adams)

burning natural gas. In the meantime, the UK has been a net importer of natural gas for over a decade and is reliant on other nations to meet any shortfalls in demand.

Developing a legacy

Our abandoned mining infrastructure now lies largely derelict and many have forgotten its existence. Yet, people in former mining towns and villages remain strongly connected to their mining heritage, even though its decline brought hardship and, in some areas, environmental pollution.

Our mining legacy and the associated infrastructure could be repurposed and has potential as a future energy source. The mine shafts and galleries that are now flooded contain copious volumes of water at 12-20°C. Clearly you would not want to take a bath in water of this temperature, but heat pumps can boost temperatures to provide hot water and space heating. Heat pumps require an energy input, but because each kW of electrical energy input could be expected to deliver a heat output of 3-4 kW, heat is provided in an energy-efficient way.

Mine water is accessed by drilling boreholes into flooded workings through which water is abstracted, heat is removed and the temperature boosted with a heat pump, before the water is returned to the subsurface (Fig. 1). Using mine water as an energy source compared with individual closed-loop, ground-source heat pumps offers some advantages for domestic properties. Decreased garden size of newer housing stock leads to reduced space for horizontal ground arrays, meaning that boreholes would be required, which are more capital intensive. Mine-water heat systems are generally operated open-loop, which offers better thermal efficiency than standard closed-loop ground-source heat systems. Finally, mine-water systems offer economies of scale, meaning that clusters of hundreds of properties could be served from a single mine and a few boreholes. To deliver this vision requires changes to planning and building control policies that support the future development of low-temperature energy systems.

Durham Energy Institute at Durham University is undertaking national, regional and local assessments of mine energy potential for a range of applications, under the auspices of BritGeothermal, which is a national research partnership for deep geothermal energy. This work includes assessing domestic residences, industrial ▶

Fig 2: Stoop-and-room (Scottish terminology for pillar-and-room) mine workings subsequently exposed by opencast coal workings at Blindwells, Scotland. Photo number P001520 BGS©UKRI. The image illustrates the connected void space ('rooms') that could be targeted for mine water geothermal projects

▶ developments and municipal buildings for mine energy systems.

For these assessments, we need to understand the nature of the subsurface infrastructure and appreciate how water quality can evolve, both during mine abandonment and following periods of abstraction. Research shows that following long periods of abandonment, water within mines can become highly stratified, with better-quality water generally lying above poorer-quality water (Nuttall & Younger, *J. Contam. Hydrol.* 2004). Pumping and abstracting water from mines induces turbulence and mixing within the mine. This means that the eventual quality might be poorer than expected and it is important to take samples of the entire water column if possible. Water quality may change with pumping rate and is linked to the areas of workings being drawn from. Quality may improve once a few shaft volumes have been pumped.

Many mine waters contain iron, which is a remnant of the interaction between the oxygenated mine-water and pyrite within the coal (particularly high-sulphur coals) and is the nemesis of mine-water management. As long as air is excluded from a mine-water heat pump system, iron remains in solution, but introducing air even when there are low concentrations of iron present (1mg/l) leads to the deposition of ochre. Though iron ochre precipitation is key for mine-water treatment, in a heat-exchange system this can cause severe clogging and fouling of system components. Ochre precipitation is normally avoided by keeping systems under positive pressure, limiting dissolution of oxygen.

To assess the potential of this resource, it is necessary to obtain from the UK Coal Authority the abandonment plans for seams within the collieries worked, and then use these to calculate the worked areas and seam thickness. The large-scale extraction of coal from the subsurface leaves voids that remain long after mine abandonment. Yet, these voids will not remain exactly as they were at abandonment. Shafts were often filled with rubble from the demolished topside colliery infrastructure before being capped, rendering many of no value for future water pumping. The floor of galleries may heave and roof material may collapse, leading to tunnels with partial blockages along their length.

The amount of remnant void space depends upon the method of deep mining employed. Early 'room-and-pillar' mining involves working a grid, leaving pillars of coal intact for roof support and mining the areas between (Fig. 2). Room-and-pillar mining was later replaced by longwall mining (first developed in Shropshire in the 17th Century), a more efficient means of removing coal that involves driving tunnels to the farthest extent of the mine, then removing coal from the seam laterally whilst retreating from the workings. Many areas formerly mined by the room-and-pillar method were latterly reworked using longwall extraction. As longwall mining proceeds the overburden above the seam subsides producing "goaf" (collapsed waste). Consequently, an area mined by room-and-pillar methods can be assumed to have around 50% of the original void space remaining and, for longwall mining, around 20% of the original void space remains (Younger & Adams, *Tech. Report* 1999). These voids, in effect, have created an anthropogenically-enhanced aquifer in which heat can be extracted from or reinjected into the large water volumes existing within the mine workings.

The potential for the flooded abandoned collieries of the UK to provide a source of heating, cooling and energy storage is huge. The UK Coal Authority estimates that abandoned flooded mines contain around 2.2 million GWh of heat, with an even greater potential for heat storage. Furthermore, because coal spawned the development of many of our towns and cities, mine energy resource aligns well with centres of heat demand. The Coal Authority estimates that around one quarter of UK housing stock overlies areas of abandoned mine workings.

There are a few examples of mine energy projects that serve smaller and individual developments in the UK. Bridgend Council in Wales is working to deliver a larger district heating system that will initially supply heat to around 150 homes. At Heerlen in the Netherlands, abandoned mines are used effectively to deliver space heating and cooling to around 200,000 m^2 of mixed use new and retrofit buildings via a 7-km-long heat network (Verhoeven *et al., Energy Procedia* 2014). In addition to delivering low-carbon energy to Heerlen, the money spent on heat by their customers is retained within the region rather than going to a major, national energy supplier, thereby promoting economic regeneration to a formerly deprived mining region.

Hostages to fortune

The UK geothermal industry has struggled to develop, not from lack of potential but because of the upfront capital cost and risks involved with drilling boreholes that are not guaranteed to flow adequate quantities of water for energy extraction. There is only one operational deep geothermal heat scheme in the UK, at Southampton. It was developed in response to a national audit of the UK's geothermal resources in the 1980s, prompted by the oil crisis.

Although abandoned mines are shallower and the temperature of water within them is cooler, copious quantities of water flow through these systems, thus reducing development risk. The UK is sitting above an extensive but yet-to-be commissioned heat network. Mine energy has a much higher technology readiness level than other low-carbon replacements for natural gas, such as hydrogen. Heat-pump technology is proven, we have a long experience of drilling in mining areas and have evidence of success, as demonstrated by projects in the UK and beyond. Why then is this type of heat not used more widely? A whole new approach to the licensing of heat, -[risk-averse attitudes] to "untested technologies" (Banks, *GSL SP* 2004) and the fact the UK has had ready access to relatively cheap gas supplies provide some answers. Complexities associated with retrofit of heat exchangers and heat pumps, economic risks linked to difficulties in securing long-term contracts for heat supply and system maintenance, as well as concerns over water quality and subsidence may present barriers to widespread development.

BritGeothermal is lobbying for changes to national planning policy, licensing and regulation of subsurface use to ensure that mine energy potential is considered when planning new developments. This group is also investigating the mine energy potential of a number of former coalfields and it is hoped that the new Glasgow Geothermal Energy Research Field Site (BGS, 2018), as well as a variety of industrial and council supported projects in north-east England, will significantly reduce subsurface, geoscientific uncertainties and risks, raise awareness and stimulate the market for this low-carbon energy source. ▶

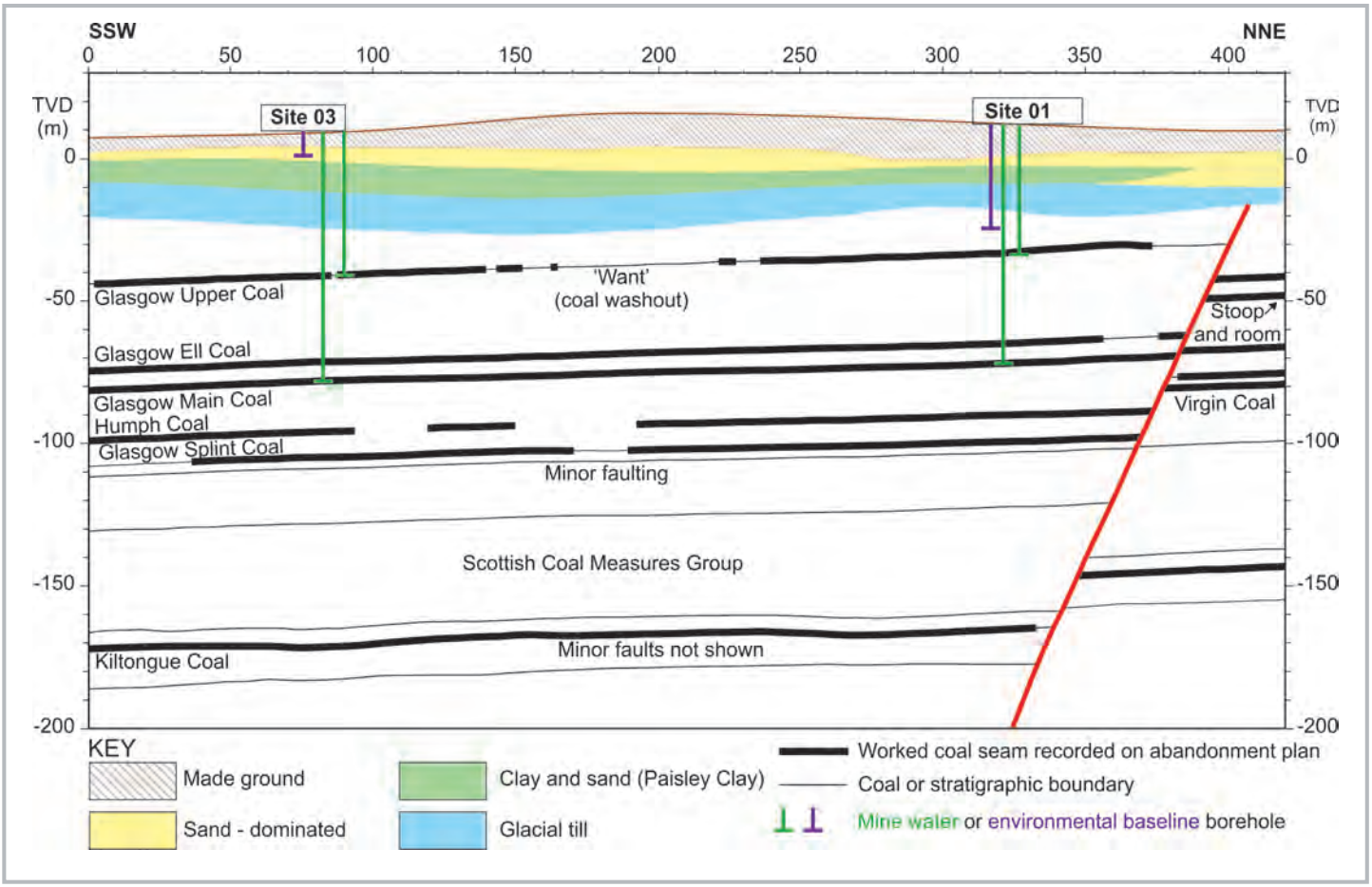


Fig 3: Cross-section of the geology in the Cuningar Loop area with the planned borehole target depths shown, UK Geoenergy Observatory in Glasgow. Note that the thick black lines represent areas recorded on abandonment plans as mine workings. TVD=true vertical depth relative to Ordnance Datum, top X-axis is in metres

