GEOSCIENTIST

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The Fellowship Magazine of the Geological Society of London

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FORGOTTEN SCANDIUM

Pete Siegfried and colleagues discuss potential new sources of this miracle metal

STRATEGISING MINERALS
The UKMS as an antidote to ignorance

DOWN THE RABBIT HOLE
Hannah Gow reports on sinkholes in Ripon

A GEOLOGIST AT WAR
W.B.R. King and the value of geology in the war effort

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Career and Industry Days 2018/19

Wednesday 7 November 2018
Venue: Our Dynamic Earth, Edinburgh, UK
www.geolsoc.org.uk/careersday18edinburgh

Wednesday 14 November 2018
Venue: BGS, Keyworth, Nottingham, UK
www.geolsoc.org.uk/careersday18nottingham

Wednesday 20 March 2019
Venue: Royal School of Mines, Imperial College London, UK
www.geolsoc.org.uk/careersday18london

The Geological Society Career & Industry Day is an essential meeting place for geoscience students and the geoscience industry, and is the most recognised geoscience careers focused forum in the country.

The day will include short career and industry presentations covering different areas of geology and academia, and there will be an exhibition consisting of industry and professional bodies, and higher education institutions promoting MSc and PhD programmes. There will also be a CV and careers workshop running alongside the talks.

Registration
This event is free to attend but there are limited numbers so pre-booking is recommended. Delegates will be required to pre-register to receive a student manual, free packed lunch and free drink at the drinks reception.

Contact Information
Rhianna McLean, Conference Office, The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: 0207 432 0981
E: rhianna.mclean@geolsoc.org.uk

Follow these events on Twitter: #GSLcareers18

Background image: Assynt, © Timothy Gregory

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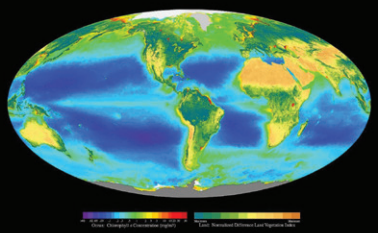
Earth System transitions

How resilient is the biosphere?

17-18 January 2019 | The Geological Society, London



Convenors

Dr Susan Canney (Oxford)
Professor Tim Lenton (Exeter)
Professor Graham Shields (UCL)
Professor Paul Valdes (Bristol)
Professor David Waltham (Royal Holloway)
Professor Paul Wignall (Leeds)
Dr Ying Zhou (UCL)

Further information

For further information please contact:
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T: 0207 434 9944
E: georgina.worrall@geolsoc.org.uk
Web: www.geolsoc.org.uk/biosphere19
Follow this event on Twitter: #biosphere19

The Geological Society, London

Earth System Science special interest group

Biosphere Evolution, Transitions & Resilience (NERC research programme)

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

The four main themes of this meeting are:

- **Earth system transitions: the Precambrian**
- **Earth system transitions: the Palaeozoic Era**
- **Earth system transitions: the Mesozoic and Cainozoic eras**
- **How resilient is the biosphere – key notes and discussion.**

Call for abstracts

We welcome oral and poster abstract contributions for this meeting. To be considered for a slot in the programme or a poster presentation, please send an abstract of no more than 500 words to georgina.worrall@geolsoc.org.uk, no later than Friday 30 November 2018.

The Geological Society

Call for meeting proposals

The Geological Society invites meeting proposals for 2019 and 2020 to be held at Burlington House, London.

For more information please visit
www.geolsoc.org.uk/meetingproposal-submit

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2019 YEAR OF CARBON

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Geoscientist is the Fellowship magazine of the Geological Society of London

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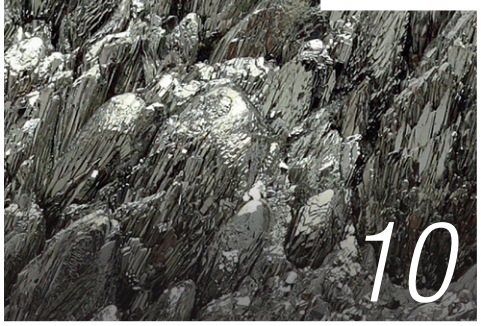

ON THE COVER:
10 IN SEARCH OF THE FORGOTTEN RARE EARTH
Could we be on the cusp of a scandium boom?

FEATURES

REGULARS

ONLINE SPECIAL

THE 111TH BIRTHDAY OF THE LATE DOROTHY HILL

Douglas Palmer on Australian palaeontologist, Dorothy Hill, her PhD research at Cambridge University with Gertrude Elles, and her work on coral faunas and biostratigraphy

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Call for Abstracts: 14 December 2018

Celebrating the life of Chris Cornford (1948-2017)

Petroleum Systems Analysis 'Science or Art?'

24-25 April 2019

The Geological Society, Burlington House, London

Approaches to tackling the scientific and practical questions in the fields of Petroleum Geochemistry and Petroleum Systems Analysis range from the entirely theoretical to the empirical. Chris Cornford embraced both in his working life. The integrated approach he espoused will form the basis of the technical programme for the Conference covering two themes:

- Recent developments in the use of data including integration of models and (big) data; use of visualisation and data exploration or mining techniques.
- Topical issues & controversies ranging from mass balance approaches, petroleum migration to specific modelling studies and practical applications.

The Conference will be inspired by Chris' ethos of innovation, encouragement of youth and challenging received wisdom.

Call for Abstracts:

Please submit abstracts for oral and poster contributions that cover any of the above themes to sarah.woodcock@geolsoc.org.uk before 14 December 2018

For further information please contact:

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG.
Tel: +44 (0)20 7434 9944 or email: sarah.woodcock@geolsoc.org.uk

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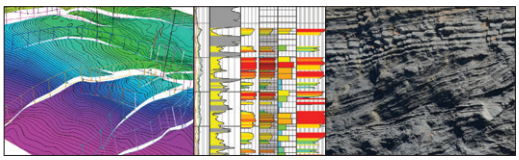
Call for Abstracts – Deadline: 29 March 2019

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.

Call for Abstracts:

Please submit talk or poster abstract to sarah.woodcock@geolsoc.org.uk by 29 March 2019.

For further information please contact:

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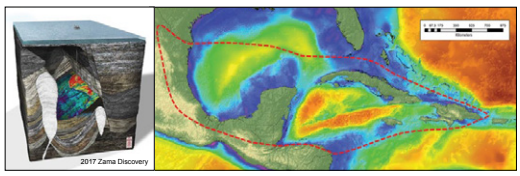
Call for Abstracts – Deadline: 30 November 2018

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.

This regional conference aims to bring together both academic and industry geoscientists together to discuss the current state of understanding of the geology and petroleum systems in these geologically complex, but prolific hydrocarbon basins.

The committee now invite submissions of abstracts along the following themes

- Regional Plate Tectonic Evolution
- Basins of Mexico and the Northern Caribbean
- Onshore Basins and the Laramide and Chiapas Fold Belt effects
- Petroleum Systems
- Exploration & Production History
- Neogene Clastic Depositional Systems
- Carbonate Depositional Systems
- Salt Tectonics
- Controls on hydrocarbon habitat – seal capacity
- Relevant GOM Analogues

Call for Abstracts:

Please submit talk or poster abstract to sarah.woodcock@geolsoc.org.uk by 30 November 2018.

For further information please contact:

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Keynote Speakers:

A diverse set of keynote speakers are being solicited from across the community

Call for Abstracts – Deadline: 1 December 2018

Hydrocarbons in Space and Time

9-11 April 2019

The Geological Society, Burlington House, Piccadilly, London

The global endowment of hydrocarbons is markedly uneven both spatially and temporally. In the 1990s, several key papers recognised that distinct stratigraphic and paleogeographic trends exist and that this knowledge was an important guide to successful exploration. So, what has changed in 30 years?

The industry has moved into new frontiers and basins, drilled deeper, found new plays and gone through a revolution that has brought unconventional resources to the fore. It is therefore timely to consider how our knowledge of the distribution of hydrocarbons in time and space has changed. What new insights have we gained? Can this new understanding be used to be better at predicting new hydrocarbon discoveries?

This 3-day conference will seek to share recent advances and case studies and will be built around four main themes:

- The known global heterogeneity of hydrocarbon resources – including source rocks
- The controls on heterogeneity – including palaeoclimates and geodynamics
- The geological and data science tools to aid prediction
- What our present understanding means for future exploration

Event to be accompanied by a post-conference field trip to the Wessex Basin.

For further information please contact:

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG.
Tel: +44 (0)20 7434 9944 or email: sarah.woodcock@geolsoc.org.uk

For Abstract Guidelines, please download a copy from the website:
https://www.geolsoc.org.uk/PG-Hydrocarbons-in-Space-and-Time

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RISING POLITICAL TENSIONS HIGHLIGHT THE NEED FOR SECURE MINERAL SUPPLIES. THANKFULLY, NUMEROUS ACADEMIA AND INDUSTRY LED INITIATIVES ARE UNDERWAY

FROM THE EDITOR'S DESK:

Diversifying supply

In mid-September, the US-China trade conflict intensified when the Trump administration slapped new tariffs on $200 billion worth of Chinese imports. In a turnaround from earlier reports, rare earth elements (REE) were spared. The omission highlights China's monopoly on the rare earth market. The US, like Europe, relies heavily on China for their supply of REE, which are used in smart phones, laptops, electric vehicles and wind turbines, as well as in military defence technologies.

It is essential to diversify REE supply. Interestingly, a rich source of REE may exist in a common waste product—coal ash. By burning coal for electricity, the US alone produces tens of millions of tonnes of coal ash annually. Much goes to landfill or is stored in open containment ponds, yet this waste product can contain REE with concentrations 100 times higher than found naturally. Attempts to extract the REE have so far proved too costly, but new research (Das et al., *Journal of Cleaner Production* **189**, 539-551, 2018) reports on a method to extract REE profitably, using supercritical carbon dioxide and a chemical, tributylphosphate, that forces the REE to clump together. Tributylphosphate is incredibly expensive, but if the coal ash contains high concentrations of REE, and particularly scandium, the most expensive REE, the process could be economically viable—and could provide an additional income stream for the waning coal industry.

The prospect of repurposing old waste to extract scandium is touched on in a feature by Pete Siegfried and colleagues on page 10 of this issue. In reviewing the various sources of this important element, they note that scandium concentrates in red muds—the waste products of aluminium processing. Like coal ash, tens of millions of tonnes of red mud waste are produced annually. Major European initiatives, such as SCALE and the Red Mud Project, are underway to research REE and particularly scandium recovery from red muds. There is scope to diversify REE supply and contribute to the circular economy in the process.

In addition to REE, construction minerals are vital for an improved standard of living. Geopolitics shouldn't be a major issue for the UK: our diverse geology provides a ready, indigenous supply of construction minerals. But, as argued by Nigel Jackson on page 16, Government ignorance may compromise supply because they fail to link the delivery of housing and infrastructure that underpins economic growth to the need for secure mineral supply. To combat this, the industry has launched the UK Minerals Strategy, which aims to galvanise action and ensure supply of over 5 billion tonnes of minerals and mineral products for the next 25 years.

Experts from academia and industry are on the case, but secure mineral supplies should not be taken for granted.

Ash waste produced by burning coal at a power plant. Image credit DuxX/Shutterstock.com

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

SOCIETY *NEWS*

What your society is doing at home and abroad, in London and the regions

Christmas and New Year closure

The Society (London and Bath) will close at 14.00 on Friday, 21 December, re-opening at 09.30 on Wednesday, 2 January 2019.

Research Grants

Applications are invited for the 2019 round of the Society research grants. Please complete the form, which can be downloaded from the Society Awards and Research Grants page at **www.geolsoc.org.uk/grants** where you will also find information about all the grants.

The Research Grants committee meets once annually. Applications must reach the Society no later than **12 noon on 1 February 2019** and must be supported by two Fellows of the Society who must each complete a supporting statement form. The committee will only consider complete applications on the appropriate form.

The Royal Commission for the Exhibition of 1851

The President of the Society is an ex-officio Commissioner of the Royal Commission for the Exhibition of 1851. Applications are open for their various awards, including Research Fellowships. For further information please go to: **www.royalcommission1851.org/awards/**

CRM project update

As Fellows are no doubt aware, the Society has been implementing a new membership management system (CRM) for some time. By the time you read this, phase 1 of the implementation should be live and online for your use. As is often the case when introducing new technology and integrating with existing platforms, the implementation has been a challenge and the delivery is somewhat later than originally envisaged.

Among the immediate benefits you will see will be improvements to the Fellowship renewals process, online management of CPD and a new online chartership application process. We hope you find the changes helpful and we welcome any feedback you have, good or not so good, to **crm@geolsoc.org.uk**.

Email Issues

In recent weeks, there have been increasing incidences of spoofing and phishing emails purportedly originating from The Geological Society. Email spoofing is the forgery of an email header, giving the impression it originates from persons in the Society and phishing is the fraudulent attempt to obtain sensitive information by various means. Often, both spoofing and phishing emails contain malware designed to compromise the recipient's computer or seek to have the recipient divulge sensitive information.

These emails do not originate from the Geological Society though they appear to do so. The first and best line of defence is to make sure you run good anti-malware software that is kept up to date. A second line is to always exercise caution when opening attachments. These types of emails tend to be plausible, so we recommend Fellows take a moment to consider whether it is an email you are expecting and whether the content is what you would expect from us. We have taken additional security measures to further combat this modern plague and will continue to adopt best practice where appropriate.

PUBLIC LECTURE SERIES

The role of geosciences in International Development

Speaker: Martin Smith, BGS
Location: Burlington House, London
Date: 21 November

Programme

- **Afternoon talk:** 14:30pm 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). Due to popularity, tickets are allocated in a monthly ballot and cannot be guaranteed.

Contact: **Sarah Woodcock,** The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: +44 (0) 20 7432 0981 E: **receptionist@geolsoc.org.uk**

Council & OGMs

OGMS: 2018: 28 November **2019:** 6 February, 3 April
COUNCIL: 2018: 28 November **2019:** 6 February, 3 April

GSDG Programme: 2018

The Geological Society Discussion Group meets at 18.30 for 19.00, when dinner is served. Attendance is open to all members of the Society. For up to date information concerning topics for discussion and speakers, please go to **W:** bit.ly/2DXiM8G

- Wednesday 5 December—Athenaeum, Mayfair

For information and reservations, contact Sarah Woodcock
E: sarah.woodcock@geolsoc.org.uk

Diversity, equality and inclusion, and the Society

In recent years, the Geological Society has taken many positive steps to expand on its commitment to Diversity, Equality and Inclusion (DEI), with the aim of making the geoscience community as welcoming and inclusive as we know it can be. George Jameson provides an update.

Declaration signed

Our first step on this journey was in 2014, when the Society became one of the original signatories to the Science Council's Declaration on Diversity, Equality and Inclusion. The declaration committed member bodies to be proactive and improve opportunities for all individuals who wish to fulfil their scientific potential, irrespective of their background or circumstances, thus helping to attract the widest possible talent into science, technology, engineering and mathematics (STEM) careers and ensuring a greater diversity of scientific ideas, research and technology.

We carried out an extensive review of our communications and attempted to better understand the demographics of our Fellowship with the introduction of our Diversity, Equality and Inclusion Survey. The survey aimed to identify real and/or perceived barriers to inclusion, guiding us on where to direct resources to make the Society and Earth science community more inclusive, and providing a baseline to track our progress.

Framework

In 2016, the Science Council and the Royal Academy of Engineering collaborated to develop a Diversity and Inclusion Progression Framework. We took part in a trial run, feeding back our experience and helping to fine-tune the process before it was officially launched in 2017. The specially created framework aims to help organisations to plan, track and assess progress in eight main areas of work: Governance and leadership; Membership and registration; Meetings, conferences and events; Education and training, accreditation and examinations; Prizes and awards; Communications, marketing and publicity; Employment; and Monitoring and measuring.

The Society was one of 21 scientific bodies to participate in the benchmarking exercise, along with 20 professional engineering institutions. The findings of this report are available in a link in the online version of this article.