UK Geoenergy Observatories

The BGS is constructing and operating the UK Geoenergy Observatories on behalf of NERC. This is an ambitious £31 million investment that will develop and operate two subsurface research observatories. Funded by the UK Government Department for Business, Energy and Industrial Strategy (DBEIS), the observatories will facilitate improved understanding of subsurface change beneath our feet.

The Glasgow Geoenergy Observatory, currently being constructed, will focus on shallow, low-temperature mine energy opportunities using the flooded abandoned mine workings below the east end of the city. The other UK Geoenergy Observatory, in the Ince Marshes area of north Cheshire, will focus on improved understanding of the subsurface environment across a 12 km^2 area, down to 1,200 m below ground. This knowledge can be applied to a range of energy technologies.

Site geology

The Glasgow Geothermal Energy Research Field Site is located on the western side of the Central Coalfield of the Midland Valley of Scotland, within glacial and post-glacial Quaternary superficial deposits, overlain by a variable thickness of made (anthropogenic) ground. The Quaternary deposits vary in thickness up to 30 m. The upper surface of bedrock was incised, with thicker accumulations of superficial deposits infilling a broadly NW-SE trending channel following the modern-day River Clyde. There is widespread made, filled and landscaped ground relating to a variety of prior industrial land use, in some places this is 10 to 15 m thick.

These deposits rest on approximately 300 m of bedrock strata of the Scottish Upper, Middle and Lower Coal Measures formation—cyclical sedimentary rocks of sandstone, siltstone, mudstone and coal. Recorded coal mine workings in the area were active from 1810 to 1934, with total extraction and stoop-and-room workings shown on abandonment plans. It is expected that total extraction areas collapsed within a few years of mining to form goaf and that the mines will be flooded. As the cross-section in figure 3 shows, there are multiple levels of mine workings in the area where the Glasgow research site will be situated.

Glasgow site aims

The Glasgow Geothermal Energy Research Field Site aims to provide access to infrastructure and a wide range of openly accessible data to answer key research questions on low-carbon, mine energy systems, to enable sustainable, responsible and more widespread use of this resource. This facility will develop understanding of factors critical to successful development of mine energy systems, such as the longevity and sustainability of the resource and the hydrogeochemistry of the mine water through time. Development of the field site will also explore the risks associated with drilling into the roadways, pillars and goaf at different depths within abandoned mines. It will also explore the potential for subsurface connections to exist between near-surface and mine waters, and the consequences of this for environmental protection.

The infrastructure to be installed will include an array of 12 boreholes at various depths equipped to provide a continuous time-series of geological, hydrogeological and thermal datasets (Fig. 3). Samples, tests and measurements will be taken from the boreholes, such as temperature and aquifer properties, water chemistry and microorganisms

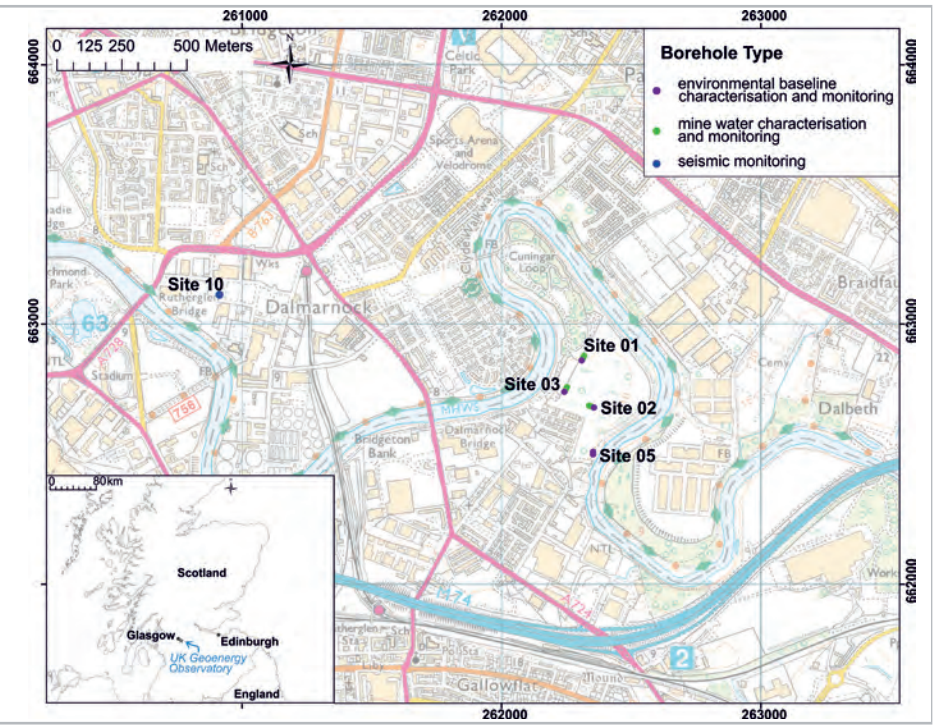


Fig 4: Map of the UK Geoenergy Observatories: Glasgow borehole locations. Contains Ordnance Survey data © Crown copyright and database rights. All rights reserved [2019] Ordnance Survey [100021290 EUL]

Taking a sample of borehole water during drilling of the seismic monitoring borehole at Dalmarnock, Glasgow in November 2018. Photo number P987023 BGS©UKRI

(geomicrobiology). Environmental monitoring of near-surface soil chemistry, soil gases, seismicity, surface and groundwaters will also be undertaken prior to development, to provide a site baseline before any geothermal research takes place. Existing, commercially developed mine energy systems focus on heat production and there is limited subsurface and environmental monitoring data. In contrast, the Glasgow research site offers huge potential for researchers to access large, integrated datasets on the mine-water system. It will also provide opportunities for researchers to undertake their own experiments, with the common aim of reducing uncertainty on mine energy systems and environmental impacts for schemes across the UK and beyond.

The infrastructure

Planning approval and permits for the characterisation and monitoring phase have been granted, with the majority of the boreholes located at the Cuningar Loop, Rutherglen (Fig. 4). Planned drill lengths are between 10 and 90 m. Six mine-water boreholes target the Glasgow Upper and Glasgow Main coal workings (Figs 3, 4). Five boreholes will help characterise and monitor the environmental baseline by targeting the upper bedrock and the superficial deposits. A range of sensors such as resistivity and temperature cables and groundwater data loggers will be installed. Regular water samples will also be taken for geochemical analysis. In addition, there is one seismic monitoring borehole of around 200 m drill length at Dalmarnock (Fig. 4), which has recently delivered a borehole core. A new core-scanning facility at BGS Keyworth will be used to give a high-resolution geophysical, mineralogical, geochemical and optical/X-ray downcore record (see BGS 2018 for more detail).

Timescale

Drilling of the first phase of boreholes started in November 2018, with construction and testing expected to take a year or so. Subsequent to that and permissions for the installation of the heat pumps and above-ground infrastructure that will allow geothermal research, the research site will be open to the whole of the UK science community to undertake research, for a 15-year lifespan.

In 2019, the continuous data from the boreholes will be available and freely accessible to the public, government, regulators, academia, and industry via an online portal. Rock and fluid sample material will also be available for research and there will be limited early access to the observatory, including training opportunities for students to observe borehole drilling and sampling.

Future energy source

The high-resolution datasets from Glasgow's subsurface will provide a step change in understanding of low-temperature heat resources, balanced with their impacts on people and the subsurface to surface environment. Clearly the potential to develop our mining heritage as a future energy source is huge. The message that our abandoned mining infrastructure, which was so hard won, could provide a source of low-carbon energy for the future is a powerful one.

Charlotte Adams is Assistant Professor at Durham University; Alison Monaghan is science lead for the Glasgow Geoenergy Observatory at the BGS; Jon Gluyas holds the Ørsted/Ikon Chair in Geoenergy and CCS at Durham University

Drilling of the Glasgow Geoenergy Observatory seismic monitoring borehole at Dalmarnock in November 2018. Photo number P987021 BGS©UKRI

GIRLS INTO GEOSCIENCE: WHERE ARE WE NOW?

GiG
GIRLS INTO GEOSCIENCE


© Sarah Boulton

Jodie Fisher and **Sarah Boulton** argue that to retain women in STEM careers we first need to raise awareness and pique their interest during childhood

Women geologists. We've certainly come a long way since Martine Bertereau, the first recorded female mineralogist, who was imprisoned for witchcraft in 1642. In the last 100 years, women have been elected onto learned societies, taken positions as geologists in industry, at national surveys, and increased in numbers in academia. However, there is still work to do. Whilst we have greater understanding of what is needed to retain women in science, technology, engineering and mathematics (STEM) professions, and a variety of initiatives exist to tackle bias and inequality in the workplace, women still only make up 22% of the UK STEM workforce (2018 Workforce statistics; **https://www.wisecampaign.org.uk/statistics/2018-workforce-statistics/**).