The Science Council and Royal Academy of Engineering brought together their respective scientific and engineering professional bodies in a steering group to address the findings and recommendations from the report. Four subgroups are now considering these in more depth, focusing on communications and language; developing better measures; extending use of the framework; and sharing of resources.

Working with others

Our work to advance inclusivity is not limited to signing a declaration and participating in a Progression Framework. We work in partnership with other key organisations who specialise in specific strands of Diversity and Inclusion work. Some of the more visible organisations include:

International Association of Geoscience Diversity (IAGD): An Associated Society founded in North America in 2008 as an advisory group that raises awareness of improving access, accommodation, and inclusion for students, faculty and geoscientists with disabilities. In 2015, the IAGD came together with others at Burlington House for the 'Confronting Barriers to Inclusion' event—a very successful and informative day highlighting the advancements the Earth sciences is making, especially around fieldwork.

Diversity in Geoscience UK (Dig-UK): The recently established UK chapter of the IAGD, DiG-UK aims to expand the mission and vision of the IAGD while focusing specifically on the needs, values and resources in the UK. Dig-UK held their launch event at Burlington House in June 2018, focussing on key themes of mental health, advocacy and leadership for supporting diversity.

Athena SWAN: Originated as a national charter mark in 2005 to recognise commitment to advancing women's careers (and men where appropriate) in STEM employment throughout Higher Education. Since 2017, The Society has facilitated workshops offering guidance and opportunities to share best practice for Earth Science Departments submitting for an award.

WISE: This year the Society joined the WISE Campaign, which provides expertise and support to organisations seeking to improve gender balance issues. WISE recently launched 'People Like Me' a fantastic project breaking down gender stereotypes and showing that anybody can be a part of the STEM community.

APPG on Diversity in STEM: The Society is involved with the All-Party Parliamentary Group on Diversity and Inclusion in STEM. Established by the British Science Association, it aims to improve outcomes for people from diverse backgrounds in STEM. Recent meetings have focused on education and skills, the Industrial Strategy and regional disparities.

Updating policies and procedures

Over the past year, we have undertaken positive strides, while recognising that much remains to be done. The Society was part of the AGI ad hoc Committee on Harassment in the Geosciences and is currently developing our own version for the Society and its affiliated groups and networks. We have a new Equal Opportunities Statement and we will to review our Professional Code of Conduct very soon, so watch this space.

Images

Top: A recent Access Anglesey Geological Field Trip (led by co-founder of DiG-UK)
Bottom: Previous GSL Executive Secretary, Edmund Nickless, and Council member, Natalyn Ala, signing the declaration

Newly Chartered Fellows

CGeol: Alexander Blake, Finlay John Booth, Thomas Anthony Cash, Paul John Joseph Daily, Jonathan Mark Davey, Alexandra Elisabeth Flint, Christopher Rhuairdh, John Gell, Graham Paul Goffey, Charlotte Laura Gwilliam, David Samuel Hinxman, Daymion Teifion Jenkins, Matthew John Lennard, Kam Hung Hazel Lo, Timothy Daimon New, Katherine Overy, Shaun Paul Paterson, Philip Ian Patterson, Geoffrey George Pook, Daniel Frederick Riding, Richard John Sorapure.
CSci: Neil William Chalmers, Andrew Michael Kelleher.
EurGeol: Simon Eden, Mike Lelliott, Christopher Thomas Dodge

Eligibility to apply for Chartered Geologist

In line with the Engineering and Science Councils and other professional institutions, the Geological Society now requires a Master's degree qualification as evidence of eligibility to apply. Those with degrees at Bachelor level only will be required to produce evidence of knowledge to the equivalent of Master's level, through the submission of Supporting Documents.

Correction

In September's *Geoscientist*, Bill Gaskarth explained why the Society has decided not to offer CEng, mentioning that the IMMM was opposed to the proposal. This statement was made in error and he apologies to the IMMM for this. Those opposing the proposal had canvassed the IMMM for support, but the institution has not publicly stated its opposition.

FROM THE LIBRARY

New e-journals

The Library can now provide Fellows with offsite online access to the following journals:

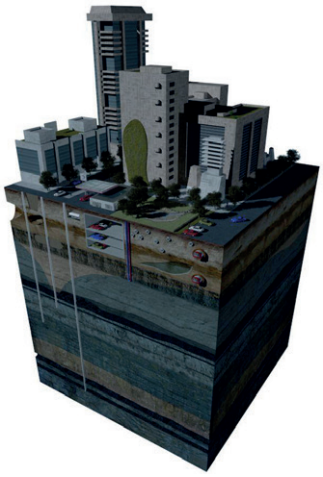
- Canadian mineralogist
- Journal of sedimentary research
- Journal of vertebrate paleontology
- Monograph of the Palaeontographical Society
- Palaios

Visit the Virtual Library E-journals webpages to apply for an 'Athens' login and for further details of all the Library's e-journals.

Latest news from the **Publishing House**

Jenny Blythe has the latest from the Geological Society Publishing House

Humankind, in its technological development, is increasingly utilizing both mineral resources from Earth's interior and developing the rock mass as a resource in itself. In this paper we review the types of anthropogenic intrusion, at different depth ranges, that can modify the physical structure and chemistry of the subsurface. Using examples from across the world, but with emphasis on the UK, and physical models of the induced modifications, we predict what kind of subsurface signatures a geologist of the future might recognize as anthropogenic, including boreholes, tunnels and caverns, waste and resource storage facilities, mineral workings and military test traces. The potential of these anthropogenic signatures to be discriminated from natural analogues is discussed against known or modelled processes of deterioration and transformation over geological timescales of millennia or longer.



Recognizing anthropogenic modification of the subsurface in the geological record By Colin N. Waters, Caroline Graham, Deodato Tapete, Simon J. Price, Lorraine Field, Andrew G. Hughes and Jan Zalasiewicz

➤ **Read full abstract and paper in the Lyell Collection**
http://qjegh.lyellcollection.org/content/early/2018/09/19/qjegh2017-007

The onset of the Quaternary (2.58 Ma) corresponds to significant paleo-environmental events, such as the intensification and southward extension of Northern Hemisphere glaciation. In the North Sea Basin a significant late Cenozoic succession has been identified as a high-resolution archive of paleo-environmental changes during the Pliocene and Pleistocene. However, the identification of the base of the Quaternary has been a long-standing issue owing to lack of stratigraphic calibration. This study incorporates continuous, regional 3D seismic data with high-quality chronostratigraphic markers to map the base-Quaternary surface at high resolution across the entire North Sea. Depth conversion, backstripping, seismic geomorphology and sedimentation rate calculations are integrated to analyse the paleogeographical evolution of the North Sea Basin and its infill of c. 83 × 103 km^3 of northward prograding marine to deltaic sediments. The basin is 600 km long from SSE to NNW and largely localized above residual topography of the Mesozoic graben system. During the earliest Quaternary (2.58–2.35 Ma) paleo-water depths were c. 300 ± 50 m and solid sedimentation rates (calculated from 0% porosity) c. 32 km^3 ka^{-1}. The base-Quaternary provides an important marker for further studies of the changing environment of the Quaternary of NW Europe as well as resource and shallow geohazard analysis.

The early Quaternary North Sea Basin By Rachel M. Lamb, Rachel Harding, Mads Huuse, Margaret Stewart and Simon H. Brocklehurst

➤ **Read more here** http://jgs.lyellcollection.org/content/175/2/275

Once a geologist, always a geologist

The Big Bang Theory may not classify geology as a science, but **John Gilbey*** begs to differ, arguing it is 'science plus'

We geologists often spend time walking, looking down, in the open air, in the real world. Understanding what it is that we are standing on is a rare gift not available to everyone or every discipline. Geology requires a unique and open way of thinking.

Transition

Aged 11, my interests were astronomy, science fiction and dinosaurs. I went on to study geology at university and spent a second-year field position working with Falconbridge Nickel in northern Ontario. Following a spell at the Ghana Geological Survey, I undertook post-graduate research on gold mineralisation in Wales. My interests in mineral exploration were crystallised, my career direction was clear.

Base-metal mineralisation experience in Yorkshire, Australia, The Netherlands, Canada and Guinea gradually led me from geologist to exploration manager to other managerial roles. But, working with teams of very talented geologists in the field and even in head offices ensured that my overriding interest in geology remained. Eventually, I became president of a US corporation mining the largest bauxite deposit in the world, but even this could not eclipse my love of geology. My geological background enhanced my management skills, imparting a clear vision of issues, from all angles, without bias.

Retirement?

Geologists interests continue and grow. Reading the article on Earth's Crustal Thickness (*Geoscientist*, August 2018) reminded me once again that I remain hooked.

Following my early retirement from business, I was able to give back to the community in ways that were not possible while living on three continents, five countries and in countless houses and tents, for 23 years. The fundamental nature of a geologist's brain, combined with the approaches learned during years of project management mean there are still useful roles for retired dinosaurs like me.

What to do?

Professional geology and management are a useful combination of abilities. Using these skills, I've helped teams build facilities from small to very large—tennis pavilions in Toronto and Canterbury, and a flint-walled village hall in Kent, built on time and to budget. I've served as a magistrate and become a councillor and successfully lead council for eight years.

I will remain a geologist with wide geological and non-geological interests. Working in the geosciences creates a network of like-minded friends across the globe. I recently revisited friends in Jackson Hole, Wyoming. We toured the geological wonderland, of Yellowstone and the Tetons, having great conversations on topics from astronomy to algal net development and the provision of free oxygen on our planet! I have excellent debates with my son, who is also a qualified geologist working on base metals and gold exploration.

Regardless of whether you end up as a professional geologist, studying geoscience provides you with transferable skills, a passion for learning and a broad interest in the natural world that lasts a lifetime.

John Gilbey is a retired geologist;
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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?

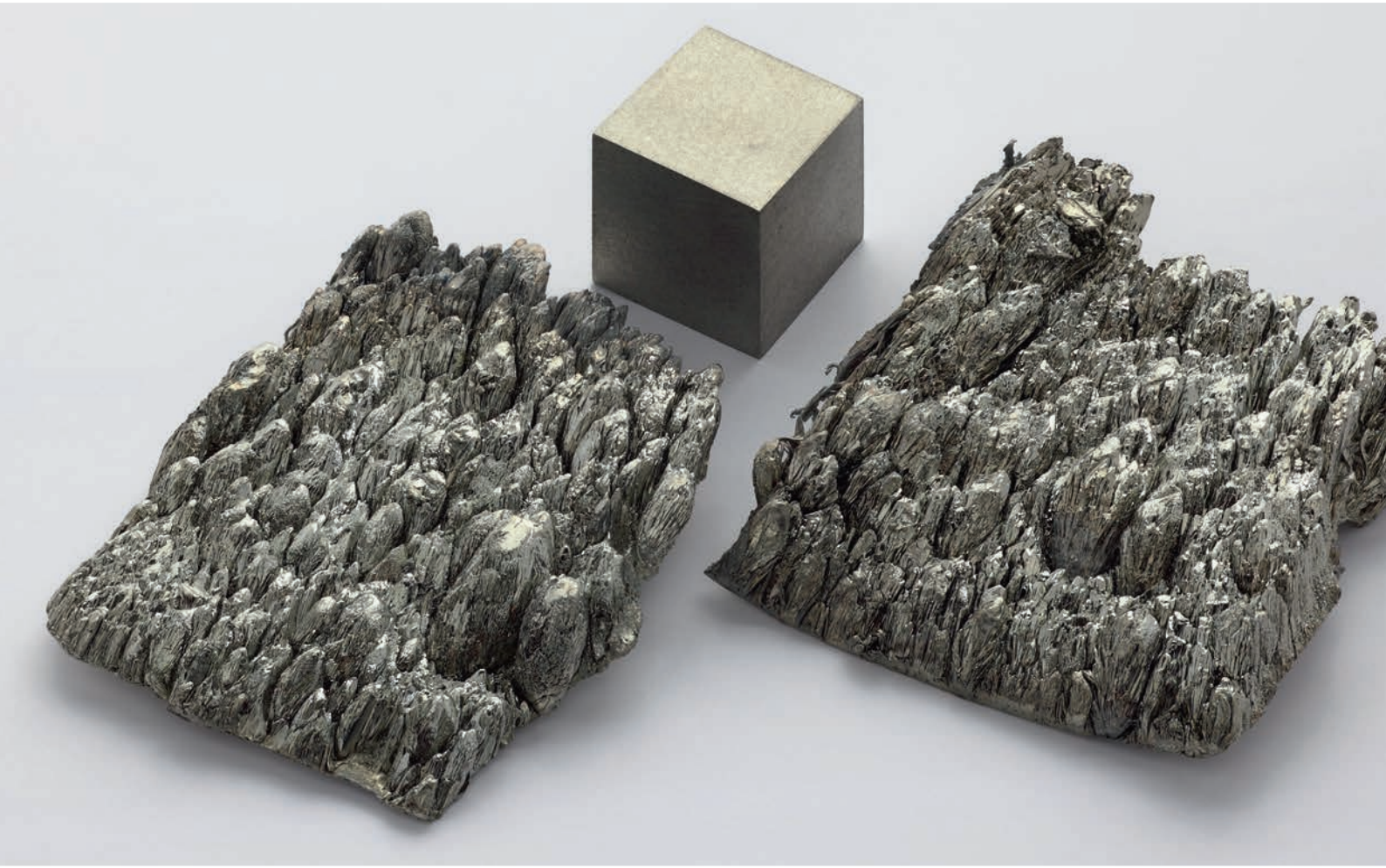
If you can write it entertainingly in **500 words**, the Editor would like to hear from you. Email your piece, and a self-portrait, to **amy.whitchurch@geolsoc.org.uk.** Copy can only be accepted electronically. No diagrams, tables or other illustrations please.

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).

> "STUDYING GEOSCIENCE PROVIDES YOU WITH TRANSFERABLE SKILLS, A PASSION FOR LEARNING AND A BROAD INTEREST IN THE NATURAL WORLD THAT LASTS A LIFETIME
>
> **JOHN GILBEY**

IN SEARCH OF THE FORGOTTEN RARE EARTH



China and Russia currently monopolise the global supply of scandium. **Pete Siegfried**, **Frances Wall** and **Kathryn Moore** examine the distributions of scandium globally and identify a number of promising targets that could help diversify supply

Scandium (Sc) has been called a 'miracle metal'. When alloyed with aluminium, it produces super-strong but lightweight materials, just right for use in the next generation of aeroplane manufacture and other high-tech applications. By definition, Sc is a member of the 17-strong, rare earth element (REE) family. Like the other REEs, Sc isn't actually rare in terms of distribution—it can be found throughout Earth's crust and has a similar abundance to lead —but unlike lead, economic concentrations of Sc are very rare, making it one of the most expensive elements in the world. Indeed, concentrations of Sc are usually so low that Sc is often excluded from geological assessments of REE—it is the forgotten rare earth.

But this may be about to change. Several research groups are turning their attention to Sc, using new data from exploration projects to identify a number of promising sources that could be mined. Here we discuss the behaviour of Sc and the distribution of these deposits worldwide. We argue that with improved understanding of how Sc associates with clinopyroxene and how it concentrates within weathering and waste products, such as laterites and red muds, these newly identified deposits could create a virtuous circle of raw materials supply and new high-tech uses.

Why Scandium?

The manufacturing industry requires a wider range of specialist raw materials than ever before, especially for digital and green technologies. In this context, Sc is used in solid oxide fuel cells, lasers,

> CURRENT INTEREST IN Sc IS DRIVEN MAINLY BY PROJECTED USE IN THE AEROSPACE INDUSTRY. Al-Sc ALLOYS ARE STRONG, LIGHT AND WELDABLE

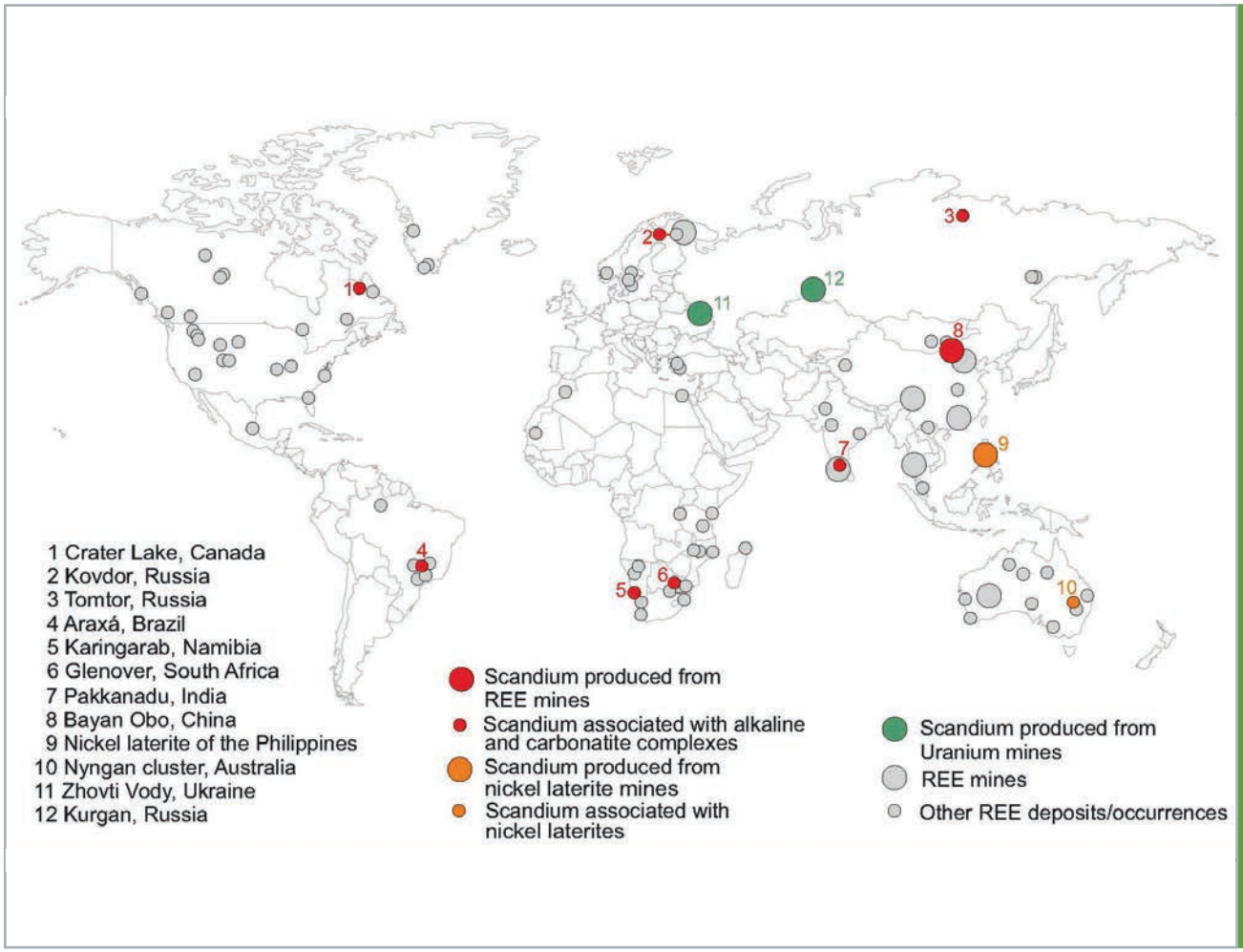


Fig 1: Sc mines and deposits compared with REE mines and deposits (courtesy of the British Geological Survey)

ceramics, neutron screens, lighting, high-specification sports equipment and amelioration of the glare from spotlights.

Current interest in Sc is driven mainly by projected use in the aerospace industry. Al-Sc alloys are strong, light and weldable. They have been used for years by NASA and the Federal Space Agency, where price was no problem, so have been tried and tested. Only tiny amounts of Sc are needed for alloys, which then create lighter, more fuel-efficient aircraft and cars. These are not only cheaper to run, but emit less CO_2, helping nations achieve long-term emission targets set by policy makers. If a ready supply were available, Sc could revolutionise the aerospace and automotive industries.

Although potentially revolutionary in terms of its applications, global demand for Sc is currently small, at around 10-15 tonnes annually, according to the United States Geological Survey. Sc exists in such low concentrations that it is difficult and expensive to extract, hampering use in commercial applications. But, this is something of a chicken-and-egg scenario. There is no shortage of applications for Sc, so if reasonably cheap and assured supplies of Sc become available, more applications will be found and demand will increase.

Sc is mainly produced as a limited by-product of conventional uranium and nickel extraction processes. The main producers of Sc are China, Russia, Ukraine, and the Philippines (Fig. 1), and production in Russia and China is thought to be accelerating. In particular, there are ongoing plans to considerably increase Sc production from waste dumps at the Bayan Obo mine in China, which will serve to strengthen China's monopoly of the whole rare earth market.

In contrast, there are currently no known, economically viable, large-scale Sc resources in the USA or western Europe, and many companies are dependent upon Sc single-sourced either from Russia or China. Such lack of diversity in supply could lead to economic issues if the current supplies are jeopardized—an increasingly likely scenario, given current political tensions surrounding Brexit, the US and Europe, and China, leading to a fear of future global trade wars. A trade dispute relating to the export of REEs occurred in 2010, for example. Low labour costs and more lax environmental restrictions meant China could more easily and cheaply produce REE than other nations, and they became the world's dominant supplier. In 2010, the Chinese ▶

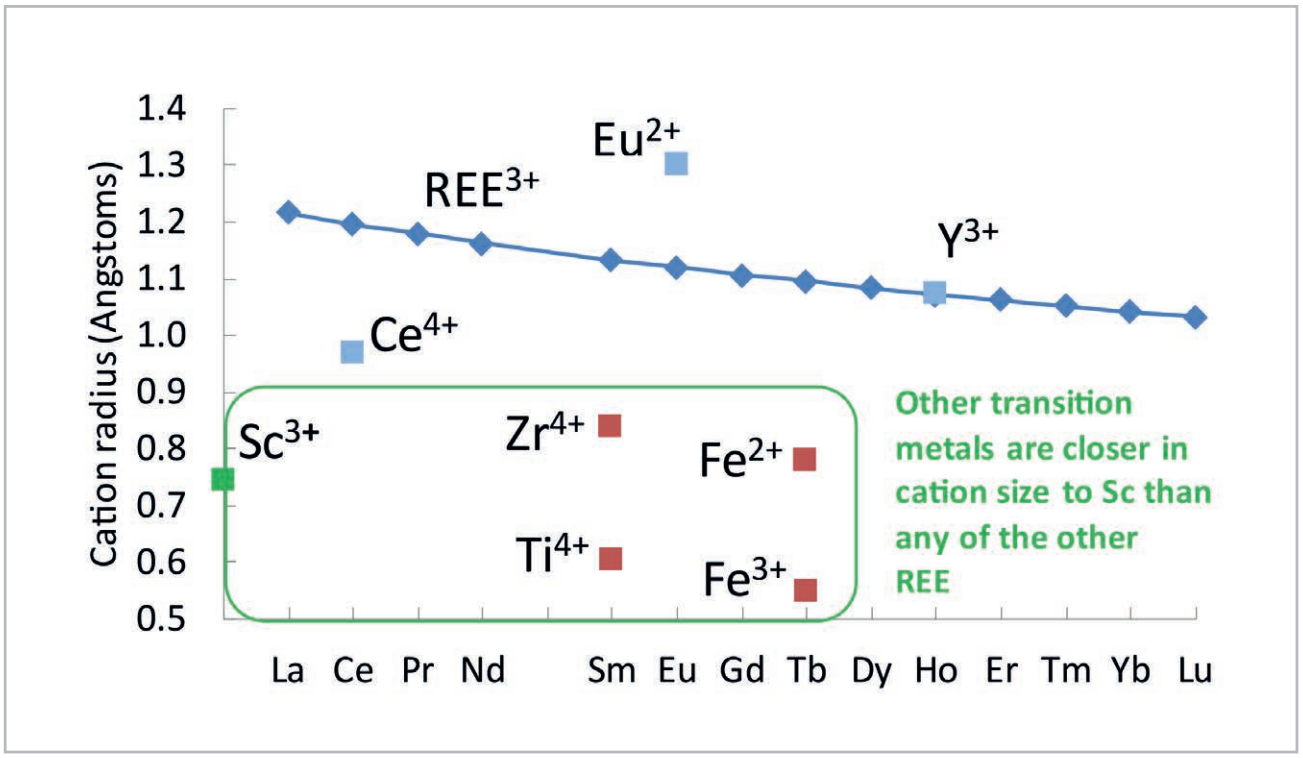


Fig 2: Plot of REE atomic number vs. cation radius. Sc3+ is not part of the 'lanthanoid contraction' (REE3+ cations decrease in size as atomic number increases), it is much smaller than the other REEs and closer in size to transition metals, such as Ti, Fe and Zr (included here in arbitrary positions on the x axis). Cation radii from http://abulafia.mt.ic.ac.uk/shannon/radius.php?

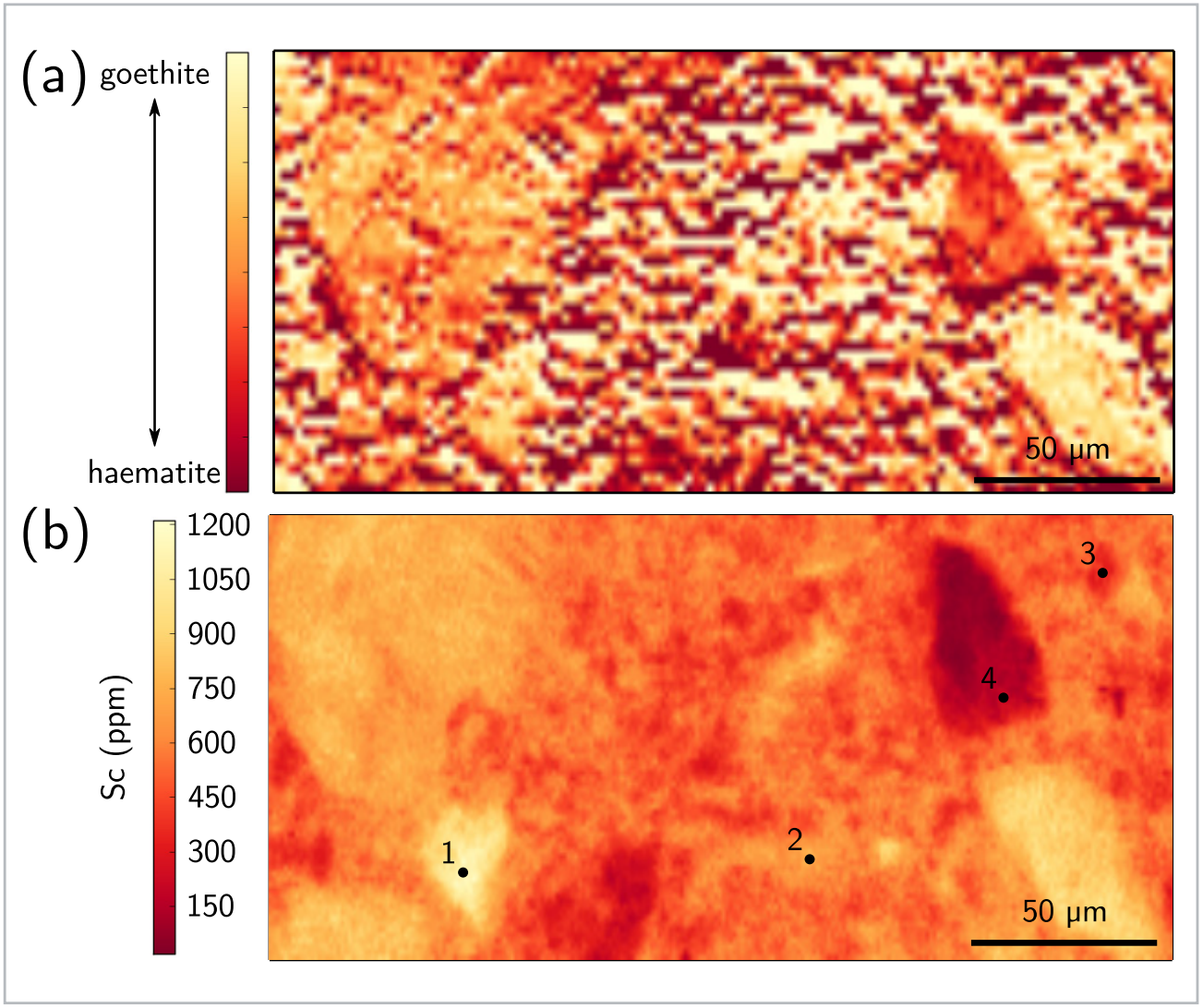


Fig 3: Maps of the oxidation state of iron, interpreted as goethite and hematite (a) and distribution of Sc (b). Maps made by Mathieu Chassé et al. (2016) using synchrotron µ-XRF and used to propose that Sc is mainly hosted by goethite in the Syerston–Flemington Ni-Co laterite deposit. (Credit: Chassé et al, 2016, Geochemical Perspectives Letters 3, 105-114; under Creative Commons Attribution 4.0 License)

▶ government reduced its export quotas by 40%, arguing that this was needed to protect the environment. REE prices outside of China soared. China finally dropped the export quotas in 2015 following a ruling from the World Trade Organisation that the restrictions violated trade regulations. But the dispute was a wake-up call, a reminder of the need for secured supply of essential elements, particularly in Europe. And several projects are currently underway. One is the SCALE EU project (**scale-project.eu/scandium**), which aims specifically to develop a stable and secure European supply chain for Sc using bauxite and titania acid wastes that can serve European aerospace and high-tech industries.

Sc properties

Sc is a soft, silvery transition metal. It is officially defined as part of the REE family together with yttrium (Y) and the lanthanoids (also called lanthanides). However, the smaller size of the Sc^{3+} cation causes rather different geochemical behaviour to the rest of its family members, so many general rules about the geochemistry of REE do not apply to Sc (Fig. 2). Most reviews of REE geochemistry (e.g. Chakhmouradian and Wall, *Elements*, 2012), mention this fact and then exclude Sc from further consideration. The United States Geological Survey treats Sc separately from the REEs. So, Sc has been rather forgotten in the REE literature.

Sc rarely concentrates in any geological setting and the rocks with highest concentrations of Sc are of extra-terrestrial origin! Lunar basalts and chondritic meteorites are enriched by a factor of three compared with terrestrial rocks. On Earth, the highest concentrations of Sc are chiefly associated with occurrences of high-field-strength elements, such as titanium, tantalum and zirconium, especially in granite pegmatites. Indeed, granite pegmatites provide a small amount of the Sc produced commercially each year. An ore deposit of Sc may well contain concentrations of just a few hundred *parts per million* (ppm) Sc in the rock. This is higher than a gold deposit, which may contain only one ppm gold, but much lower than copper or the other main REE, such as neodymium (Nd).

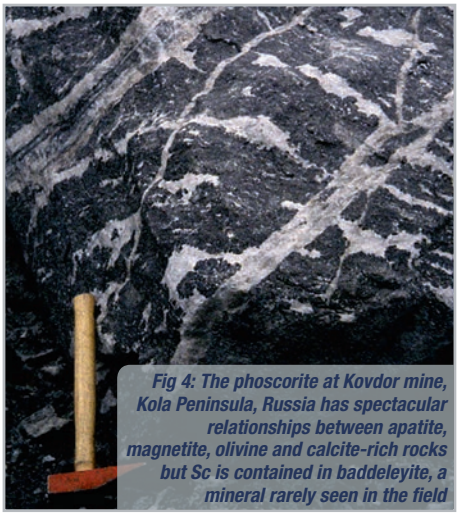


Fig 4: The phoscorite at Kovdor mine, Kola Peninsula, Russia has spectacular relationships between apatite, magnetite, olivine and calcite-rich rocks but Sc is contained in baddeleyite, a mineral rarely seen in the field

Bayan Obo in China—the world's largest REE mine—is a source of Sc (Williams-Jones and Vasyukova, *Economic Geology*, 2018). This seems at odds with our assertion that Sc does not follow the other REE in natural environments until we learn that the Sc comes from pyroxene re-processed from the waste tips at Bayan Obo, rather than from the REE ore minerals themselves. Indeed, figure 1 shows that highly anomalous Sc chemistry also appears to be associated with some alkaline silicate rocks and with carbonatites, but REE deposits are not necessarily Sc deposits.