A similar pattern is seen in the geosciences, and although the number of females undertaking geology degrees in the UK has risen to about 40 % of total student numbers over the last five years, we can still do more to challenge stereotypes within the Earth and physical sciences, to empower women to continue on into STEM careers, and to help retain women as their careers develop. But, in order to retain women in STEM, we clearly need to do something to get girls interested in the first place.

Addressing imbalance

To address the gender imbalance in geoscience, in 2014, we began Girls into Geoscience (GiG). GiG is an outreach initiative primarily based around an annual two-day event held at the University of Plymouth, and this year sees the 6th annual event taking place on July 1-2. Aimed at year 12 (aged 16-17) female students who are thinking about applying for university, we welcome all students who are interested in geoscience, from those who have studied geology, have some geological knowledge, or are completely new to the geosciences. On day one we offer an optional fieldtrip, to demonstrate that there are no barriers to female inclusion in the field. In 2016 and 2017, we visited Dartmoor National Park, and last year we headed to Torbay to find out about sedimentology and palaeontology. A day in the field introduces the students to the observation and description of geological materials and features, while giving the girls the chance to get a taste of fieldwork.

The second day consists of morning talks and afternoon workshops, with topics from across the geosciences. The talks showcase the range of geoscience career pathways that are possible from across industry and academia, and importantly provide role models for the girls. Speakers span the career spectrum, from early career to experienced scientists, and they talk about their unique journey to becoming Earth Scientists, as well as informing the students about the different disciplines and roles possible after graduation. The girls then network over lunch with the speakers, as well as with staff and female students studying the Earth sciences at the University of Plymouth. In the afternoon, an insight into the university experience is given through hands-on workshops, again across a range of geoscience topics.

Since 2014, 328 girls from schools across the country (Fig.1) have attended these two-day GiG events. Feedback from the girls and teachers has been fantastic. One student said, "Amazing event, would recommend to anyone thinking of a career in geoscience", while another commented "Lovely to get a hands-on experience with the different areas in geology, especially using real samples under the microscopes". Others appreciated the opportunity to network with likeminded girls: "I think it was really great to meet girls with similar interests to myself and all learning new things at the same time". ▶

Monitoring progress

This qualitative feedback has enabled us to adapt the fieldtrip, talks and workshops to the girls' interests. However, to properly monitor our impact on getting girls into geoscience over the last six years, further evaluation has been key. A post-event questionnaire on the day and a follow-up questionnaire to attendees a year later allows us to track the students through their university application process. These data have enabled us to fully monitor if, and how, attending GiG may have shaped girls' ideas about the geosciences, and establish if the girls have chosen to take a geoscience degree at university. These data are summarised in table 1. 84% of our 2018 attendees said they were more likely to consider the geosciences following GiG18, so we are looking forward to hearing from them later this year as we continue to monitor our impact on the progression of women into geoscience degree programmes.

These data show the significant impact that this event has had on university degree choices of the students. And it doesn't stop there. With our first attendees now graduating from university we are seeing them entering into their own careers, and it is wonderful to hear their stories. For example, Jessica Kitch from Bridgewater College in Somerset attended GiG2014, and following her graduation from the University of Plymouth is now working as a research technician on soil erosion in Latin America. Jessica is also part of the organising team of GiG19, sharing her experience with the next generation.

If you have attended one of our GiG events, and are now embarking on your own geoscience career or degree course, do get in touch, we'd love to hear from you!

Year	% more likely to consider studying geology following attending GiG	% going on to do geoscience or related degree course 1 year later
2016	75% (9% already intended to do so)	78% (55% response rate)
2017	61% (9% already intending to do so)	63% (39% response rate)
2018	84% (2% already intended to do so)	Watch this space….

Table 1: Summary of survey results showing the impact of attending GiG on studying geoscience at university, both immediately after the event and one year later.

Expansion

Since 2014, GiG has evolved and developed. Growing from a one-day event, to a network of girls, academics, teachers and industry geoscientists. We have seen the event become residential, include a fieldtrip and become international, with GiG Ireland joining the team in 2017 (holding 2 events in 2018, and the next taking place in Dublin in November 2019) and GiG Scotland scheduled to run for the first time this August at the University of Glasgow. We have been invited to provide editorials and articles for a number of geoscience journals and magazines, and were awarded the Geological Society's premier outreach award—the R H Worth Prize in 2018.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© University Plymouth

Social networking has also proven key in expanding the GiG network. Our Twitter account (**@girlsingeosci**) is successfully engaging potential attendees, female geoscientists and others keen on supporting women into the geosciences. We have 1,764 followers and regularly reach more than 5,000 people with our tweets. We have a blog (**https://girlsintogeoscience.wordpress.com/**) that has similarly affected people globally, with hits from more than 100 countries and over 6,500 visitors since 2016. In 2018, we also launched our ESRI (Environmental Systems Research Institute) Crowdsource Story map (**https://arcg.is/1SuO0i**), which saw more than 375 women globally show where geoscience has taken them, showcasing an inspiring range of field locations, geocareers, and role models.

Going forward

However, we realise there is still more we can do in order to break down the barriers that may exist to females when thinking about STEM subjects and careers. Many girls make their career choices by the time they are 14, and gender stereotypes about potential careers are set as early as the age of four, with seven-year-old's career aspirations being strongly shaped by gender-specific ideas about certain jobs (Drawing the Future 2018; **https://www.educationandemployers.org/wp-content/uploads/2018/01/DrawingTheFuture.pdf**). So, whilst we are promoting STEM and the geosciences to girls interested in knowing more, we may already be too late for many girls who have already ruled out STEM subjects.

Consequently, this year we are launching a secondary GiG event for year 8 and 9 girls (aged 12-14) to get these younger girls inspired by STEM and show them where the geosciences could take them. Linking with other universities (initially the universities of Leicester and Hull) we hope to develop a network of smaller hub events across the country, in turn feeding into the larger initiative and broadening our network. The University of Leicester will be holding the first 'Junior GiG' event in October, during Earth Science Week 2019.

GiG is growing, and following the launch of GiG Ireland, GiG Scotland, and international links with the American Association of Women Geoscientists, we are creating a multinational network for women in the geosciences. With additional links to professional bodies in the UK, and the promotion of our initiative at key events across the UK we are excited to see where GiG will take us in the future!

Dr Jodie Fisher and Dr Sarah Boulton are both at the University of Plymouth

ACKNOWLEDGEMENTS

We thank all the students, teachers, families, sponsors and GiG team members without whom these events would not be possible.

FURTHER INFORMATION

Booking is now open for both GiG19 at the University of Plymouth, 1-2 July 2019 (**bit.ly/1X5vbGg**) and for GiG Scotland at the University of Glasgow, 1 August 2019 (**bit.ly/2Vhrpiu**). GiG Ireland, 16 November at University College Dublin will be opening for bookings soon https://girlsintogeoscienceireland.wordpress.com/

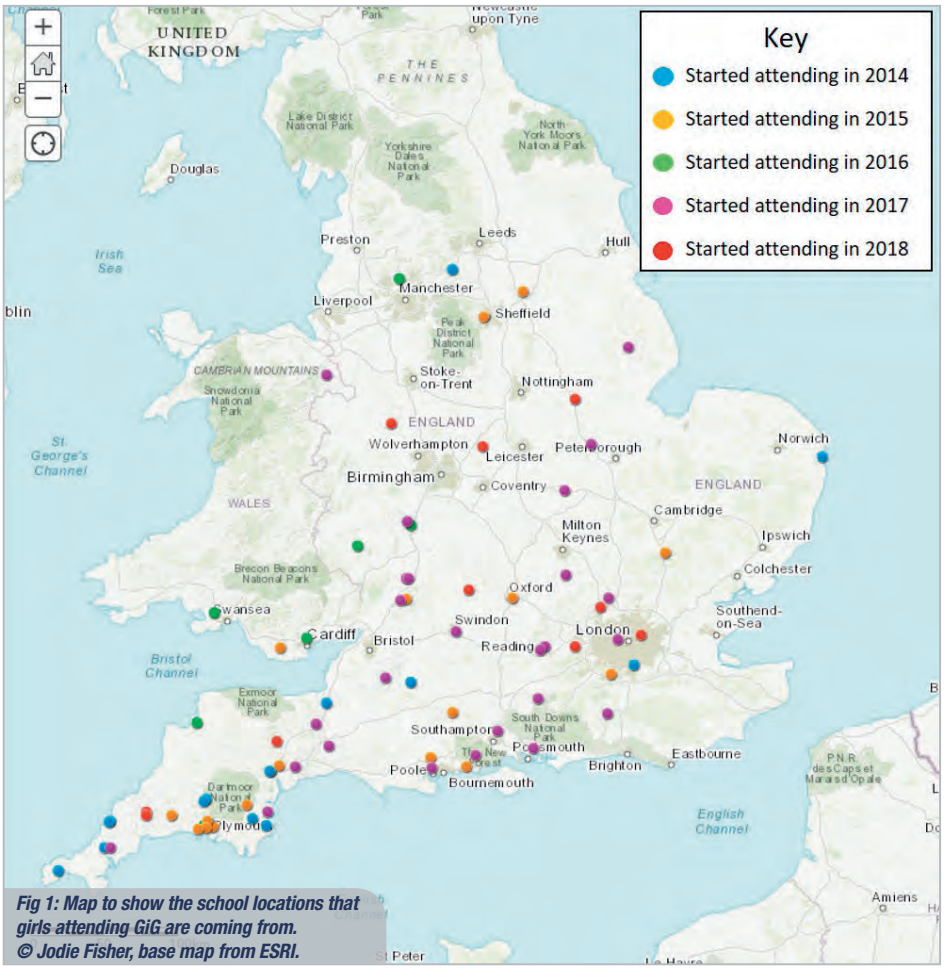
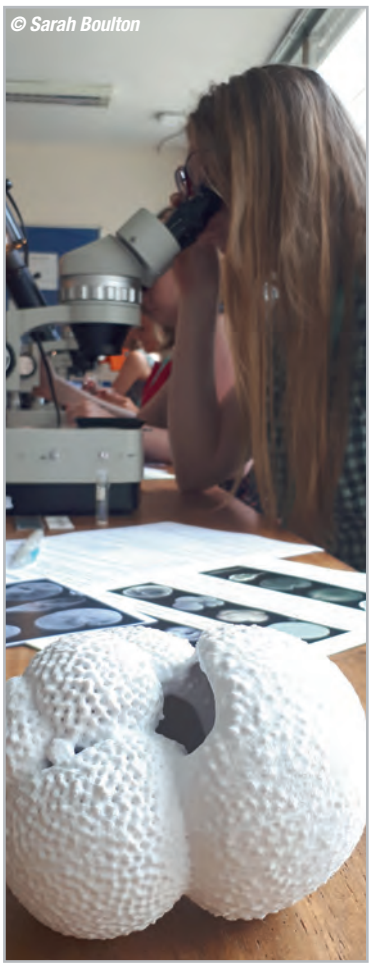


Fig 1: Map to show the school locations that girls attending GiG are coming from. © Jodie Fisher, base map from ESRI.