Sc in minerals

Of the 5,000-odd species in the mineral kingdom, only sixteen are Sc minerals, and these are all rare. The most common Sc mineral, thortveitite, occurs in granite pegmatites (table 1). It contains the highest weight percent Sc at 32% and has been mined as a Sc ore in the past.

Mineral	Formula	Occurrence
SILICATES		
bazzite	$Be_3(Sc,Al)_2Si_6O_{18}$	granitic pegmatite, also rodbergite, Fen carbonatite complex, Norway; albite, beryl and amazonite pegmatites, Telemark, Norway; Zr-REE-F metasomatites, Altai area, Russia
cascandite	$Ca(Sc,Fe)Si_3O_8(OH)$	cavities in alpine granites, Italy
jervisite	$Na,Ca,Fe)(Sc,Mg,Fe)Si_2O_6$	cavities in alpine granites, Italy
thortveitite	$(Sc,Y)_2Si_2O_7$	granitic pegmatite
PHOSPHATES		
juonniite	$CaMgSc(PO_4)_2(OH)\cdot4(H_2O)$	carbonatite-phoscorite Kovdor, Russia
kolbeckite	$ScPO_4.2(H_2O)$	associated with crandallite group minerals
pretulite	$ScPO_4$	xenotime-zircon-lazulite veins, Austrian Alps

Table 1: Examples of scandium minerals

Sc also occurs as a minor component in hundreds of minerals, substituting for titanium, zirconium, iron or tantalum. Other important Sc-bearing minerals likely have names unfamiliar to most geologists and include scandium-columbite, davidite, tantalite, samarskite, ixiolite, rutile, Ti-aeschynite, zircon, catapleiite and baddeleyite. Additionally, Sc isn't always incorporated into a mineral structure, and may instead be adsorbed onto the surfaces of iron oxide and hydroxide minerals.

Sc in laterites

Laterites are iron- and aluminium-rich rocks and soils formed by a prolonged process of chemical weathering. At least four Sc laterite deposits in eastern Australia are undergoing feasibility studies that may bring them into production as mines. The Sc was hosted originally in clinopyroxene and then released and adsorbed onto iron oxides during the strong weathering process that produced the laterite. The Nyngan laterite deposit in New South Wales, Australia, developed by weathering of basic rocks. It has grades up to 409 ppm ▶

▶ Sc and has been touted as the world's first stand-alone Sc deposit.

The mineralogy of the weathering process has been studied in the Syerston–Flemington deposit of New South Wales. This Co+Ni+Sc deposit contains about 1,350 tonnes of Sc at an average concentration of 434 ppm. Mathieu Chassé recently found that deposit formation requires a high initial concentration of Sc in clinopyroxene. These are then weathered leading to Sc-rich waters circulating below the water table. Seasonal precipitation allows the adsorption of Sc3+ onto goethite, which accounts for about 80 % of the Sc budget (Fig. 3). The deposit contains up to 800 ppm Sc in its limonitic laterite compared to about 80 ppm in its parent rock. This exceptional concentration of Sc in lateritic deposits requires a combination of three circumstances: (1) anomalously high Sc concentration in the parent rock, (2) long time-scales of alteration in a stable tectonic environment and (3) lateritic conditions during weathering, allowing the trapping of Sc by Fe oxides.

Sc in red muds

'Red muds' are the waste products of aluminium processing after bauxite ores have been treated by the Bayer process. Vast tailings dams of this material occur in many parts of the world and there has been recent interest in recovering REE from this waste product. This is one of the few environments where REE, *including* Sc, are concentrated together. Grades of about 100 ppm Sc have been found in red muds in Greece waste and so research is ongoing (e.g. **scale-project.eu/**) to determine if any economic recovery processes for Sc can be found.

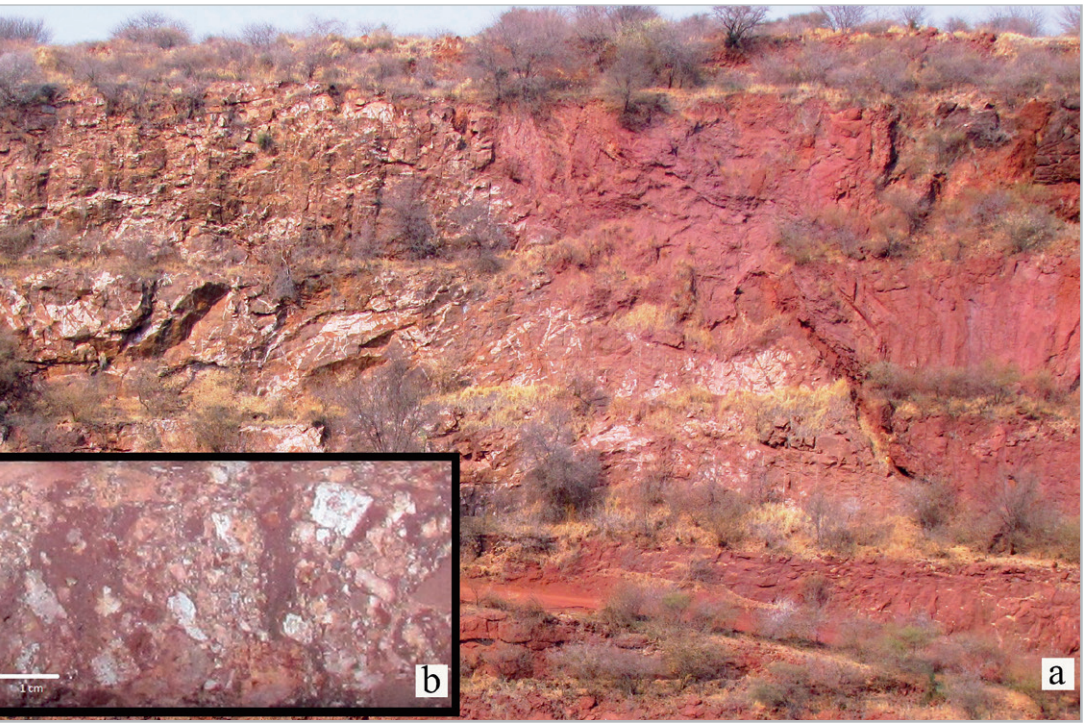
Sc in carbonatites and alkaline rocks

Carbonatites (igneous carbonate rocks) and alkaline rocks (some of the most bizarre and extreme composition igneous silicate rocks) are the main types of deposits mined currently for REE, so we turned to existing geochemical databases to see if these rocks typically contain high concentrations of Sc. According to the GeoRoc database (**georoc.mpch-mainz.gwdg.de/georoc**) a single carbonatite sample from Pakkanadu, India, revealed a Sc content of 237 ppm. A sample from Bayan Obo, China had a high Sc value of 111 ppm.

The REE exploration boom of 2010 to 2013, and the increase of the traded price of Sc from $2,000 to $5,000/kg in 2012, encouraged a number of mining companies to include Sc in their initial resource calculations. Our review of these results, however, supports the idea that REE-rich carbonatites and alkaline rocks do not *necessarily* contain high concentrations of Sc (although some localities are worthy of future attention).

The best-known example of Sc enrichment in carbonatite is probably the carbonatite-phoscorite deposit at Kovdor, Kola Peninsula, Russia (Fig. 4). This deposit is mined for magnetite, apatite and baddeleyite (ZrO2). Sc substitutes for Zr in baddeleyite (Kalashnikov and colleagues, *Ore Geology Reviews*, 2016), which contains an average of 780 ppm Sc.

Africa's best Sc potential may be in the Glenover pyroxenite-carbonatite complex in South Africa, with a Sc content of 300-500 ppm in a supergene apatite-martite breccia (Fig. 5). The complex was mined for apatite, while the low-grade ore was stockpiled rather than processed. This stockpiled material is of interest for its REE—including Sc—potential. The REE are hosted mainly in monazite but the Sc is hosted in zircono-silicates, aeschynite and secondary Nb-oxides. Sc-bearing aeschynite is now also recognised in the carbonatite and regarded, together with aegirine, as an important host for the primary Sc mineralisation.



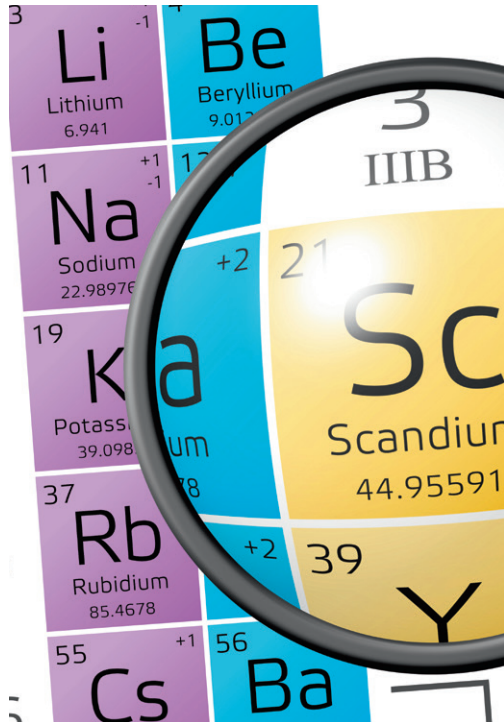


Fig 5: The Glenover open pit mine, South Africa. (a) Secondary red coloured apatite-martite breccia (right) formed through weathering of carbonatite veins intruding apatite pyroxenite (left). Height of profile is approximately 20 m. (b) Diamond drill core sample of apatite-martite breccia containing angular white and cream coloured secondary apatite clasts

The sign, atomic number and atomic weight of chemical element Scandium. Image credit: GrAl/shutterstock.com

Recent exploration work by Imperial Mining on the Crater Lake alkaline complex located in Quebec, Canada, outlined significant Sc hosted in a magnetic ferro-syenite. The main host to this Sc is the clinopyroxene, hedenbergite.

Values of nearly 450 ppm Sc were reported in the weathered Karingarab carbonatite in Namibia (Fig. 6), suggesting that weathering is a key factor in concentrating Sc. Tomtor (Yakutia, Russia) is a huge deposit of weathered carbonatite with exciting grades of niobium and REE, including average grades of 391 ppm Sc. Weathered carbonatites at Araxá and Catalão (Brazil), Mt Weld (Australia), Sukulu (Uganda), Mabounié (Gabon) and Sokli (Finland) all may be of interest for their Sc potential.

The future for Sc

Although classed as a REE, the smaller cation size of Sc means that it doesn't behave in the same way and its mineral hosts are not the same as for the other REE. So, we can't use current understanding of REE behaviour to identify promising deposits of Sc and shouldn't assume that REE-rich deposits will contain high concentrations of Sc. Our assessments of the concentrations of Sc in various rock types and deposits globally show that Sc associates with niobates, titanates, iron oxi/hydroxides and, importantly, clinopyroxene. Focused study of Sc content in clinopyroxene is therefore a necessary avenue for further research, and it may be worth looking again at previously investigated alkaline complexes and carbonatites. Successful, cheap and easy extractive metallurgy needs to be developed and fine-tuned to target this important potential host.

Potential Sc deposits exist in Canada, Namibia, Brazil, Australia, Uganda, Gabon, and in Europe, Finland. Clearly, there are a number of promising deposits of Sc that could increase and diversify supply, and potentially reduce overreliance on China and Russia.

Given the numerous applications of this 'miracle metal', Sc exploitation seems ripe for development. Research time and funds should be devoted to identifying viable Sc deposits in more western nations to secure supply, as well as to better understand how Sc can be more efficiently extracted from its many different sources. There is still plenty for geoscientists to do to improve our understanding of the geology, geochemistry and mineralogy of this rather neglected element. If successful, we could be on the cusp of a Sc boom. ◆

Note: *All three authors are researchers on the EU H2020-funded HiTech AlkCarb project, grant number 689909.*
Pete Siegfried is also an independent consultant and has carried out consulting at the Glenover, Karingarab, Araxá and Catalão localities mentioned in this article.

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Fig 6: Examining drill core at Karingarab, Namibia. This material may contain as much as 437 ppm Sc

STRATEGISING MINERALS:
SECURING SUSTAINABLE SUPPLY

Aerial image of traffic on the approach roads to the Queensferry Crossing bridge near Edinburgh
Image credit: TreasureGalore/shutterstock.com

The UK economy depends on one million tonnes of minerals and mineral products every day, yet few recognise the importance of this sector. **Nigel Jackson*** lauds the UK Minerals Strategy for raising awareness

There is widespread ignorance generally, and more worryingly within Government, of the importance and economic contribution of the UK minerals industries. That is, non-energy related minerals and mineral products, such as aggregates, concrete, asphalt, agricultural and industrial lime, potash, clays and sands—raw materials that are essential to build infrastructure, fertilise our soils, and sustain construction and the economy.

To combat this ignorance, the UK Minerals Strategy (UKMS) has just been launched. This industry-led response is designed to raise awareness of the minerals industry, its contribution to the economy and our way of life, among central and local Government, key stakeholders and the general public. The strategy also aims to bring the industry together, to shape a common approach and ensure sustainable supplies for the next 25 years.

A mining nation

The entire UK economy relies on minerals (Fig. 1). They are critical to develop and maintain our built environment and sustain our quality of life. Most people do not think about where the materials for construction and manufacturing come from and many assume that, with the decline of coal, we are no longer a mining nation. Not so. The UK has diverse geology—on land and offshore—meaning that the vast majority of the demand can be met from indigenous sources. We remain very active, with over 2,000 extraction, processing and production sites onshore and offshore using ports, wharves, rivers, canals and the rail network (Figs. 2 and 3). Activity spans construction and industrial minerals, with recent tungsten and planned polyhalite operations in Devon and Cleveland, respectively, and active interest in tin, gold and lithium all testifying to the potential that remains. But mineral supply cannot be assumed: it needs planning, monitoring and managing. Planning authorities lack the resources to undertake meaningful assessments, so there are no up-to-date estimates of future requirements, risking under provision. The current mineral planning system enables planning applications for new mineral sites to be converted into production via a 'predict-and-provide' approach based on local plans. Whether this is a robust and appropriate basis on which to meet demand for the biggest material flow in the economy going forward is an open question.

Based on recent consumption, the industry estimates that more than five billion tonnes of minerals and mineral products will be needed over the next 25 years. Current replenishment rates, particularly for aggregates that represent over 80% of our mineral needs, have been languishing at around or below 60% for over 10 years. Given that it can take anything from 10 to 15 years to move from exploration to production, alarm bells should be ringing.

Strategic vision

Support for the minerals industry should be a national priority and policy imperative. Yet, there is no overarching Government strategy. Instead, individual planning documents exist for England (the National Planning Policy Framework, NPPF), as well as for Scotland, Wales and Northern Ireland. There is an emerging Industrial Strategy that aims to boost productivity and create jobs through investment. And this strategy will link with the Construction Sector Deal which aims to cleanly and efficiently build smarter, safer homes and buildings, through a strategic partnership between Government and the industry.

The UKMS was developed in anticipation of this emerging Industrial Strategy, to champion the minerals industry, the essentiality of its products and the need to ensure a steady and adequate supply of minerals to meet societal demand. ▶

▶ The development of this industry-led strategy has been a unique process that has taken around 25 years.