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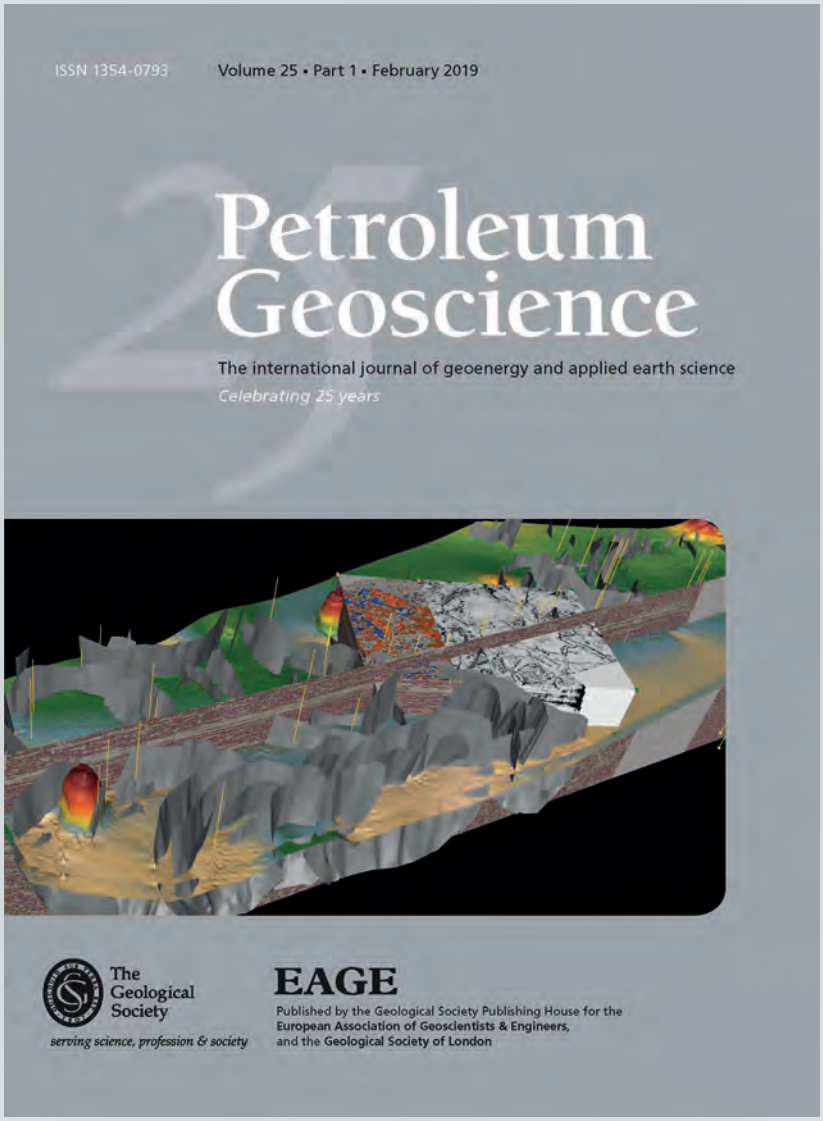
Celebrating 25 years of Petroleum Geoscience

The international journal of geoenergy and applied earth science



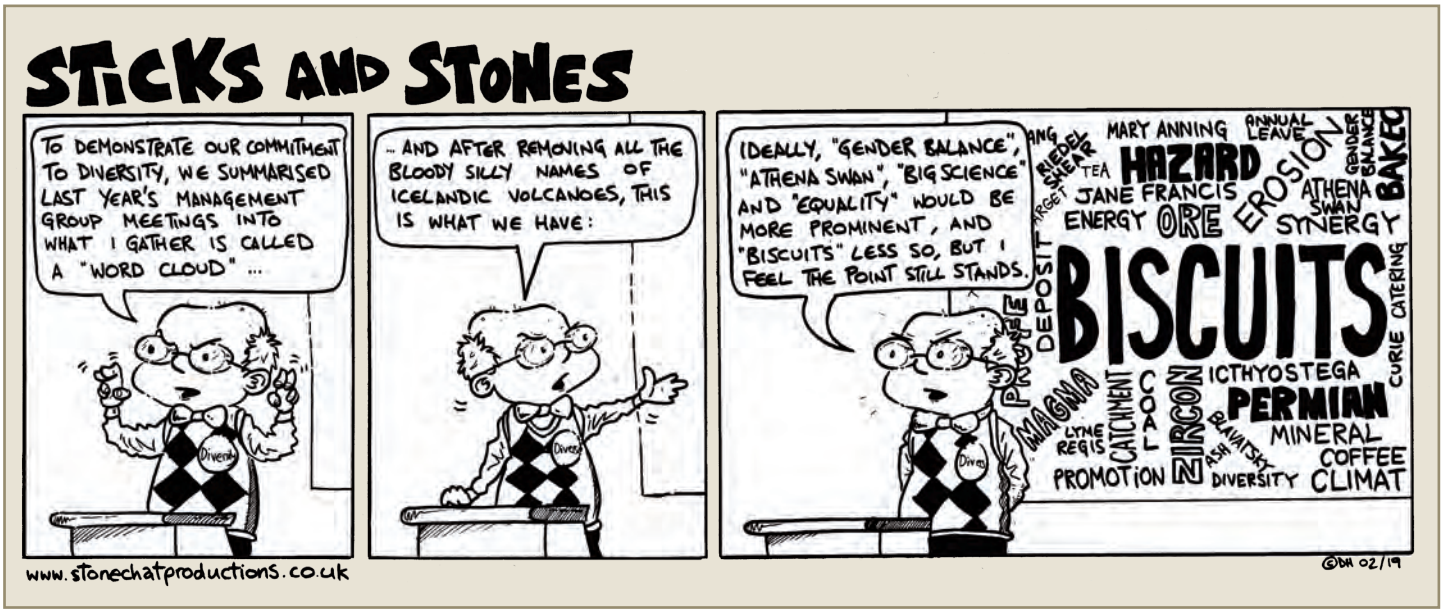
Petroleum Geoscience transcends disciplinary boundaries and publishes a balanced mix of articles covering exploration, exploitation, appraisal, development and enhancement of sub-surface hydrocarbon resources and carbon repositories. The integration of disciplines in an applied context, whether for fluid production, carbon storage or related geoenergy applications, is a particular strength of the journal. Articles on enhancing exploration efficiency, lowering technological and environmental risk, and improving hydrocarbon recovery communicate the latest developments in sub-surface geoscience to a wide readership.

Celebrating our 25th Year by Philip Ringrose
https://pg.lyellcollection.org/content/25/1/1

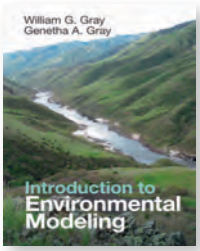
CAN'T FIND YOUR MEETING? VISIT WWW.GEOLSOC.ORG.UK/LISTINGS FULL, ACCURATE, UP-TO-DATE

ENDORSED TRAINING/CPD AND EVENTS

MEETING	DATE	VENUE AND DETAILS
Lapworth's Logs	n/a	Training. 'Lapworth's Logs' is a series of e-courses involving practical exercises of increasing complexity. **Contact:** Michael de Freitas or Andrew Thompson (First Steps Ltd) **E:** office@firststeps-geo.co.uk (mention Lapworth's Logs as the subject)
3rd International Critical Metals Conference	30 Apr-2 May	Conference **Venue:** Surgeons Hall, Edinburgh **W:** www.minersoc.org/3rd-international-critical-metals-conference.html
The Hydrogeology of the Superficial Deposits	1-2 May	Conference **Venue:** Burlington House, London **E:** claire.howarth@mottmac.com **W:** www.hydrogroup.org.uk/hydrogeology-of-the-superficial-deposits/
Geology of the Lakes: An Introduction	3-5 May	Endorsed CPD Course, Field Trip **Venue:** Higham Hall College, Cumbria **E:** annettemcgrath@aol.com **W:** www.geolsoc.org.uk/Higham-Hall-Lakeland-Rocks_intro_May19
GeoWeek 2019	4-12 May	Field Trip, Geology Walk, Lecture, Open Day **Venue:** Multiple **W:** www.bgs.ac.uk/geoweek/
Petroleum Geology of Mexico and the Northern Caribbean	14-16 May	Conference **Venue:** Burlington House, London **E:** sarah.woodcock@geolsoc.org.uk **W:** www.geolsoc.org.uk/PG-Mexico-and-Northern-Caribbean
A Centenary Celebration of the First Female Fellows of the Geological Society of London	21 May	Conference **Venue:** Burlington House, London **E:** sarah.woodcock@geolsoc.org.uk **W:** www.geolsoc.org.uk/HOGG-Female-Fellows-Event



Introduction to Environmental Modeling



While being described as an introduction, this book is pitched at upper-level undergraduates and masters-level graduates in the field of environmental modelling. It is aimed at readers with limited modelling experience, but with an understanding of mathematics (in particular calculus and differential equations) and environmental scenarios.

It is written in the form of a textbook (it is based on university courses) with questions placed throughout, which are designed to allow the reader time to reflect on the concepts described as they are covered. More detailed questions at the end of each chapter provide an overview of the material. The aim of the summary questions is to promote debate in group discussions, which would work well in tutorial settings, where the non-unique nature of the answers could be explored in depth. These may not work so well for individual readers, and the lack of solutions to either the summary questions, or the other "in-text" questions, could be a drawback for self-learners. The solutions are available online, but access is limited to lecturers who might wish to adopt the book for a particular course. In this respect the book would be an excellent set textbook for a university modelling course, particularly as additional extra material is also provided online.

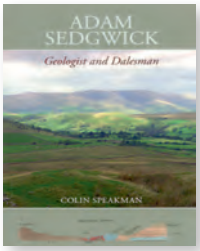
With the above in mind, the book is extremely useful in gaining an understanding of environmental modelling. It is well written and logically structured, with each chapter building on the previous. The introductory chapter sets out the expectations and limitations of the book clearly, giving it context in the larger environmental modelling field. This section also provides examples of poor modelling practice, before introducing better alternatives. The book then proceeds through the fundamentals of environmental modelling, from conceptualisation through derivatives and integral theorems, to the conservation of mass and momentum. It finishes with some specific modelling examples, such as flow in porous media and groundwater systems. Figures and flow diagrams are used throughout to effectively explain complicated mathematical problems.

This could be a very dense tome on what could be a relatively dry subject, but the authors succeed in making it accessible and engaging, with interesting anecdotes and footnotes. More difficult concepts are explained through analogies, which even with an American slant can be appreciated by all. The authors' creative side also comes through, showing that environmental modelling requires some artistic flair, as well as an understanding of the mathematical equations and processes.

Reviewed by: ***Fiona Todd***

INTRODUCTION TO ENVIRONMENTAL MODELING
by William G. Gray & Genetha A. Gray, 2017. Published by: Cambridge University Press 435pp. ISBN: 9781107571693
List price: £44.99 W: https://www.cambridge.org/core/books/introduction-to-environmental-modeling/3335425998504E02F2051A07D4DCB923

Adam Sedgwick—Geologist and Dalesman



Adam Sedgwick [1785-1873], Woodwardian Professor in Cambridge from 1818 until his death in 1873, and one of the pioneering geologists in the 19th century, became a geologist almost by chance. As Sedgwick himself noted when he applied for the Woodwardian professorship, "I knew very little indeed of geology – just enough to know that it was a glorious and healthy field in which I might find ample enjoyment and better health." But once elected as Woodwardian Professor he took his new role to heart, saying "hitherto I have never turned a stone; henceforth I will leave no stone unturned." It was a promise he kept for the rest of his long life.

In this book, a reprint of a book first published in 1982, Speakman, a fluent writer and poet with a passion for, and deep knowledge of Yorkshire, focuses on a number of the highlights of Sedgwick's life in a series of 12 related chapters—any one of which could be read as a separate essay. As the book reveals, from humble beginnings in Dent in Yorkshire, Sedgwick went on to become a lifelong Cambridge don, but he never forgot his rural Yorkshire roots. Although several of the chapters specifically focus on Sedgwick's geological achievements, Speakman is not a geologist. The book includes a very good bibliography and reference list, but it does not presume to present a comprehensive discussion of Sedgwick's geological achievements, or to serve as a scholarly scientific biography. Rather, it aims to highlight the many facets of Sedgwick's life. And it does this very successfully.

By drawing heavily on, and quoting from, Sedgwick's own writings about his background and lifelong love for the place of his birth—most notably from Sedgwick's own 'Memorial' (available to read for free on Google Books, and a great read in itself) Speakman really brings the personality of Sedgwick to life—and provides a fascinating picture of rural life in Yorkshire in the 19th century. All in all, it's a very enjoyable read that will appeal to geologists interested in the history of geology, local and social historians in Yorkshire and Cambridge, and all lovers of Yorkshire and its landscape.

Reviewed by: ***Nina Morgan***

ADAM SEDGWICK—GEOLOGIST AND DALESMAN
by Colin Speakman. Published by Gritstone Publishing in partnership with the Yorkshire Geological Society, 2018. 145 pp. ISBN 978-0-9955609-4-9
List price: £12.25
W: http://www.yorksgeolsoc.org.uk/book.php

The Continent of Antarctica

Many years ago, when the great explorers Captain Scott and Ernest Shackleton first stepped foot on the Antarctic continent it was all unknown. However, as the world developed and geological knowledge increased so did the exploration of this landscape, with maps being drawn up and ships traipsing through the icy seas.

When one ponders the wider world and the least explored continent on Earth, it may be a fantastic opportunity to pull

this book from your shelf and become immediately inspired. Written by Julian Dowdeswell and Michael Hambrey, this book is a beautifully illustrated and provides a special look into what the relativity unknown continent is like. The reader is taken through all aspects, from the geography, to the sea life, to managing and working on the relatively mysterious landscape.

The book is full of photos, each one excellent in quality, with some taking up a two-page spread so that the reader can really feel immersed in the surroundings. It also includes illustrations, such as maps and paintings, to aid the descriptions. The number of pictures is just enough to leave the reader wanting more, if they so desire, yet would satisfy a reader who may have simply wanted to know more about Antarctica.

Each chapter is detailed, covering not just the geology and perhaps encouraging a reader wanting to know more about the geological processes behind the continent to research further and find more detailed geological volumes. However, for someone who wants to know everything there is about this continent at an introductory level, it is the perfect book to read.

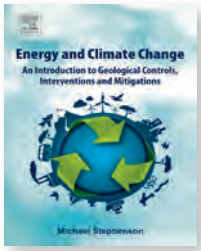
The book also includes anecdotes from each author about their time on the continent, relating to the chapter at hand and aided by pictures so that you're not simply reading a fact book about Antarctica, but a story that takes you there, wandering across the vast landscape yourself. The reader can imagine traversing the sea ice with your team to your base, whilst observing how animals interact from afar as waves crash against the coastline.

Antarctica is looked at from a global context down to the very details that make it what it is today. Dowdeswell and Hambrey draw from their own experiences, as well as those of their colleagues, putting everyone's collective enjoyment of such a fantastic untouched land into an awe-inspiring book.

Reviewed by: ***Eleanor Dunn***

THE CONTINENT OF ANTARCTICA
by Julian Dowdeswell & Michael Hambrey, 2018. Published by: Papadakis Publisher 298pp. (hbk.) ISBN: 9781906506643 **List price: £35.00**
W: http://papadakis.net/books/the-continent-of-antarctica/

Energy and Climate Change: An Introduction to Geological Controls, Interventions and Mitigations



This wide-ranging book starts by explaining how the carbon cycle links energy and climate change. It discusses the role of fossil fuels in the economy, examines some geological aspects of climate change impacts and mitigations, and concludes with the feedbacks and tipping points of both the Earth and energy systems. The author notes that his aim is to highlight the connections between the different topics, rather than provide in-depth analysis, and with such a range of topics covered in under 200 pages, the book can only provide a brief overview of each.

Geologically minded readers will be familiar with the first third of the book, and probably find the last third the most novel. The language and illustrations used assume more than a basic level of knowledge—the author does not shy away from scientific and technical language and makes extensive use of graphs and charts to demonstrate his points. Most graphs are from academic papers and some are hard to interpret for non-specialists.

Examples of climate change in the geological record, such as the Palaeocene-Eocene Thermal Maximum (PETM), are used to demonstrate both the potential scope of climate change and its impact on life. However, the author makes the important point that attempts to model future climate change based on geological 'deep time' do not produce results on a scale that is useful to planners or policymakers. More detailed projections, for example that forecast potential changes to the UK climate (warmer and wetter winters, hotter and drier summers), are based on climate models that are more akin to complex weather forecasting.

Meteorologists and oceanographers have benefitted from technological advances in sensing and monitoring to collect data to inform their models. The author suggests the development of a geological 'macroscope' is needed to gather data on the whole Earth system. Better data and measurements of subsurface processes would allow improved modelling of geological impacts, such as groundwater flooding, cliff falls and erosion.

Many existing books on climate change and renewable energy provide more detailed information, and popular science books covering the same issues may be easier to read, but this book offers the serious reader a good opportunity to learn about a wide range of connected issues, with supporting data. There is a bibliography at the end of each chapter for the reader interested in further research.

Reviewed by: ***Georgina Blair***

ENERGY AND CLIMATE CHANGE: AN INTRODUCTION TO GEOLOGICAL CONTROLS, INTERVENTIONS AND MITIGATIONS
by Michael Stephenson, 2018. Published by Elsevier 186 pp. ISBN: 9780128120217 (pbk.)
List price: £88.95.
W: https://www.elsevier.com/books/energy-and-climate-change/stephenson/978-0-12-812021-7

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- **NEW! Aeolian Geomorphology: A New Introduction**, by Ian Livingstone & Andew Warren (eds), Wiley Blackwell 2019, 318pp. hbk.
- **NEW! Paleozoic Plays of NW Europe** by A.A. Monaghan et al. (eds), Geological Society SP 471, 398 pp. hbk
- **NEW! The Encyclopedia of Engineering Geology** by Peter T. Bobrowsky & Brian Marker (eds), Springer 2019, 978 pp. hbk.
- **NEW! Water Harvesting for Groundwater Management: Issues, Perspectives, Scope, and Challenges** by Partha Sarathi Datta, Wiley Blackwell 2019, 203 pp. hbk.
- **NEW! Drought: Science and Policy** by Ana Iglesias et al. (eds), Wiley Blackwell 2019, 257 pp. hbk.
- **NEW! Reconstructing Archaeological Sites: Understanding the Geoarchaeological Matrix** by Panagiotis (Takis) Karkanas & Paul Goldberg, Wiley Blackwell 2019, 279 pp. hbk
- **Fluvial Meanders and their Sedimentary Products in the Rock Record** by Massimiliano Ghinassi et al. (eds), Wiley Blackwell 2019, 592 pp. hbk
- **Martian Gullies and their Earth Analogues** by S.J. Conway, J.L. Carrivick, P.A. Carling, T. de Haas and T.N. Harrisin (Eds), GSL SP467 2019, 434 pp. hbk
- **A Practical Guide to Rock Microstructure (2nd Edition)** by Ron H. Vernon, Cambridge University Press 2018, 431 pp. hbk

Outnumbered and surrounded: Women working in male-dominated research fields

Malin Kylander on the obstacles still faced by women in science and how we can tackle them

At one of the entrances to my department at Stockholm University, you will find a wall of portraits. These portraits are of the professors who have worked at our department since its beginnings in 1881. Among the portraits, you will find geology giants like Gerard De Geer and Lennart von Post, but you will not find a single woman. The reason for this is of course partly historical, and partly the rugged nature of the geology discipline. So, what challenges do women in male-dominated research areas face and what can we all do to increase the presence of women and other minorities in these fields?