The trigger

In 1993, a number of trade associations, geologists, mineral planners, consultants and lawyers formed the then CBI Mineral Committee. Frustrations with the planning and permitting system were raw. The committee concluded that enough was enough; the industry must get its act together if it was to survive and prosper, and to ensure the economy received sustainable supplies of the minerals it needs, at the right level and the right rate.

The committee published 'Living with Minerals' as a first attempt to set out the scale, importance and nature of the industry, and to make the link between minerals and their end use. The document includes a cut away of the minerals and mineral products used in a typical home, which is emblematic of the case being made.

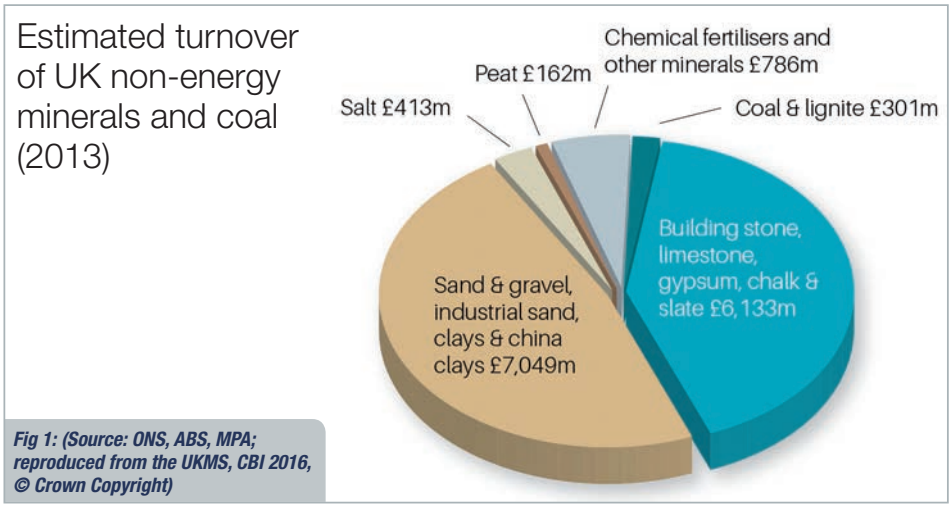

Fig 1: (Source: ONS, ABS, MPA; reproduced from the UKMS, CBI 2016, © Crown Copyright)

ECONOMIC	Demand & Importance	Supply & Distribution	Trade & Investment
	Government should provide **clear national policy** and a **statement of need** for minerals and mineral products to **underpin local plan-making, policy and decisions** to enable a steady and adequate supply of minerals and mineral products to be maintained.	The *Industry* will **submit sufficient planning or marine licence applications**. Mineral planning authorities and marine regulators should **ensure that sufficient sites are allocated** in plans and consents or marine licences granted, to maintain a steady and adequate supply of minerals and mineral products to meet demand, while also ensuring that **reuse and recycling is maximised**.	*Government* should ensure there is a **supportive regulatory, operating and trading environment** to encourage investment, trade and export of UK minerals and mineral products, and reduce risks from insecurity of international supply.
ENVIRONMENTAL	**Planning & Regulation**	**Environmental Benefits**	**Environmental Impacts**
	Government should ensure that the **mineral planning system is properly resourced** to operate effectively and that duplication with other regulation, particularly environmental permitting, is minimised.	The *Industry* will aim to deliver **environmental net gains through responsible site management and high-quality restoration**, adding to the wildlife, recreational and landscape assets already created.	The *Industry* will continue to **avoid and mitigate the impacts of extraction, processing, manufacturing and transportation** as part of the transition to a low carbon and circular economy.
SOCIAL	**Education, Skills & Employment**	**Public Understanding & Engagement**	**Research & Innovation**
	The *Industry* will continue to **provide attractive career opportunities and meet skills needs** for a modern, healthy, safe, well-educated and diverse workforce and encourage people to choose to work in the industry.	The *Industry and Government* should work with stakeholders to **improve public understanding of the need for minerals and mineral products** and their associated supply chains, and strengthen the evidence base and availability of relevant data.	The *Industry* will **encourage and invest in innovation, research and development**, including the identification of new resources and the development of new markets.

Tabel 1: The key building blocks of the UKMS

But knowing there is a problem was the easy part. Developing a solution is what has taken the time. The industry needed to organise itself, engage with others using evidence-based dialogue, debate key issues, put its ideas together, consult and conclude.

The response

The CBI Minerals Group brought together 99.9% of the industry, in concert with the Mineral Products Association which, representing over 90% of the UK mineral products industry, has the resources to help deliver solutions.

To engage with key stakeholders, the UK Minerals Forum (UKMF) was formed in 2007. Although funded by the industry, the forum is independently chaired and brings together the planners, NGOs, and representatives from Government and its agencies across the UK to debate important and controversial issues. The forum produced consensus reports and helped build trust between industry and its stakeholders.

In parallel, six 'Living with Minerals' conferences held since 2004 have identified key issues necessary to shape a credible strategy. Together, these forums and conferences led to the publication of three important documents between 2014 and 2016: 1) the House of Commons Select Committee Investigation into the Extractive Industries Sector (Nov 2014), which endorsed the development of a strategy; 2) the UK Minerals Forum report 'The Future of our Minerals' (Nov 2014), which examined recent and future trends in production, and recommended developing a long-term vision for UK mineral supply; and 3) the CBI Minerals Group report 'The UK Minerals Extraction Industry' (Feb 2016), which quantified the economic contribution of the industry.

These outputs motivated the industry to keep moving forward and convert years of preparation into a UK Minerals Strategy.

The Strategy

The first ever UK Minerals Strategy launched this summer (Fig. 4). The overarching aim is to ensure that UK demand for minerals and mineral products is supplied sustainably for the next 25 years, by identifying and permitting at least five billion tonnes of minerals to be sourced primarily from indigenous sources.

The strategy is multi-layered, from the political to the operational. It aims to raise awareness and make the link between our mineral resources and their end use, thus selling the importance of this industry to

the next generation. The document serves as a reference and reminder for the industry, Government and planners of the crucial need for these minerals, encouraging them to view planning applications favourably, invest in research, development and exploration to find new indigenous resources, invest in skills to create a new generation of specialists to work in the industry, and, importantly, to do all this safely and sustainably.

The UKMS is constructed around three building blocks of sustainable development (table 1): economic, environment and social. In turn, these are divided into nine blocks, creating the opportunity to build bespoke communities of interest, to ensure manageability and affordability.

Work on the three building blocks will start soon. Mineral extraction is a long-term business, where lead-in times for planning and permitting to production can typically take up to 10 to 15 years. Thus, to meet demand in 25 years' time, the nine key blocks need to be completed in around three years.

The project is ambitious, but, significantly, already has support from the industry's sponsoring Government Minister, Richard Harrington MP. The aim of linking the UKMS to Government's own ambitions for the industry and the economy has been recognised, which is both satisfying and welcomed. The strategy is also attracting support from non-industrial organisations with a legitimate interest in the industry.

UKMS should be viewed as this generation handing the baton to the next, to ensure that this great industry continues to thrive for the good of the economy and our quality of life. ◆

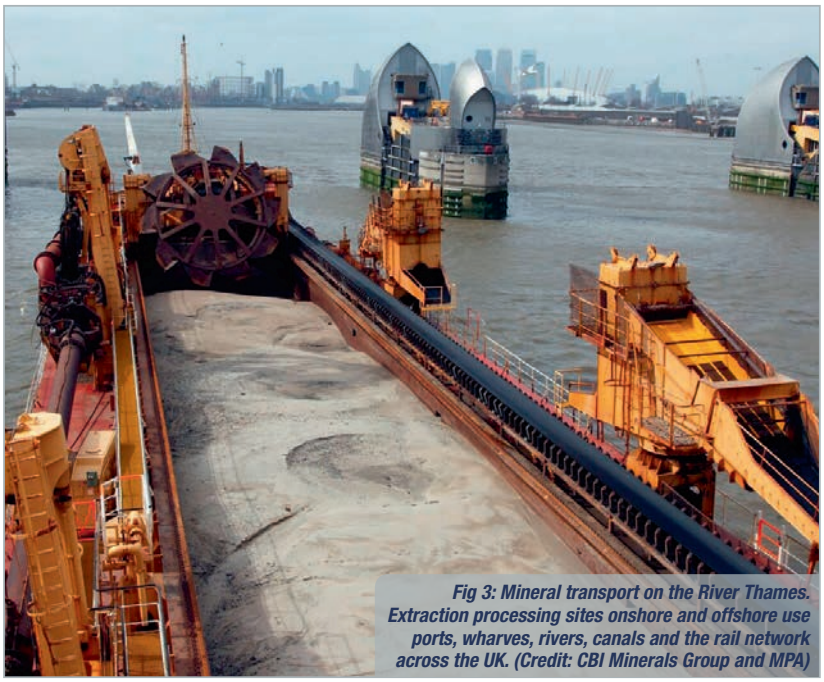

Fig 3: Mineral transport on the River Thames. Extraction processing sites onshore and offshore use ports, wharves, rivers, canals and the rail network across the UK. (Credit: CBI Minerals Group and MPA)

Fig 4: A panel of industry specialists discusses the launch of the UK Minerals Strategy at the recent 'Living with Minerals 6' conference

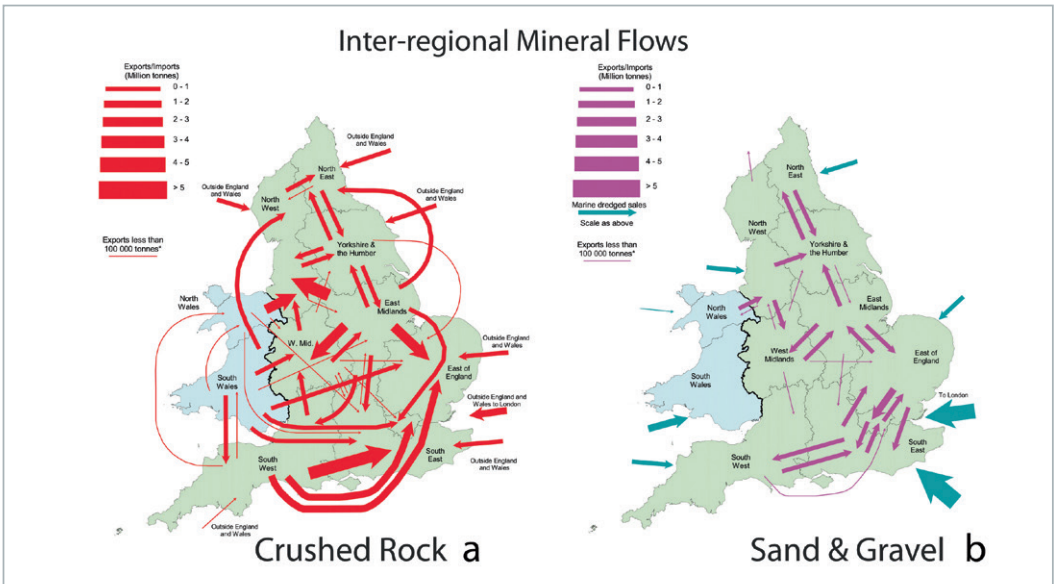

Fig 2: Crushed rock (a) and sand and gravel (b) inter-regional flows, 2014 (Source: Collation of the results of the 2014 Aggregate Minerals Survey for England and Wales. reproduced from the UKMS, CBI 2016, © Crown Copyright)

Nigel Jackson BSc (Hons) CGeol CSci FGS, Chief Executive of the Mineral Products Association & Chairman of CBI Minerals Group; E: Nigel.Jackson@mineralproducts.org

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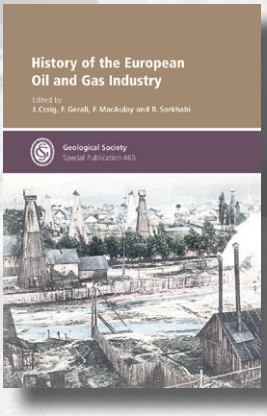


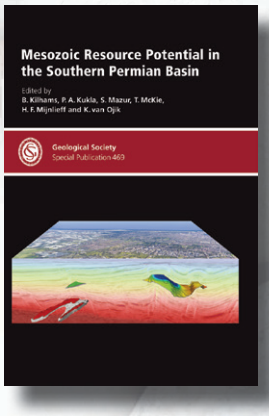
History of the European Oil and Gas Industry

Edited by J. Craig, F. Gerali , F. MacAulauy and R. Sorkhabi

List price: £ 125, Fellow's price: £ 62.50

The history of the European oil and gas industry reflects local as well as global political events, economic constraints and the personal endeavours of individual petroleum geoscientists as much as it does the development of technologies and the underlying geology of the region. The first commercial oil wells in Europe were drilled in Poland in 1853, Romania in 1857, Germany in 1859 and Italy in 1860. The 23 papers in this volume focus on the history and heritage of the oil and gas industry in the key European oil-producing countries from the earliest onshore drilling to its development into the modern industry that we know today. The contributors chronicle the main events and some of the major players that shaped the industry in Europe. The volume also marks several important anniversaries, including 150 years of oil exploration in Poland and Romania, the centenary of the drilling of the first oil well in the UK and 50 years of oil production from onshore Spain.

Find out more or buy online at www.geolsoc.org.uk/sp465



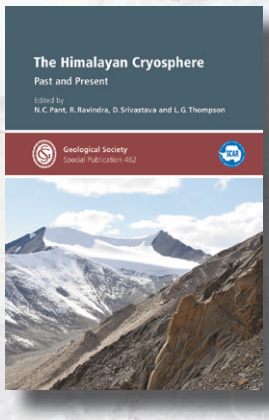
Mesozoic Resource Potential in the Southern Permian Basin

Edited by: B. Kilhams, P. A. Kukla, S. Mazur, T. McKie, H. F. Mijnlieff and K. van Ojik

List price: £ 130, Fellow's price: £ 65

The Southern Permian Basin, as its name suggests, is a historical heartland for hydrocarbon production from the Palaeozoic Rotliegend interval. However, in this mature basin the Mesozoic presents further possibilities to offer resource security to NW Europe. Such opportunities include increasing efficiency in the production of discovered hydrocarbons, exploration for further hydrocarbons (both conventional and unconventional) and efficient exploration for, and production of, geothermal energy. All these potential resources require a grounding in technically sound geoscience, via traditional scientific observation and the application of new technologies, to unlock their value.

Find out more or buy online at www.geolsoc.org.uk/sp469



The Himalayan Cryosphere: Past and Present

Edited by: N. C. Pant, R. Ravindra, D. Srivastava and L. G. Thompson

List price: £ 90, Fellow's price: £ 45

The Himalaya mountains contain not only one of the largest concentrations of ice outside the polar regions, but contribute to the hydrological requirements of large populations spread over seven nations. The exceptionally high elevations of this low-latitude cryosphere presents a natural laboratory and archives to study climate–tectonics interactions as well as regional v. global climate influences. The existing base-level data on the Himalayan cryosphere are highly variable. Several climate fluctuations occurred during the late Quaternary (MIS1–MIS5, especially the last c. 100 ka), which led to the evolution of the Himalayan landscape. Detailed studies of these archives, along with those of the present cryosphere and related hydrosphere, are essential for understanding the controls on present and future hydrology of the glacial-fed mountain rivers.