Historical hurdles

During the early waves of feminism in the 19th century, women had to fight to get into both classrooms and voting booths. Sweden for example, only saw its first officially registered female university student, Betty Petterson, start in 1871 at Uppsala University. Women were barred from reading a number of programmes and were certainly not allowed to study for a higher degree. Even the first female professor in northern Europe, Sofia Kovalevskaya, who started at the Department of Mathematics at Stockholm University in 1884, had not been allowed to attend classes in her native Russia. Needing the permission of her father or husband to leave the country, she had a fictitious marriage and left for Germany where she attended classes by special permission or received private lessons. She finally completed her PhD *summa cum* laude at the University of Göttingen in 1874.

Women of the time were expected to be modest and ladylike, conditions that contrast with digging around in rocks and dirt. Mary Anning, the famous English palaeontologist, made a number of important fossil finds, but was often not credited for her work. Indeed, she was barred from the Geological Society of London because she was a woman. We can only imagine what a curious figure she would have been for her contemporaries, with her geology hammer and cumbersome skirts combing the seashore. If she had lived until 1888, she might have breathed a sigh of relief when the Rational Dress Society of London recommended that "the maximum weight of underclothing [for women] should not exceed seven pounds"[1]. It would appear that education, social constructs, and even clothing, slowed the rise of women in geology.

Our team from a peat sampling campaign in Sichuan, China in 2006 (author middle) is not atypical of a field campaign in geology, which remains a male-dominated discipline. ©Malin Kylander

Women in the sciences today

Geology remains a male-dominated discipline where challenging field conditions and hammers are more associated with the "lads" than the "ladies". The proportion of women completing PhDs in the geosciences has risen from 4% in 1974 to 40% by 2009. However, women hold just 13% of full professorial positions (US numbers for 2010-2011)[2]. The dearth of female professors in geology, and elsewhere in the natural sciences, could lead female students and junior researchers to wonder if there is a place for them in academics.

Hypotheses as to why women still haven't reached these top positions are many and can be linked to the individuals, the institutions in which they work, and the cultural baggage we all carry. In the geosciences many women leave academia between postdoc and assistant professor positions. Some women (and men) chose to leave academia due to their belief that they lack the traits required for research, for example, ambition, leadership and the ability to handle criticism. These losses could be minimized in a more supportive and encouraging environment. Others are faced with lifestyle choices, such as family or immobility due to a partner's job. In some countries, like Sweden, women are well supported by the social welfare system if they chose to have a family. Women working in countries without this type of culture may look to their institutions for such support and find it lacking. Institutions may not distribute resources (laboratory space, money) and tasks fairly, with "soft issues" like mentorship and administration belonging in the female realm.

What does the research suggest?

It is suggested that gender imbalances in the sciences will even out with time. A recent study looking at differences in productivity between men and women, a key parameter in promotion, shows however, that the much-lauded academic pipeline is still leaking. The study's authors, Peter van den Besselaar and Ulf Sandström, base their study on a database of 47,000 Swedish researchers covering 2008-2011[3]. Researchers were divided into seven different productivity

classes for different disciplines. They found that within the same productivity class, women and men generally had the same impact (i.e., citations). In certain male-dominated fields, such as geology, women even out performed men in terms of impact. There were however, significantly fewer women in the highest productivity class (32 papers or more over a four-year period). As a result, when looking at overall publishing rates, women are producing 67% of what their male colleagues do. This number is virtually unchanged from that reported for the 1960s (65%).

If the academic pipeline was really working, the productivity differences between the genders should have declined over the last half-century. The authors propose that women get stuck in a vicious cycle with lower academic positions and fewer leadership roles, which leads to less research money, visibility and impact, as well as diminished productivity. This prevents women from getting into that crucial top productivity category, further reinforcing gender bias in research, and keeping the proverbial glass ceiling in place. The lower status of women has been further confirmed by a recent examination of *Nature* articles between 2008 and 2016 where only 18% of the prestigious last author positions (i.e., research leader) were occupied by women[4].

Discrimination, harassment and unconscious bias

Women in academia also face barriers related to how we interact with each other. A positive outcome of the #metoo campaign is that awareness about direct discrimination and sexual harassment has increased, and moved it into an even more socially unacceptable place. Sexual harassment in field-based disciplines is common, with a reported 64% of women having experienced some form of inappropriate sexual behaviour, and just over 20% being victims of sexual assault when in the field[5]. In comparison to private and governmental sectors, women in academia reported higher rates of sexual harassment (58%), which was topped only by women in the military (69%)—both male-dominated fields[6]. It is perhaps not surprising that research shows that this leads to lower job satisfaction and lower retention of women in science[7].

Mary Anning, based on a portrait from 1842, and a painting of the first Plesiosaurus macrocephalus fossil, discovered by Mary Anning at Lyme Regis in December 1830. © The Geological Society of London

Even for those who actively work against discrimination and harassment, there are still a number of unconscious biases that need tackling. A well-cited example of unconscious bias comes from Corinne Moss-Racusin and co-workers[8]. People were asked to evaluate one of two CVs for a laboratory position with the only difference being the sex of the applicant. In comparison to the female candidate, evaluators, regardless of gender, consistently rated male applicants as more qualified, giving them higher starting salaries and more mentoring (although the female applicant was more "likable"). Examination of reference letters for postdoctoral fellowships showed that females were less likely to receive excellent letters versus good letters than male applicants and that letters were shorter in length, regardless of the gender of the referee[9]. There is also a tendency to use more "grindstone" (e.g., industrious, conscientious, dependable), rather than "stand out" terms (e.g., exceptional, amazing, magnificent) to describe women, which could limit their chances of winning prestigious positions[10].

One could link this language to cultural stereotypes of women in the western world. In general, women are expected to be nurturing and socially orientated, while men are expected to be achievement orientated and competitive. Studies have shown that men benefit more than women when they show altruistic behaviour in the workplace, since it goes against our unconscious expectations of men. Conversely, a woman who doesn't show altruistic behaviour is more heavily penalized than a man with the same behaviour, regardless of whether the person making the behaviour judgement was male or female[11]. In the same vein, women have been shown to experience a "co-author penalty". Men and women who produce single-author papers are as likely as each other to receive tenure, whereas women who co-author more papers are less likely to be given tenure than men who do the same[12].

Advantages of gender parity

We are facing a future shortage of people in the Science, Technology, Engineering and Mathematics (STEM) fields. As such, we cannot afford to exclude people based on gender, ethnicity, sexuality or religion. And we work better together. Diverse teams perform better than those comprised of only women or only men. The collective intelligence of the group exceeds that predicted by the individual IQ of the members. Both the groups' collective intelligence and equality in participation increased with the number of women in the group[13,14]. In contrast to people working in homogenous groups, ▶

Times have changed since Mary Anning's days and women don't shy from the field. Coring of lake sediments (with Joanne Muller, Florida Gulf Coast University and the author), peats (Jenny Sjöström and Mikaela Holm, Stockholm University and Richard Bindler, Umeå University) and ice (Sophia Hanson, Aarhus University) shown. © Malin Kylander

people working in groups with greater diversity (not just in terms of gender or expertise) tend to be better prepared. They don't necessarily expect to reach consensus as easily since they are not assured that the rest of the group will share the same opinions. Rather, there are more unique perspectives, information and experiences being shared. This leads to greater creativity and problem solving[15].

Levelling the field

So, what can we do on a daily basis to reach gender parity? Institutional leadership has been found to be important for improving workplace conditions for women, as it sets the tone for what is acceptable or not, particularly when it comes to sexual harassment. Women who described their departments as having good collaboration, cooperation, respect and collegiality had higher job satisfaction, productivity and felt influence[7]. Institutions can foster an inclusive environment by making sure everyone receives the same information through formalized channels of departmental communication. Expectations from the leadership can be made clear by having written codes of conduct, while assessment (e.g. for promotion) and recruitment processes should be transparent and involve gender-balanced panels.

We can all support minorities around us. If you are in a meeting and a female colleague is interrupted, redirect the conversation ("I would really like to finish hearing what Jenny has to say…"). If you catch a colleague condescendingly explaining to a woman something that she clearly knows (so called "mansplaining"), give them a nudge. If you are in a position to organize speakers, committees, teaching staff, etc., strive to have diverse representation of your research community. Mentorship can also improve a person's chance of staying in academics. Mentors can provide mentees with an outside perspective on their research process, introduce them to the unwritten rules of their research community, as well as provide extra encouragement, career advice and contacts. Five years ago, along with my colleague Agatha de Boer, we launched a mentorship programme at the Bolin Centre for Climate Research at Stockholm University, Sweden. This programme was open to everyone, regardless of rank or discipline. By and far the most requests we get are from junior female researchers asking for senior female mentors. As the saying goes, you cannot be what you cannot see.

For women, be seen. If you are given the chance to play a leadership role, take it. At meetings, sit where you can be seen and heard. For example, in Sweden, it is required that at least one member of a PhD examination committee is female. While nobody likes to be the token representative, I think of the women in the auditorium behind me—they see a woman where the decisions are being made.

Removing gender biases

We can help ourselves be more objective by removing some of the gender cues we unconsciously look for. In the world of music, the introduction of blind auditions for symphony orchestras in the 1970s can explain the 30% increase in the proportion of women being hired. While it may be hard to apply this model in the merit-based world of research, wherever possible when evaluating applications, project proposals and scientific publications, we should use double-blind reviews. Budden *et al.*[16] found that representation of female first authors increased 33% when double-blind review of manuscripts was used.

Awareness is the key to reducing gender biases, which are held by both sexes and unfair to men and women alike. The best way to achieve this in science is by using science. We have studies and data, just a handful of which are discussed above, that show women are at a disadvantage in the research world. We cannot be complacent and wait passively for the pipeline to do its job. We need to help women get up the academic ladder and lead the way for coming generations. To that end, I am pleased to say that our department installed its first female professor in 2007 with another two following in 2010, allowing all the women who follow to believe that we too can have our portraits placed on the wall.

End Note: This article is slightly modified from the original: Kylander, M. (2019, Jan). Outnumbered and Surrounded: Women Working in Male Dominated Research Fields: Women in Science. *Angle Journal*. Retrieved from http://anglejournal.com/article/2018-12-outnumbered-and-surrounded-women-working-in-male-dominated-research-fields-women-in-science-000128/ (Published under a CC BY-ND license). References are available online.