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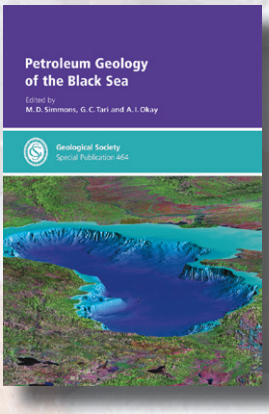


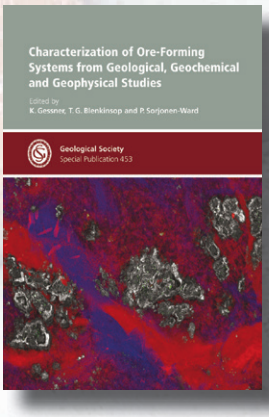
Petroleum Geology of the Black Sea

Edited by: M. D. Simmons, G. C. Tari and A. I. Okay

List price: £ 120, Fellow's price: £ 60

The Black Sea remains one of the largest underexplored rift basins in the world. Future success is dependent on a better understanding of a number of geological uncertainties. These include reservoir and source rock presence and quality, and the timing of migration of hydrocarbons relative to trap formation. An appreciation of the geological history of the Black Sea basins and the surrounding orogens is therefore key. The timing of basin formation, uplift of the margins, and of facies distribution remain issues for robust debate. This Special Publication presents the results of 15 studies that relate to the tectono-stratigraphy and petroleum geology of the Black Sea. The methodologies of these studies encompass crustal structure, geodynamic evolution, stratigraphy and its regional correlation, petroleum systems, source to sink, hydrocarbon habitat and play concepts, and reviews of past exploration. They provide insight into the many ongoing controversies concerning Black Sea regional geology and provide a better understanding of the geological risks that must be considered for future hydrocarbon exploration.

Find out more or buy online at www.geolsoc.org.uk/sp464



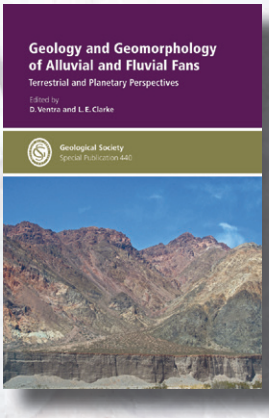
Characterization of Ore-Forming Systems from Geological, Geochemical and Geophysical Studies

Edited by K. Gessner, T.G. Blenkinsop and P. Sorjonen-Ward

List price: £ 120, Fellow's price: £ 60

Economically viable concentrations of mineral resources are uncommon in Earth's crust. Most ore deposits that were mined in the past or are currently being extracted were found at or near Earth's surface, often serendipitously. To meet the future demand for mineral resources, exploration success hinges on identifying targets at depth. Achieving this requires accurate and informed models of the Earth's crust that are consistent with all available geological, geochemical and geophysical information, paired with an understanding of how ore-forming systems relate to Earth's evolving structure. Contributions to this volume address the future resources challenge by (i) applying advanced microscale geochemical detection and characterization methods, (ii) introducing more rigorous 3D Earth models, (iii) exploring critical behaviour and coupled processes, (iv) evaluating the role of geodynamic and tectonic setting and (v) applying 3D structural models to characterize specific ore-forming systems.

Find out more or buy online at www.geolsoc.org.uk/sp453



Geology and Geomorphology of Alluvial and Fluvial Fans: Terrestrial and Planetary Perspectives

Edited by D. Ventra and L.E. Clarke

List price: £ 100, Fellow's price: £ 50

Alluvial and fluvial fans are the most widespread depositional landform bordering the margins of highland regions and actively subsiding continental basins, across a broad spectrum of tectonic and climatic settings. They are significant to the local morphodynamics of mountain regions and also to the evolution of sediment-routing systems, affecting the propagation and preservation of stratigraphic signals of environmental change over vast areas.

The volume presents case studies discussing the geology and geomorphology of alluvial and fluvial fans from both active systems and ancient ones preserved in the stratigraphic record. It brings together case studies from a range of continents, climatic and tectonic settings, some introducing innovative monitoring and analysis techniques, and it provides an overview of current debates in the field.

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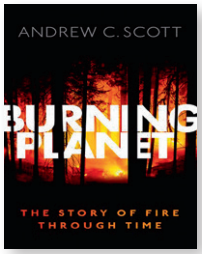
Burning Planet: The Story of Fire Through Time



This is an excellent and interesting book. Aimed at lay readers, it hits the target spot-on while including some fascinating scientific insights. The history of fire is written in the geological record in charcoal. That fire figures so much in the record, and that its residues provide such extensive and useful information, has little recognition within the geological profession, let alone elsewhere. Scott's book will help fill that blank.

A useful introduction clarifies many basic issues. The author then discusses why charcoal is so important to the story—how it formed, and what the various types and forms show. One thinks of charcoal as wood residue, but that is by no means the whole truth. Any and every part of a plant can be preserved beautifully in charcoal. There are astonishing pictures of pollen grains, parts of leaves, individual wood cells, minute flowers and even parts of insects. The pictures are very good, the explanations add even more to them—Scott is a good communicator.

The figures give rise to one minor gripe. The plates—colour (14) and monochrome (11)—are well produced and provide important information. The 61 monochrome figures also clarify and enhance what is said, but are printed with the text on a matt surface. The graphs and time-lines amongst them are fine, even if some might be clearer in colour. As charcoal tends to be black, however, pictures of burnt forests and heaths, and both recent and fossil plants, can be hard to see clearly on the matt finish.

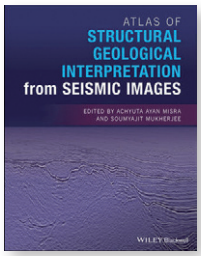
Fire, natural or otherwise, needs both kindling and enough atmospheric oxygen (about 15%) to take hold. Evidence of fire is first found in Devonian strata, around 400 million years ago. When humans first "used" it is not known. One of the issues addressed in this context is that, nowadays, it is almost always seen as a threat. In fact, some ecosystems depend on fire for their continuance and this, too, needs to be recognised.

This book is recommended for all. It should be bought not just read, as readers will want to return to it to confirm items and learn more. I have one suggestion for the author. Now that this excellent book is "out of the way", please write a substantial two-volume tract containing a lot more technical detail. Perhaps that should be a demand, not a suggestion.

Reviewed by: ***Jeremy Joseph***

BURNING PLANET: THE STORY OF FIRE THROUGH TIME
by Andrew C. Scott, 2018. Published by: Oxford University Press, Oxford, UK. ISBN: 978-0-19-873484-0. 231 pp. hbk.
List Price: £20.00. www.oup.com

Atlas of Structural Geological Interpretation from Seismic Images



Geological interpretation from seismic data can be a difficult task, due to a range of issues relating to data (quality, resolution and density) and geology (ambiguity and complexity). As such, this recently published atlas is a welcome addition to a reference collection.

Divided in five sections, the book first introduces the reflection seismic method before providing a raft of data examples from a range of geological settings. These examples, terrestrial and marine, are sourced globally, though dominantly from India and Europe. They show a combination of density plot and wiggle-trace data, with a strong emphasis on deep-penetration hydrocarbon-exploration-type data. Higher-resolution, shallow-penetration systems are not generally considered.

The introductory chapters provide a solid overview of the reflection seismic method, including discussion of processing and data resolution. Interpretation case studies are presented in the main body of the volume. These generally take the form of a page of summary text followed by two to four figures, which include an interpreted and un-interpreted seismic section. However, there is some variation in the structure of these case studies and formatting of figures can be inconsistent with, for example, variation in the notation of horizontal and vertical scale. In the best examples, structures are well imaged by high-quality data, allowing direct comparison with the interpretation shown immediately below. In some cases, the structures are less clear. However, such examples can be considered a useful inclusion within a collection of analogues; as the geophysicist does not always have the benefit of the highest-quality data.

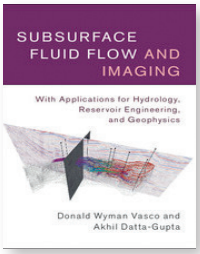
The main limitation of the atlas is the lack of metadata surrounding the seismic examples shown. For example, seismic source volume, and thereby frequency, is not generally stated; nor are any other acquisition or processing parameters. Considering the first chapter of the book discusses issues concerning seismic data resolution, this represents an opportunity missed: one of the challenges of seismic interpretation is the correct identification of geological structures via seismic systems employing different source and acquisition parameters.

This last point notwithstanding, the atlas provides a good number of interpreted sections and should prove a useful source of data examples for reflection seismic interpretation.

Reviewed by: ***Matthew Owen***

ATLAS OF STRUCTURAL GEOLOGICAL INTERPRETATION FROM SEISMIC IMAGES
edited by A.A. Misra and S. Mukherjee, 2018. Published by: Wiley Blackwell 267 pp. hbk. ISBN: 9781119158325
List Price: £100.00 W: www.wiley-blackwell.com

Subsurface Fluid Flow and Imaging: With Applications for Hydrology, Reservoir Engineering, and Geophysics



Some readers may scratch their heads when they see the title of this text. After all, it is not common to see subsurface flow as an imaging problem. However, there were in fact significant developments in the past couple of decades to turn the problem of subsurface flow characterisation into an imaging problem, like in geophysical tomography—the idea being that observations from different excitations are used to reconstruct the distribution of

subsurface properties. Vasco and Datta-Gupta are among the pioneers in this field.

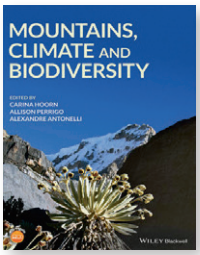
This text uniquely presents a unifying theory to tackle a wide range of subsurface imaging problems using trajectory-based techniques. By doing so, the same framework can be applied to wave-like hyperbolic problems, diffusive parabolic problems, and a mixture of the two. Both the mathematical formulation and asymptotic solutions of the imaging equations are presented, highlighting the efficiency and adequacy to describe spatially varying properties of these techniques. A key feature of trajectory-based modelling is that it separates the spatial heterogeneity from the transport computations themselves. By transforming coordinates to one where the time of flight is an independent variable along a trajectory, the 4-D problem can be solved in 2-D, where time and time of flight are the coordinates. Examples of the problems considered include transient pressure tomography, tracer response and transport tomography, multi-phase fluid flow and production tomography, geophysical time-lapse imaging, and imaging using deformation and strain.

As mentioned in its preface, this text is intended for imaging research practitioners. It is quite mathematically evolved because it aims to bridge the gap between imaging theories and subsurface applications. It is no easy introduction to geoscientists new to this topic, but I am sure those curious enough among us will read this text with great interest. The free software accompanying the book allows intuitive understanding of the concepts discussed, without worrying too much about the maths. For the academic researchers and industry practitioners working on subsurface characterization, this serves as an important and helpful reference. It should help us to appreciate the elegance of trajectory-based modelling and promote future applications. The book's presentation is clear, systematic, innovative, and complete. It could benefit from having a summary chapter at the end of the book and not limiting its colour figures at the centre of the book.

Reviewed by: ***Michael Tso***

SUBSURFACE FLUID FLOW AND IMAGING: WITH APPLICATIONS FOR HYDROLOGY, RESERVOIR ENGINEERING, AND GEOPHYSICS
by Donald Wyman Vasco and Akhil Datta-Gupta, 2016. Published by: Cambridge University Press (HBK) ISBN: 9780521516334. **List Price: £89.99.**
W: http://www.cambridge.org/

Mountains, Climate and Biodiversity



Mountains and volcanoes have long received attention from geoscientists, being such impressive geological features. Alexander von Humboldt (1769-1859), following travels in Latin America, noted that there is a global relationship between biota and elevation in addition to that between biota and latitude. Even so, the climatic effects of orogenisis, and how mountains and (palaeo)climates together influence extinction, speciation (the evolutionary origin of species) and species' migrations, remain topics of debate. Prior to this publication, no single volume had addressed the complexities of these interactions. The 31 chapters presented here address our current knowledge of these topics more or less comprehensively.

Mountains are landforms that rise prominently above their surroundings, have relatively confined summit areas (sometimes forming biotically isolated "sky islands") and considerable relief (ruggedness). Early chapters review our knowledge of mountain formation through tectonic plate collisions and dynamic topography (uplift by mantle convection). Means of measuring palaeotopography are outlined, such as exploiting altitudinal changes in oxygen and hydrogen/deuterium isotopic ratios of rainfall and deposits. Also described is the field of phytopalaeoaltimetry—using plant fossils and leaf shapes (the Climate Leaf Analysis Multivariate Programme—CLAMP) as proxies for altitude. A regrettably brief chapter discusses measuring biodiversity, but most chapters present primarily species richness as a measure.

How can there be a relationship between dynamics and species richness, given that mountain building and evolution are processes acting at markedly different rates? We are informed that stable mountain areas (e.g., in Australia) host diverse, mature radiations, while rapid radiations are occurring in tectonically active areas (e.g., New Zealand). Mountains with much ruggedness have greater richness than do those with little topographic complexity, especially in the tropics. Meanwhile, continuous mountain chains act as corridors for migration for high-altitude species, while also being barriers for low-altitude ones. A trio of maps contrast present-day ruggedness, vascular plant species per 10,000 km^2, and terrestrial mammals, and make the links visually clear. Five major global centres for vascular plant diversity are identified, all in or adjacent to mountainous regions (Andes, Rockies, East African Rift System, the European Alps and Yunnan, SW China).

Ten chapters provide case studies worldwide. Each makes interesting reading. I was particularly intrigued to read, for example, that the isolated ice-free coastal areas and nunataks (ice bound "mountain islands") in Antarctica have rich, geologically ancient moss and lichen communities occupied by tardigrades and mites nowadays able to withstand prolonged desiccation and freezing. This welcome volume deserves to be widely read.

Reviewed by: ***Brent Wilson***

MOUNTAINS, CLIMATE AND BIODIVERSITY
by Carina Hoorn, Allison Perrigo, Alexandre Antonelli (eds), 2018. Published by: Wiley-Blackwell, 544 p. hbk. ISBN: 978-1-119-15987-2. **List Price: £70.00.**
W: www.wiley.com

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- **NEW! Minerals of the English Midlands,** by Roy E. Starkey, British Mineralogy Publications 2018, 426 pp. pbk.
- **NEW! Characterization of Ore-Forming Systems from Geological, Geochemical and Geophysical Studies,** by K Gessner, TG Blenkinsop & P Sorjonen-Ward (Eds), GSL SP 453, 2018, 424 pp. hbk.
- **NEW! History of the European Oil and Gas Industry** by J Craig, F Gerali, F MacAulay & R Sorkhabi (Eds), GSL SP 465, 2018, 472 pp. hbk
- **NEW! Mesozoic Resource Potential in the Southern Permian Basin** by B Kilhams, PA Kukla, S Mazur, T McKie, HF Mijnlieff & K van Ojik (Eds), GSL SP 469, 2018, 572 pp. hbk
- **NEW! Petroleum Geology of the Black Sea** by MD Simmons, GC Tari & AI Okay (Eds), GSL SP 464, 2018, 484 pp. hbk
- **NEW! Geology and Geomorphology of Alluvial and Fluvial Fans: Terrestrial and Planetary Perspectives** by D Ventra & LE (Eds), GSL SP 440, 2018, 353 pp. hbk.

That sinking feeling?

***Hannah Gow** reports on the use of improved conceptual models of subsurface geology to aid planning and hazard mitigation in a region renowned for complex engineering geology and sinkholes*

Ripon, a small and pleasant cathedral city in North Yorkshire, made headlines in recent years when sinkholes opened up in 2014, 2016 and as recently as this August. During the 1980s and 1990s, sinkholes appeared in the area every two to three years. The geological sequence of marls, limestone and gypsum, combined with the topographic groundwater flow, makes Ripon highly susceptible to dissolution features such as sinkholes. On September 7-9, the Engineering Group of the Geological Society met for their Annual Field Meeting to discuss the geological hazards and engineering implications of the dissolution features there. We also discussed the Quaternary Geology of the Vale of York, which is characterised by glacial moraines and lake sediments, till and gravel left over from the last ice age. The aim was to explore conceptual ground models for these regions and to share our knowledge and experience with engineering geologists across academia and industry.

Organised by David Giles (University of Portsmouth) and led by staff from the British Geological Survey and Technical Solutions in Partnership (TSP) Projects, over 40 delegates with backgrounds ranging from engineering geology to consultants to students attended to learn about the geological history of the Vale of York and sinkholes in Ripon.