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DISTANT THUNDER

Beauty and Brains

Geologist and science writer Nina Morgan recalls the early attitudes towards female geologists

Many pioneering geologists depended on the encouragement and practical help of their wives and sisters to allow them to carry out their scientific investigations. In those early days, a number of women made important contributions to geological research on their own account. But, as the accomplished female palaeontologist Etheldred Benett [1775-1845] lamented in a letter to the English geologist Samuel Woodward [1790-1838] in 1836, 'scientific people in general have a very low opinion of my sex'.

Slow off the mark

Geologists, it seems, were particularly slow to formally recognise women's contributions to science. The Zoological Society of London, founded in 1829 and the Royal Entomological Society, founded in 1833, both admitted women from the word go. But the Geological Society, having begun life in 1807 as a 'little talking Geological Dinner Club', restricted its membership to gentlemen—initially to only those of a certain class—until the early 20th century. It wasn't until March 1919 that a resolution stating "That it is desirable to admit Women as Fellows of the Society" was put forward. This was passed with a majority of 55 to 12 and the first eight women Fellows were elected on 21 May 1919. But the Society did not elect its first female President, Janet Vida Watson [1923-1985] until 1982.

The Geologists' Association (GA), established in 1858 as an Association of Amateur Geologists, took a more liberal attitude and accepted women right from its start. Its Association Rule III (1858) reads: 'Ladies shall be eligible for election as members of the Association'.

But in spite of these fine words, more than 20 years after its founding, women were not considered entirely as equals in the modern sense. In his address at the Opening of the Session, 1880-81, Professor T. Rupert Jones [1819-1911] noted that:

"In one aspect particularly it is well that women should know Geology, for thereby they are enabled to sympathise with, and to understand man's work in this interesting and not always easy line of Scientific work and thought. One link the stronger between educated man and woman!"

Sign of the times

Sad to say, comments like this—however well meaning—demonstrate how little attitudes towards female geologists had changed since the beginning of the 19th century. In a letter dated March 16 1835 sent to William Buckland [1784-1856], reader in Geology at Oxford University, the publisher and author Joseph Cottle [1770-1853] detailed an 'amusing' anecdote about a caller who "brought his Wife with him, a portly Lady, who is no doubt consummately skilled in the profound science of Preserves &c". On being shown the bones of tigers, hyaenas and wolves, the wife apparently remarked "I can't think, Mr Cottle, all these things are half so pretty as shells!"

I am glad, concluded Cottle, "[that] you & Cuvier were not present. It would be worth an Oxford discussion to determine how many years it would take to make a Lady a Geologist."

Fear of flirtation

What lay behind this condescending attitude towards women amongst geologists? One reason, revealed in a letter from the then Geological Survey geologist and later Director, Jethro Teall [1849-1924], to Charles Lapworth [1842-1920], a graptolite expert and pioneer of faunal analysis, was fear of flirtation.

Writing in March 1889 to describe a discussion about whether women should be allowed to attend Geological Society lectures, Teall reported:

"We had some fun yesterday, but were beaten on all points. Ladies excluded by only three or four votes.

The anti-lady party had no arguments. Evans thought that the admission of young ladies might take off the interest of some fellows – lower the tone of the Society &c. In reply to this Hinde made the greatest point of the evening – he should object as much as Evans to anything tending to convert the G.S. into a Flirtation Society – but there was no danger – 'we are not attractive enough'.

A Gorilla-faced person got up and in the most solemn tones implored the fellows to pause before taking such an important step.

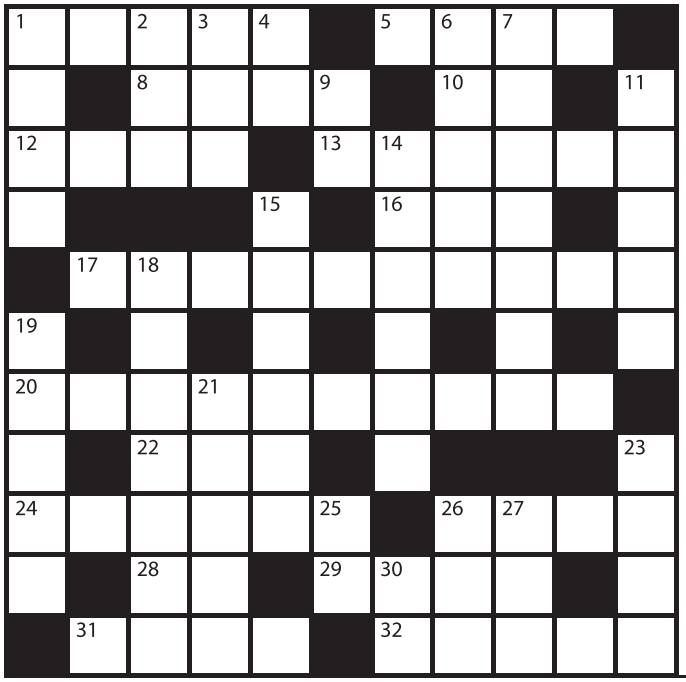
'Why', said he, 'the proposal is absolutely revolutionary'. This was too much for us and we absolutely roared. The person's face was a sight to see."

It's nice to know that at least some of the gentlemen of the Geological Society appreciated that beauty and brains are not mutually exclusive.

End notes: Acknowledgments and sources listed online

* **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

PEOPLE *NEWS*



GEO CROSSWORD

Across
1 City in Tanzania near crater Lake Ngozi (5)
5 Chops that sound like the inventor of the roller bit (4)
8 Maize dish from Southern Africa (4)
10 Clinkery lava... (2)
12 ...possibly from Brighton or Blackpool (4)
13 Edge of a plate as identified by 17ac (6)
16 Catalogue in which 14d is No 15795 (3)
17 Cartographer who identified the mid-Atlantic ridge (5,5)
20 1 Down... polymath, said to be the first scientist (10)
22 A 'cent' in Macau used in seismology? (3)
24 See 1 Down
26 A dry battery for example (4)
28 As in Capone or element 13 (2)
29 9th month of the Solar Hijri calendar (4)
31 A type of computer interface (4)
32 Bridget Riley made it (2,3)

Down
1/24 British palaeontologist (4,6)
2 Usually the top left key (3)
3 Talk about Himalayan bovid (3)
4 Element used in smoke alarms (2)
6 Soil the third planet from the sun (5)
7 Motacilla, perhaps originating during the Pliocene (7)
9 May? Or the element of fire (2)
11 Take a shot at a wader (5)
14 One corner of the summer triangle (6)
15 One ten-thousandth of a centimetre (6)
18 Annual catalogue of miscellany (7)
19 Tea from North East India (5)
21 Contents of a box left after Prometheus stole fire (5)
23 Horizontal mineral vein (4)
25 Half a lady, 2/3 of an oven, or the element of France (2)
26 Percussion, Dutch or 23d (3)
27 Geological time unit longer than a period (3)
30 Cross between 3d and a cow (2)

By Bindweed

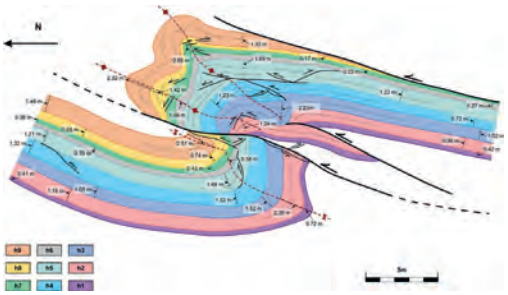
Solutions April| Across: 2 Buat **6** Weather ship **10** Rias **11** Abba **12** Caudal **15** IGS **16** Arctic Ocean **20** Tog **21** Ibidem **23** Haar **25** CBSO **27** Earthenware **30** Flor **Down: 1** Strait **2** Beachcomber **3** Ursa **4** As **5** Th **7** Ebb **8** Hi **9** Pilsner **11** Apatite **13** Die **14** Aga **17** Rob **18** CGI **19** Cahows **22** Echo **24** Air **26** Sn **28** RF **29** Tl

Latest news from the **Publishing House**

Broadhaven revisited: a new look at models of fault–fold interaction

By J. Cawood and C. E. Bond

Classic fold-thrust structures within Carboniferous-age strata at Broadhaven, SW Wales are well-known for their excellent preservation of Variscan deformation. These sites have been important for conceptual model generation of the link between faulting and folding, and are often cited as exemplars of fault-propagation folds following work by Williams & Chapman. Here we employ the virtual outcrop method to digitally map and measure, in detail, the classic Den's Door outcrop. 3D reconstruction of the site by digital photogrammetry allows us to extract high-density structural measurements, reassess the existing model of structural development for the outcrop, and re-evaluate the link between faulting and folding. We find that digital mapping highlights greater variability in fault displacement and bed thicknesses than previously documented. Fracture analysis shows that fracture intensity is closely linked to structural position and bed-thickness variability, and fracture orientations record the existence of discrete mechanical boundaries through the structure ...continue reading in the Lyell Collection ...



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The Best of *Geochemistry: Exploration, Environment, Analysis* Collection

This collection comprises 11 papers recently published in *Geochemistry: Exploration, Environment, Analysis* (GEEA). GEEA focuses on mineral exploration using geochemistry: related fields also covered include geoanalysis; the development of methods and techniques used to analyse geochemical materials such as rocks, soils, sediments, waters and vegetation; and environmental issues associated with mining and source apportionment. Published by both the Geological Society of London and the Association of Applied Geochemists, the journal encourages the exchange of concepts and data between exploration and environmental geochemistry; in particular, to differentiate various sources of elements.

➤ **View the Collection online now**
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OBITUARY John Veevers 1930-2018

John was born in Sydney in 1930. He won a scholarship to Sydney University where he majored in geology and agricultural chemistry, graduating with First Class Honours in 1951. While at university, he was awarded a Cadetship by the Bureau of Mineral Resources (BMR) that led to a summer job mapping the area of the forthcoming Snowy Mountains Hydro-Electric Scheme.

He joined the BMR in 1952, prospecting for coal in the Hunter Valley and mapping the Bowen Basin in Queensland. This formed the basis for an MSc from Sydney University.