The Friday evening kicked off with talks by Holger Kessler, Callum Irving, Vanessa Banks and myself. We gave an overview of the Quaternary history, mapping and modelling of the areas we would visit over the next two days. The talks went on late into the evening, but we were raring to go again on Saturday morning, starting the day with site visits to the Escrick Moraine. Jon Ford, Holger Kessler and Callum Irving, provided an in-depth narrative of the geological history and engineering properties of the ground in the area. The shallow geology and landscape of the Vale of York between Selby and York records a legacy of dynamic Quaternary evolution. The group retraced this geological history, visiting key localities that reveal the diverse and often complex nature of the superficial deposits. Our discussions focussed on relationships between geological processes and the ground properties, their engineering implications, as well as impacts on the region's hydrogeology. We saw how the depositional environments and glacial history, including 'glaciotectonism', affect materials and their potential applications. Our excursion led us to the University of York campus where we were able to bring our geological history tour into the Anthropocene, discussing the role of human landscape modification on the region's Quaternary geology.

As is typical for a field visit, it rained for most of the day and we came away a few inches taller due to clay from Wilberfoss Quarry that stuck to the bottom of our wellingtons!

On Sunday, Tony Cooper led us to various sites around Ripon to look at sinkholes. One had opened up only in the last five months. At first glance, it could be mistaken for a lovely village pond, were it not for the bright orange fencing and the fact that similar-looking holes appear quite often in Ripon! The sinkholes form because Ripon is underlain by gypsum that rapidly dissolves in water on a human timescale of years to decades. This dissolution causes cavities to open and the ground above to collapse—a process that can be triggered by natural dissolution or human intervention, such as a burst water pipe. Dave Morgan demonstrated to the group a range of geophysical survey techniques that can be used to better understand the geometry and processes occurring within a sinkhole. With improved understanding of sinkholes, we can create more detailed ground models and interpretations of sinkhole formation to aid hazard mitigation in the city.

This part of northern England has truly intriguing geology. It is easy to see why some believe the Ripon sinkholes were the inspiration for Lewis Carroll's Alice in Wonderland falling down a deep hole following the white rabbit.

Hannah Gow (BGS)

Hannah Gow is a Spatial Data Specialist and Geoscientist at the British Geological Survey; e-mail: hcullen@bgs.ac.uk

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

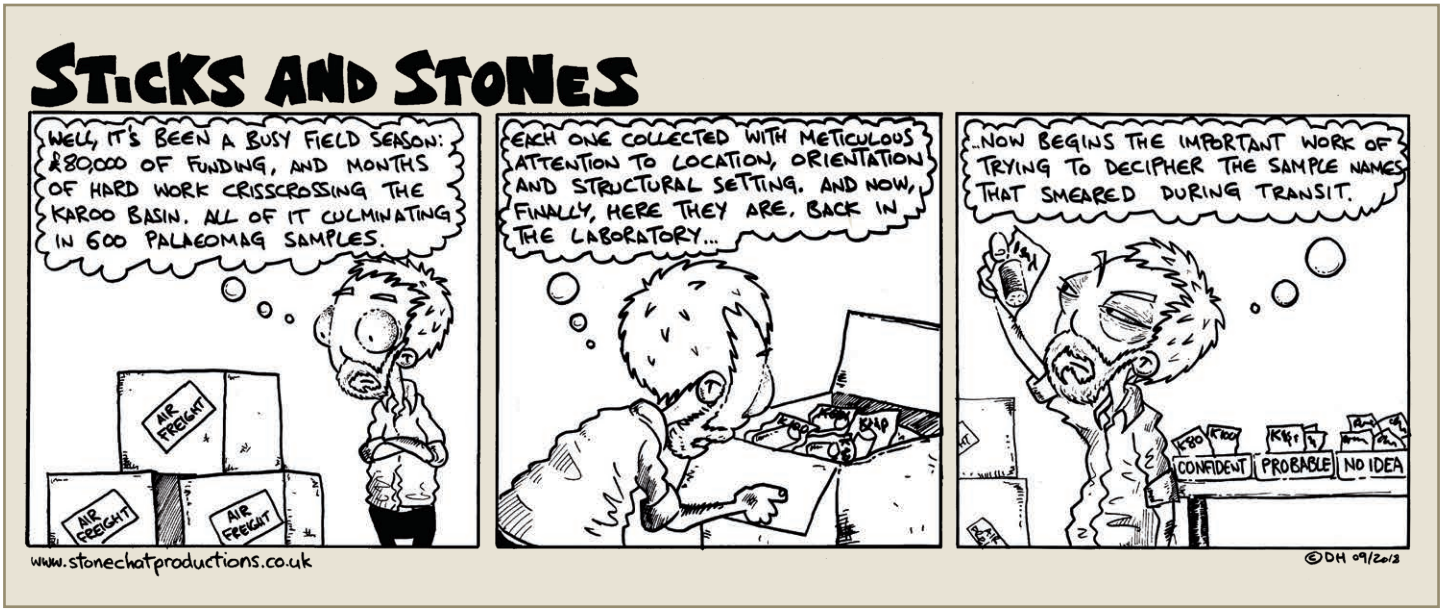
ENDORSED TRAINING/CPD

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)

EVENTS

PLEASE NOTE THAT THERE ARE MANY MORE MEETINGS FOR WHICH WE DO NOT HAVE SPACE. ALWAYS CHECK WITH **WWW.GEOLSOC.ORG.UK/LISTINGS**

MEETING	DATE	VENUE AND DETAILS
Marine Minerals: A New Resource for the 21st Century	31 Oct-1 Nov	**Venue:** Burlington House **Contact:** Georgina Worrall **E:** georgina.worrall@geolsoc.org.uk **W:** www.geolsoc.org.uk/marineminerals18
GSA 2018 Annual Meeting	4-7 Nov	**Venue:** Indianapolis, Indiana, USA **W:** https://community.geosociety.org/gsa2018/home
Operations Geoscience Adding Value	7-8 Nov	**Venue:** Burlington House **Contact:** Sarah Woodcock **E:** sarah.woodcock@geolsoc.org.uk **W:** www.geolsoc.org.uk/PG-Ops-Geo18
Brownfield Redevelopment: North 2018	7 Nov	**Venue:** Park Plaza Hotel, Leeds **Contact:** Rebecca Nolan **E:** rebecca.nolan@environment-analyst.com **W:** www.geolsoc.org.uk/EnviroAnalyst-Brownfield-Redevelopment-2018
Petroleum Engineering Conference	12 Nov	**Venue:** Athens, Greece **Contact:** Sarah Wilson **E:** sarahwilson1234@protonmail.com **W:** https://petroleumengineering.euroscicon.com/
XV Chilean Geological Congress Geoscience toward the community	18 Nov	**Venue:** University of Concepcion, Concepcion, Chile **Contact:** Andres Tassara **E:** monica.sorondo@gmail.com **W:** http://congresogeologicochileno.cl/en/home/



DISTANT THUNDER

Rock star

Geologist and science writer Nina Morgan celebrates a geologist who went to war

When Sir Aubrey Strahan [1852-1928] became Director of the Geological Survey of Great Britain in January 1914 he faced a baptism of fire. Eight months after he took office, Britain entered the First World War and Strahan faced a catastrophic loss of personnel. By the end of 1915, 68 staff members—more than a third of the workforce of the Geological Survey and Museum—had joined up.

Survey geologist, William Bernard Robinson (W.B.R.) King [1889-1963] was one of those who was quick to volunteer for active service. He was given a commission as a second lieutenant in the Seventh Battalion of the Royal Welsh Fusiliers on 21 September 1914 and in April 1915 was appointed to the War Office. In June 1915, he was transferred to France to serve as Geological Advisor to the Chief Engineer of the British Expeditionary Forces with regards to water supply.

Call the Geologist

The idea of turning to a trained geologist to advise on geological problems in a war zone was a new one. King—nicknamed 'Rocks' by the Royal Engineers—was the first geologist in either the Allied or the German armies to receive a military assignment for work in his own profession. Until May 1916, when he was joined by Major T.W. Edgeworth David, Professor of Geology at the University of Sydney, Australia, King was the only geologist actively working in the battlefield. His work demonstrated clearly the value of geology in the war effort.

Concrete Evidence

Along with his work on water supply, King also drew on his geological training to identify the source of aggregate present in the concrete used by the Germans to build their pill boxes. This work provided the key evidence to demonstrate that Dutch neutrality was being compromised.

Writing to P.A. Sabine in 1961, King explained that: "The point, of course, was that the Germans were sending gravel from the Rhine thro' neutral Dutch waterways and we claimed that it was being used for war purposes and the Germans said that they would never do such a wicked thing and it was used for peaceful purposes only."

But after Canadian troops obtained a sample of the concrete used in a German emplacement that contained granite, King's suspicions were aroused and he persuaded his General to order personnel at the 5th Army HQ to collect samples. As King recalled:

"...I arrived at 5th Army HQ to find much wrath at all the Intelligence staff having to waste a day getting bits of concrete for a very youthful Captain from GHQ to examine. But by luck, [from] the first sandbag when opened, out fell a lump of concrete with a piece of Niedermendig lava."

King's instant identification of a rock from the Niedermendig–Andernach–Eifel region of the Rhineland, provided proof positive that the Germans were using Dutch canals to transport war materials to the front line.

War hero

King went on to serve in the Second World War as the senior of three geologists who provided expertise to the British Army in North West Europe, North Africa and the Italian Campaign. After WWII he became Geological Adviser to the War Office and saw the creation of an emergency reserve of geological officers.

King was mentioned twice in dispatches during the First World War, and later received awards for his war work, including an OBE for geological services in the First World War. Twenty-two years later he was awarded a Military Cross for bravery during the Second World War, for volunteering to drive the leading lorry of a convoy of high explosives back from Boulogne to Bailleul and Cassel, an area he knew intimately from the First World War. After WWII he first returned to the Geological Survey, and then went on to have a distinguished academic career, working first at Cambridge, then at University College London, and finally returning to Cambridge in 1943 as Woodwardian Professor of Geology.

Geologists admire him particularly for his contributions to Palaeozoic palaeontology and stratigraphy. But in the public imagination it is surely his war time work that made him famous. He was the only geologist to serve in both World Wars.

End notes: Sources for this vignette include: Sabine, P.A., 1961, Geologists at war: a forensic investigation in the field of war-time diplomacy, *Proc. Geol.* Assoc, **102**, 139-141; D.G. Bate & A.L. Morrison, 2018, *Proc Geol.* Assoc. **128**, 3-11; Peter Doyle, 2014, Geology and the war on the Western Front, 1914-1918, *Geology Today* **30 (5)**, 183-191; *Nature* **152**, 531 (06 November 1943), http://dx.doi.org/10.1038/152531b0; and an article about King by Benedicte Windle of the NE Yorkshire Geology Trust, available for download from http://www.neyorksgeologytrust.com/pages/ww1/willking.html; Keep calm and carry on, *Geoscientist*, November 2013.

* **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

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

The meeting that wasn't

In May 2018, the Geological Society of Japan turned 125. Hugh Torrens reports on his eventful and rather dramatic recent trip to Hokkaido to celebrate this milestone

To mark the 125th anniversary of the Geological Society of Japan (GSJ), an anniversary conference and international symposium on "Geology and Society" was organised at Hokkaido University, over 5-7th September 2018. I attended, with my wife, to represent the Geological Societies of London and Hungary, present the GSJ with our Bicentennial History, give a lecture on how geology and society should better co-operate in future, and read addresses from both Presidents.

But, sadly, disasters struck. In the days leading up to the conference, powerful Typhoon Jebi battered the region, bringing violent winds and flooding. Then, in the early morning of September 6th, a moment magnitude 6.6 earthquake struck Iburi Subprefecture in southern Hokkaido. The earthquake triggered major landslides and an electrical power outage throughout Hokkaido, causing a blackout that shut down all public transport. 41 people are confirmed dead and over 600 were injured. The decision had to be taken to cancel the 125th anniversary conference.

But we should congratulate the GSJ for organising such an important topic for discussion and for their resilience in the face of such island-arc-related activities, with which they have so often to contend. We should also thank the Japanese engineers for designing hotels in which we felt 'as safe as houses', despite being on the sixth floor (of many more), and for the safe routes our beds took to dissipate this earthquake's energies laterally.

At a later Quaker meeting in Tokyo, we met a Bristol engineer who discussed how the Japanese might now farm more wind-born energy at sea. He explained how the greater water depths around Japan meant that these would have to be surface tethered, as any bottom tethering would mostly be too deep. Geology certainly involves society in Japan more than in Britain.

The GSJ conference team, with those international delegates from the partner Geological Societies of Korea, London, Mongolia, and Taiwan who could get to Sapporo. Professor Millard Coffin (Hobart, Tasmania), this year's GSJ award winner, stands at the right of the front row, next to the GSJ president, Hiroki Matsuda

The Society notes with sadness the passing of:

Barnes, Simon James *
Booth, Tony *
Bowen, Geoffrey Gordon *
Carmichael, David*
Casey, Raymond *
Fletcher, Brian *
Gladwell, David Robert *
Ince, David Martyn *
Kenna, Raymond *
Lambert, John F *
Llewellyn, Peter L
Lynch, Edward *
Matheson, William *
Milward, Anthony Frederick *
Morgans, Michael William *§
OKADA, Hakuyu *
Pegg, Eric Arnold *
Roberts, Brinley
Shrimpton, Godfrey *
Smith, Howard James *
Thomson, Martyn Hugh *
Veevers, John James *
White, Owen *

In the interests of recording its Fellows' work for posterity, the Society publishes obituaries online, and in *Geoscientist*. The most recent additions to the list are in shown in bold. Fellows for whom no obituarist has yet been commissioned are marked with an asterisk (*). The symbol § indicates that biographical material has been lodged with the Society.

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

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

Staff matters

Georgina Worrall, Head of Events, who has worked for the Society for 12, years left us in October to take up a role as Head of Events at the British Property Federation. The Society wishes Georgina well for the future and thanks her for her valuable contribution to its work.

Essential tips for a rock-solid geoscience PhD: Part III

In the last part of this three-part focus, Melanie J Leng & Anson Mackay give some final advice

We've previously explained how important it is to carefully choose your PhD project and supervisor, to manage your time and relationships, and given more detailed advice on the practical side of doing a PhD. To finish, we'll cover social media, CVs and some guidance on what to do if a PhD isn't, after all, for you.

Social media

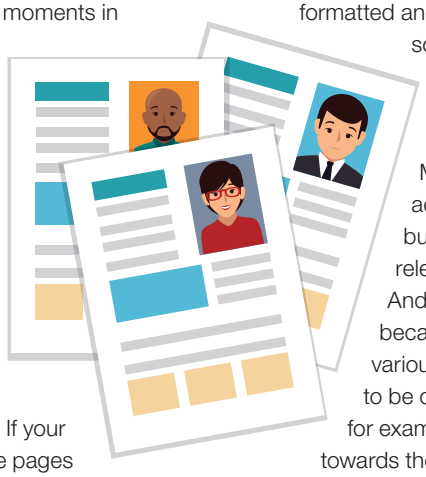
Join up! From day one start to build your online presence (there will be one anyway, so create your own). If using Facebook decide whether it's private (family and friends), work, or a mix. If a mix, bear in mind that posts can be shared, and people may be checking you out. Microblogging and photo/video-sharing platforms, such as Twitter and Instagram, are popular with geoscientists for sharing moments in the field or lab and seeing what other geoscientists are doing. Searchable hashtags (#) are a great way of getting involved with many different communities, ideas and campaigns. Twitter and Instagram are open for all to access unless you lock down your account. If your university personal profile pages are brief then consider using freeware such as WordPress or About.me to create your own personal profile. Keep it up to date with conferences, papers, blogs, social media, contact information, and plenty of action photos.

Blogs are a great way to practise writing short (400-800 words) "stories" on things you have been up to, or fancy talking about. Use lots of interesting photos. Most universities have blog sites for staff and students to contribute to, else create your own using freeware or your website. Video is increasingly popular. Short, one-to-two minute clips shot on a smart phone can be effective for showing others what you do.

Social media can help build your CV by improving your network outside of your institution and internationally as well; if done well, it will help you stand out from the crowd. But balance your time spent on social media with other forms of writing. Platforms such as Twitter are great for finding out about the latest developments in your field, from a professional, scientific level, to more personal issues related to workloads and stress. But social media has downsides, too, and it is good to recognise these early on to limit the detrimental impacts. Read up on tips for getting the most out of a platform, as well as codes of conduct (held by universities) one should follow.

Curriculum Vitae

There is no one-size-fits-all solution for the perfect CV, but it should always be clearly formatted and short enough to be scanned quickly—and most importantly—tailored to the role you're applying for. Many websites offer advice on writing CVs, but take care to keep it relevant and academic. And keep it up-to-date because you may need it for various purposes; if you apply to be on a committee or panel, for example, and eventually towards the end of your PhD when you will apply for future roles.



CVs should never be completely formulaic, but they should always contain: personal details (name, email, contact phone number and address, social media handles); personal statement (this helps you to stand out from the crowd by explaining who you are, what you're offering and what you're looking for); education (dates, the type of qualification and/or the grade you achieved); publications (published conference abstracts, papers, preprints, blogs); work experience (with the most recent first); achievements (explain how your previous experience has given you the skills needed to make you a suitable candidate for the position you are applying for); any relevant prizes or scholarships, hobbies and interests that demonstrate your skills and provide interview talking points.

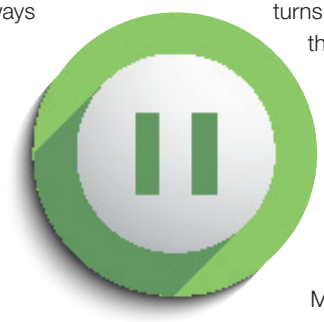
Get involved

Learn to say yes! Grab opportunities as they arise; everyone loves positivity and you will demonstrate energy and teamwork. Apply for positions of responsibility when they arise; early career representatives are often sought. Such positions can provide great experience to find out how learned societies work, and give you opportunities to influence what and how decisions are made.

Learn to say no! As important, is knowing when not to say "yes" all the time, especially if it's a yes for the wrong reasons, or you are just simply over-committed. Saying yes should be an opportunity—not just a request from others. If you are not used to relying on intuition, then think about how a request makes you feel. Knowing when to say no is important for developing healthy, balanced relationships with colleagues. Remember that when you say "no" to things you don't want to do, it frees your time to focus on the pursuits that you really want to do and can be liberating. Never give an immediate answer—think over the request for a day or so and use friends as sounding boards.

What if it all goes wrong?

If for whatever reason PhD research turns out not to be for you, there is often an option to "press pause". That is, you can interrupt your PhD with a break, which might eventually result in withdrawing from your PhD altogether, writing up an MSc or MPhil instead, or transferring to a different PhD project or supervisor. The main thing is to talk



to your supervisors, your postgraduate tutor, your Head of School, and welfare services within the university. Universities have careers services that can advise on the options and possibilities open to you, and any potential implications, as well as appropriate timings and time-limits of interruptions. Universities have forms to complete and approvals to seek, so follow the procedure. If you are an international student, on a Tier 4 visa for example, contact your graduate tutor immediately. They will be able to guide you on who to talk to within your university so that you do not break any visa rules.

In summary

Our advice given in this three-part series is not exhaustive, but it comes from many years of personal experiences. Remember that you have some choice when deciding on a PhD supervisor, take care to build professional relationships and manage your interactions and expectations. Presentations, writing and social media are significant parts to your PhD that must be tackled head-on. Training and building a CV are vital to enhance your further employment prospects. We briefly touched on critical care, which is all too important these days. Learning to say "no", as well as "yes", is essential.

There are many things to consider when embarking on PhD research, but the experience will increase your confidence, communication and managements skills, and improve your abilities to understand and solve problems. Enjoy your PhD. It may be tough at times, but it will be an amazing experience. When you pass your viva, be proud of this major achievement and call yourself doctor—you earned it.

Melanie Leng[1] is Director of Geochemistry at the British Geological Survey, UK, and Professor in Isotope Geoscience at the University of Nottingham, UK.

Anson Mackay[2] is Professor in Environmental Change at UCL, UK, and an Honorary Research Associate at the British Geological Survey.

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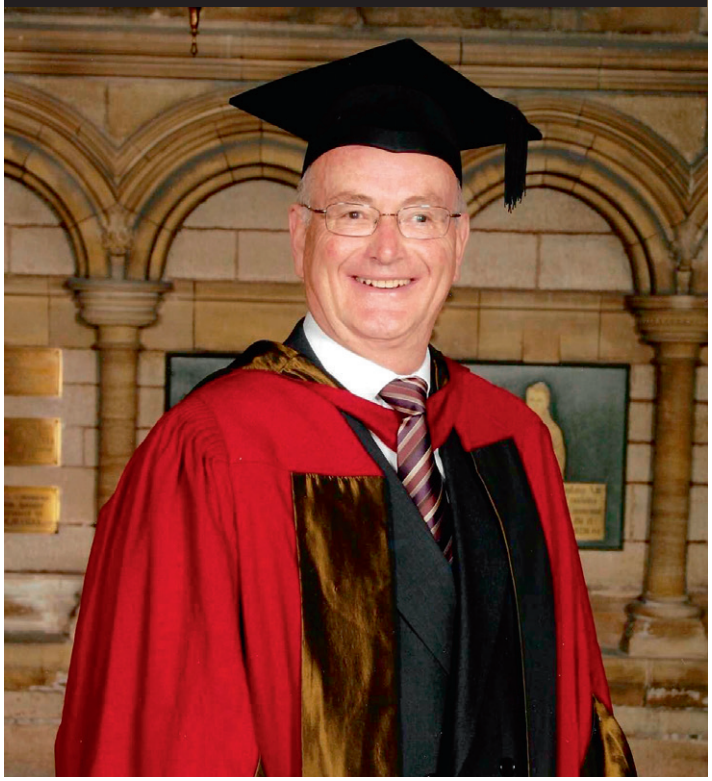
OBITUARY Keith Atkinson 1942-2017

Head of Camborne School of Mines, who helped bring about its merger with Exeter University



Emeritus Professor Keith Atkinson died from cancer on 2 August 2017 at Treliske Hospital, Truro, aged 74. He faced his illness with great courage and his customary humour, emailing friends from his hospital bed with the news that he was emulating Tony Hancock by giving an armful of blood.

Port Talbot

Keith was born and grew up in Port Talbot, where he attended Dyffryn Grammar School. He then spent eight years at Aberystwyth University as undergraduate, postgraduate and finally Research Fellow. So Wales was his launching pad and spiritual home, and this allegiance emerged in his passionate support for the Welsh Rugby team. However, Cornwall was Keith's adopted home, living in the County for nearly 50 years.

Appointed Lecturer in Geology at the Camborne School of Mines in 1969, he could teach across a range of geological subjects. He was equally at home making a presentation to an international conference or to a classroom of primary school children. He always brought tremendous energy to the task.

Keith's research and publications were as wide ranging as his teaching. In 1986 he and I co-authored '*Ore Deposit Geology*'. At that time Keith was increasingly involved in administrative duties at the Camborne School of Mines, so his contribution was mainly written during the night. The book had very good reviews, but also received the withering wifely rebuke "Book is a four letter word".

Research

His research interests were eclectic and included geophysics, slope stability, minerals processing and Tertiary geology. However, the main thrust was based on a research team he and I established in the mid-1980s to investigate different aspects of mine waste in Cornwall. Some aspects of this work led to a paper for which the four authors were awarded silver medals by the Institution of Mining & Metallurgy.

> "HE WAS EQUALLY AT HOME MAKING A PRESENTATION TO AN INTERNATIONAL CONFERENCE OR TO A CLASSROOM OF PRIMARY SCHOOL CHILDREN. HE ALWAYS BROUGHT TREMENDOUS ENERGY TO THE TASK"

Increasingly Keith's energies were channelled into administrative duties within the Camborne School of Mines, firstly becoming the Course Director of the newly established master's degree in Mining Geology. Later he played an important role in the negotiations that led to the merger between the School of Mines and Exeter University.

Restructuring

Keith was appointed Head of the School of Mines in 1994 and in 1997 became Deputy Vice-Chancellor of Exeter University, where he carried out a number of important roles, including the re-structuring of university departments and the creation of the Institute of Arab and Islamic Studies. This led to a very fruitful period of collaboration with the Ruler of Sharjah, United Arab Emirates. In 2002 he was appointed as the first Provost of Exeter University in Cornwall, where he helped to establish its first campus.

A genial, but private and modest man, Keith never boasted about his many achievements. He was always full of good humour with an endless repertoire of amusing anecdotes. He will be sorely missed by his family and friends.

➤ By Richard Edwards

* Read Richard Edwards' personal memoir of Keith online – *Editor.*

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.

THE JANET WATSON MEETING 2019

The Geological Society
serving science, profession & society

From core to atmosphere: Deep carbon

26-28 February 2019 — The Geological Society, Burlington House

Carbon is the element central to the evolution of life and maintenance of the Earth's habitability. Though the presence of carbon at Earth's surface is well known and vitally important, the majority of Earth's carbon is thought to reside in the Deep Earth. Constraining the magnitudes of the fluxes to and from the Earth's interior, and how they are controlled, is vital for understanding how the present-day Earth came to be and how it may develop in the future.

This three-day meeting will bring together early career geoscientists and senior members of the Deep Carbon research community. Presentations and discussions will encompass the latest advances in our understanding of the behaviour of carbon at the extreme pressures and temperatures of the Earth's deep interior, the exchange of carbon between the near-surface and deep reservoirs, the abiotic development of organic compounds through deep time, and the extreme limits of life on Earth. Mentoring activities will take place throughout the meeting, where senior scientists will lead small group discussions about their research careers and experiences in academia.

Conference themes

- Deep Carbon origins, storage and transport
- Carbon in the deep biosphere
- Deep Carbon through time
- The future of Deep Carbon research
- Deep Carbon synthesis

The final day of the conference is dedicated to workshops addressing the future of Deep Carbon research and exploring the application of new software driven tools for understanding carbon in the Earth.

Call for abstracts

There is a call for abstracts and oral and poster contributions are invited. Abstracts should be sent in a Word document to rhianna.mclean@geolsoc.org.uk by 14 December 2018. The abstract should be approximately 500 words and include a title and acknowledgement of authors and their affiliations where possible.

Convenors:

Simon Matthews (University of Cambridge)
Lotta Purkamo (University of St Andrews)

Further information

For further information about the conference please contact:
Rhianna Mclean, Conference Office,
The Geological Society, Burlington House,
Piccadilly, London W1J 0BG
T: 0207 434 9944
E: rhianna.mclean@geolsoc.org.uk
Web: www.geolsoc.org.uk/jwatson19
Follow this event on Twitter: #jwatson19

The Geological Society — 2019 YEAR OF CARBON

The Geological Society
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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 rhianna.mclean@geolsoc.org.uk by 4 February 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:
Rhianna McLean, Conference Office,
The Geological Society, Burlington House,
Piccadilly, London W1J 0BG
T: 0207 434 9944
E: rhianna.mclean@geolsoc.org.uk
Web: www.geolsoc.org.uk/lyell19
Follow this event on Twitter #lyell19

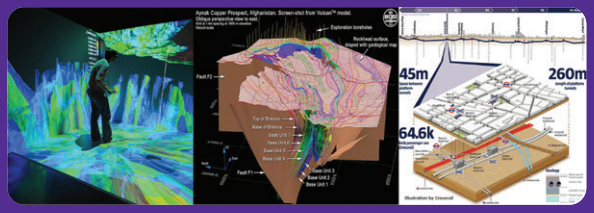
The Geological Society — 2019 YEAR OF CARBON

The Geological Society
serving science, profession & society

4D Subsurface Modelling: Predicting the Future

A workshop for mining, civil engineering & energy

20-21 February 2019 — The Geological Society, Burlington House, London



Science and analysis of the solid earth is often conducted based on only sparse, incomplete or unverified information. To counter this, as Earth Scientists, we rely on remote sensing techniques across a broad range of scales to extrapolate from the limited number of data points in order to build models of what the "real" picture might be. To enable and manage this ambitious process, we capture our current thinking in the form of models, each one shaped by the problem it is specifically built to examine, the techniques that will inform it and the mindset of the people that will build it.

A comprehensive model of the Earth's subsurface will want to account for:

- Structural history that provides the geological framework & wider regional context
- Effects of past & present stress fields & resultant pore pressure regime
- Mechanical properties of the observed lithologies & regoliths
- Genetic processes that have led to the deposition of lithologies
- Distribution of relevant minerals within any commercial deposit & their quality
- Actions of all fluids likely to be present & their reactions with lithology
- Quality & distribution of data available seeking to discern the subsurface
- Uncertainties inherent in techniques & theories used as premises for interpretation
- Changes induced through modification of the volume of interest by human activities

This pioneering event examines current approaches and the vulnerabilities they create for high quality depictions of the subsurface in industrial contexts, the decisions we need to make about it, and our ability to accurately predict its future evolution.

In this forum earth scientists building virtual representations of their target environment share ideas with the engineers who build structures in response to them and managers who make decisions based on them. The event is also designed to build on previous related GSL events to continue to raise debate on how and why we build such depictions of the subsurface, the nature of inter-disciplinary interaction that goes on around them, and their effectiveness in risk mitigation and value creation.

Convenors

John Booth (Geotechnics) *GSL Science Committee Advisor*
Glen Burridge (Glen Burridge & Associates) *Co-chair*
Thomas Finkbeiner (KAUST) *Co-chair*
Jorg Herwanger (MP Geomechanics)
Wolfgang Hohl (Hohlraum ZT)
Richard Plumb (Plumb Geomechanics) *Co-chair*
Michael Prycz (University of Austin)
Katherine Royse (British Geological Survey)
Benedikt Steiner (Camborne School of Mines)

Further information

For further information please contact:
Georgina Worrall, Conference Office,
The Geological Society,
Burlington House, Piccadilly,
London W1J 0BG
T: 0207 434 9944
E: georgina.worrall@geolsoc.org.uk
Web: www.geolsoc.org.uk/4dsubsurfacemodelling19
Follow this event on Twitter: #4dsubsurfacemodelling19

The Geological Society
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In association with EAGE

BRYAN LOVELL MEETING 2019

Role of geological science in the decarbonisation of power production, heat, transport and industry

21-23 January 2019 — The Geological Society, Burlington House

In the UK and elsewhere, decarbonisation of power production, industry, transport and heating to meet climate change targets is a major challenge and one that intrinsically involves the subsurface and geoscience.

Decarbonisation is central to Government and international policy and this three day conference will host national experts from industry, academia, and government to look at the geological and reservoir engineering aspects of the problem. The main objective will be to identify the high level barriers to progress and the main science questions - and begin a roadmap to solve the problems.

Keynote speakers confirmed

Spencer Dale, Group chief economist, BP; Chris Stark, Chief Executive, Committee on Climate Change; Nick Pidgeon, Cardiff University.

Other speakers confirmed

Martin Blunt, Frances Wall, Jonathan Turner, Seamus Garvey, Clair Gough, Sebastian Bauer, Martin Smith, Jon Gibbins, Jonathan Pearce, Stephen Bull, Thomas Koebel, Thomas Driesner, Adele Manzella, Henrik Solgaard Andersen, John Underhill, Ben Sovacool, Toby Peters.

Call for abstracts

Abstracts are invited from early career researchers who wish to exhibit posters at the conference. Posters that address any aspect of decarbonisation geoscience are encouraged, for example geothermal, gas storage, compressed air energy storage, critical metals, radioactive waste disposal, CCS, and bio-energy and CCS (BECCS). Abstracts should be approximately 500 words and include a title and acknowledgement of authors and their affiliations where possible. Please send your abstract as a Word document to rhianna.mclean@geolsoc.org.uk by 1 October 2018.

Convenors
Mike Stephenson (British Geological Survey)
Dave Schofield (British Geological Survey)
Sebastian Geiger (Heriot-Watt University)
Philip Ringrose (Statoil/NTNU)

Further information
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The Geological Society — 2019 YEAR OF CARBON