Marine geology

Following a fire in the BMR's Canberra offices in 1953, John went to the Kimberleys to collect fossils from the Fitzroy River area. He took leave and, with those fossils and without pay, undertook a study of Devonian brachiopods at Imperial College London, and was awarded a PhD in 1956.

In 1957, John led the BMR Canning Basin party to the Great Sandy Desert in Western Australia. During a helicopter survey, he discovered a meteorite impact crater that later was named after him. John compiled a chart summarising the off-shore extension of the Canning Basin. That led to participation in Indian Ocean and Timor Sea cruises and the beginning of a strong interest in marine geology. John was awarded a Harkness Fellowship to work at the Scripps Institution of Oceanography in California, where he heard Bob Dietz's announcement of the recognition of seafloor spreading.

John joined the newly formed Macquarie University in 1968 and stayed there until his retirement. He spent much of his time researching the rapidly developing theory of plate tectonics. In 1971, he visited the Lamont-Doherty Earth Observatory in New York state to learn about seafloor magnetic anomalies and to gather seismic information about drilling sites in the Indian Ocean.

A pioneer of plate tectonic theory, John was characterised by focus and discipline throughout his career

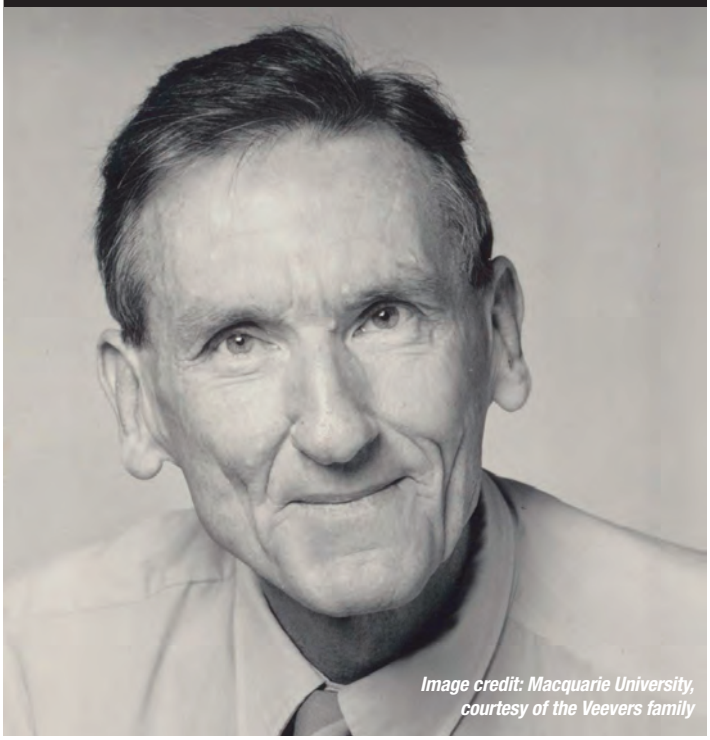

Image credit: Macquarie University, courtesy of the Veevers family

Syntheses

During the 1970s and 1980s, John participated in Deep Sea Drilling Project cruises to the Indian Ocean, one as co-chief scientist. This led to numerous publications on the geology of the oceans surrounding Australia and a grand synthesis, *Phanerozoic Earth History of Australia*, edited and partly written by John.

In collaboration with Chris Powell and others, John published extensively on the geology of Gondwanaland and tectonic supercycles, culminating in 2000 in another grand synthesis: *Billion-year earth history of Australia and neighbours in Gondwanaland*.

Honours

In 1992, he received a Special Investigator Award from the Australian Research Council and won the S W Carey Medal of the Geological Society. In 1995, John's outstanding contribution to science was honoured by election to the Fellowship of the Australian Academy of Science. John thought of himself as a "general practitioner", but he researched thoroughly, read voraciously and always kept in mind the big picture.

John "retired" in 1998 (and was made Emeritus Professor), but continued his research. His final paper, on the Antarctic subglacial Gamburtsev Mountains and East Gondwanaland, was published in 2018.

John was a brilliant and very productive scientist, but he had other interests, particularly classical music, art, films and rugby. He was a devoted family man, his wife accompanying him on much of his fieldwork, sometimes with their children in tow.

John is survived by his wife, Erica, and his children, Tom, Kirstina and Elisabeth, and fondly remembered by his seven grandchildren.

By Malcolm Walter (using notes compiled by John Veevers and with the assistance of his family and Dr Richard Flood). This obituary is modified from the original version by Malcolm Water, reprinted with kind permission from the Geological Society of Australia, *The Australian Geologist*, December 2018

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 Amy Whitchurch at the Society.

OBITUARY Aubrey Manning 1930-2018

Professor Aubrey Manning, OBE, FRSE zoologist and broadcaster, was born on April 24, 1930. He died from cancer on October 20, 2018, aged 88. Aubrey was a zoologist of considerable distinction, specialising in animal behaviour. He was educated at Strode's School in Egham, at University College London, and then at Merton College, Oxford where he completed his DPhil under Niko Tinbergen.

He joined the University of Edinburgh as an assistant lecturer, held the Chair of Natural History from 1973-1997, and thereafter became Professor Emeritus. His main interests were animal behaviour, development and evolution, and he authored "An Introduction to Animal Behaviour". He was involved with the Centre for Human Ecology from its inception at the University of Edinburgh in 1970. In 1997, a gallery in the Natural History Collection of Edinburgh University was named in his honour.

Earth Story

The hugely popular television series "Earth Story" was a milestone in the engagement of the public with modern Earth science. To get Aubrey to present this series was inspirational. He was the proxy for every viewer who wanted to ask a question but didn't know quite what to ask. "Earth Story" opened to viewers the exciting story that we geologists take for granted; the emergence of that amazing paradigm Plate Tectonics! He recalled to me interviewing some of the people who contributed to the concept, not least Marie Tharp who, with Bruce Heezen, mapped out the Mid-Atlantic Ridge in the 1950s. He said that for a biologist "it was like talking with Darwin"!

More than just an excellent zoologist; Aubrey was in every sense a natural scientist with an infectious curiosity about the world around us—a true polymath

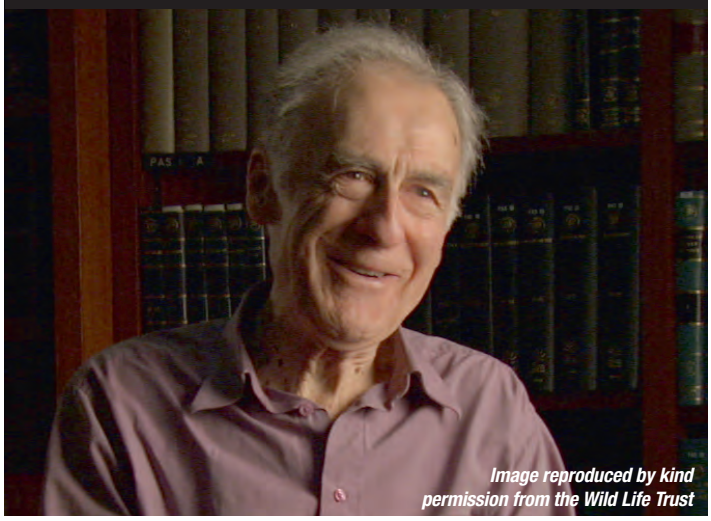

Image reproduced by kind permission from the Wild Life Trust

The English Geologist

Bill Bryson, in his "A short history of nearly everything" referred to Aubrey as "the English geologist" and we in the Geological Society of London were delighted to make that right by electing Aubrey an Honorary Fellow in 2009. Aubrey relished the company of geologists. He was a great supporter of the Society and a Goodwill Ambassador for the "Year of Planet Earth".

Aubrey went on to present other television and radio programmes. I have fond memories of a day out with Aubrey looking for graptolites for the radio programme "Sounds of Life". His enthusiasm for all aspects of the natural world was boundless—we spent as much time looking at birds as we did the graptolites. He was of immense assistance to Dr Sandy Crosbie and me as we put on paper the scientific story for Dynamic Earth, the Edinburgh science centre focusing on Earth and environmental science.

Passionate about the role of humanity and its relationship with the natural world, Aubrey had a life-long concern about an ever-expanding population and its influence on nature. He was not afraid to address controversial issues, including how genetically modified crops and nuclear energy might be necessary for the long-term sustainability of the planet. Aubrey expressed his arguments clearly and cogently, with a respect for others' views.

As a teacher, he was inspirational. Generations of students remember him with boundless affection. His ability to excite and enthral put him in constant demand as a speaker. All he came in touch with left with a new understanding of the natural world and some of Aubrey's concerns for its future.

Numerous obituaries document Aubrey's many contributions as a zoologist, television presenter and teacher. Here it is a privilege to document what he has done for Earth science. Aubrey will be fondly remembered by all whose lives he touched but especially by his wife, Joan and his three sons.

➤ By Prof Stuart K Monro, OBE, FRSE

The full version of this obituary appears online. *Editor*

The Society notes with sadness the passing of:

Barber, Peter Marriott
Barnes, Barry *
Blanche, James Bruce
Bott, Martin Harold Phillips
Bradshaw, Reginald
Broecker, Wallace *
Burke, Kevin Charles Anthony *
Butler, Raymond John Thomas *
Clayton, Keith *
Cooke, Herbert Basil *
Cornes, Barbara Charlotte *
Dobson, Margaret *
Herries-Davies, Gordon L *
Huckerby, John Andrew *
Ireland, Richard *
Jobbins, Alan *
Kempton, Nicholas Hugh
Manning, Aubrey
Moores, Eldridge *
Simpson, Ian Morven
Westhead, Robert Keith
Whyatt, Stephen John *
Whitham, Andrew Gordon

In the interests of recording 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 amy.whitchurch@geolsoc.org.uk to be commissioned.

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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NCS Exploration 2019

Recent Advances in Exploration Technology

DAY 1

The Next Technological Breakthrrough
Derisking the Petroleum System: How to Integrate Technological Innovations in the Work Flow
Exploration Innovation Prize
Imaging: Present and Future of Seismic Acquisition on NCS
Imaging: Examples from Regions with Complex Geology

DAY 2

Big Thoughts/Big Data
The Petroleum System
Imaging of Injectites
CSEM – Fortunes and Misfortunes
The Exploration Forefront

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