GEOSCIENTIST

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The Fellowship Magazine of the Geological Society of London

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Fifty years on

Dan McKenzie, plate tectonics, and more. Sue Bowler interviews.

THE TRANSLATORS
Ted Nield on the first English version of *De Re Metallica*

DISPOSAL TIME
Phil Davies thinks communities should be offered a stake

ONLINE SPECIAL
John Black on drawing for insight in the computer age

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Structural Soils is one of the UK's leading and award-winning ground investigation contractors. It is a national company with offices in Bristol, Castleford (near Leeds), Coventry, Hemel Hempstead, Glasgow and Tonbridge. For over 50 years, we have provided comprehensive site investigation and ground investigation services in the UK, across Europe and, more recently, further afield.

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Please download our free *Engineer's quick reference guide* from **www.soils.co.uk.**

GROUND ENGINEERING AWARDS 2017 WINNER

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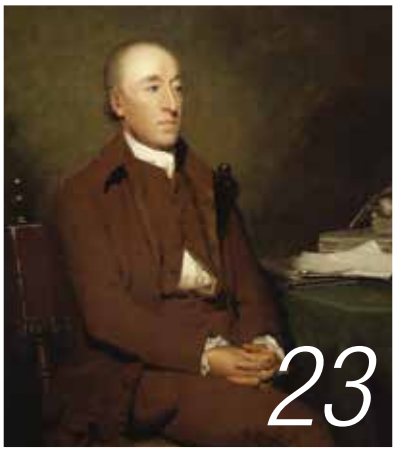
RAIL SI+PLUS
NEW integrated SI and supporting services to the rail industry



IN THIS ISSUE...

FEATURES

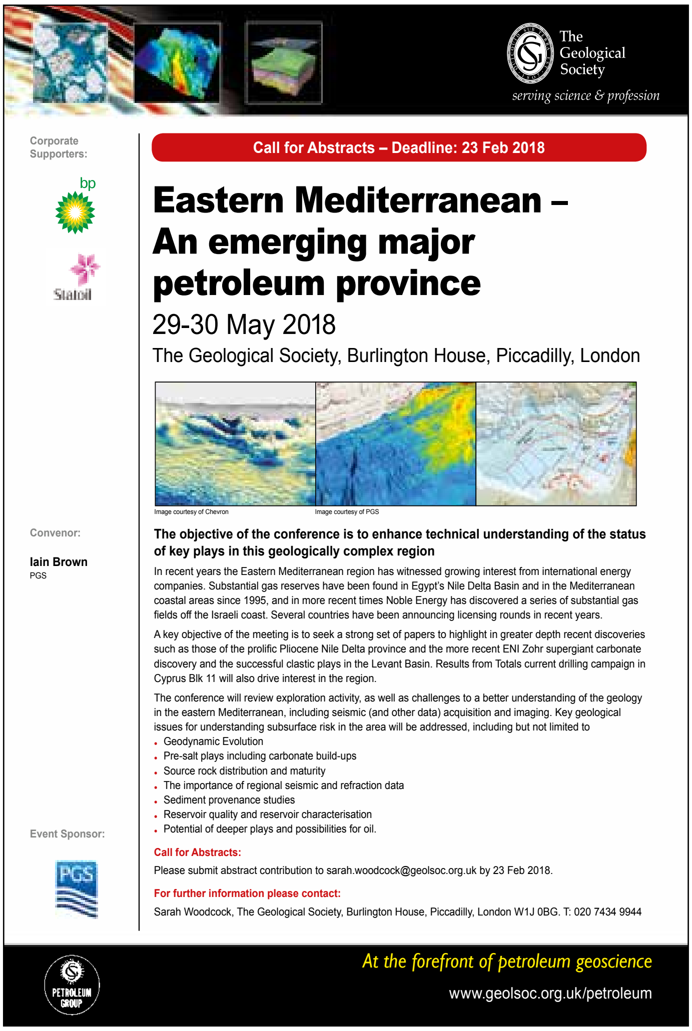
REGULARS

ON THE COVER:

ONLINE SPECIAL

DRAWING TO GAIN INSIGHT
John Black's experience with computer graphics reveals that the act of drawing is still a major help to 3D thinking.


The Geological Society
serving science & profession
YEAR OF RISK
THE JANET WATSON MEETING 2017
The Future of Contaminated Land Risk Assessment: stakeholder perspectives
6-7 November 2017
The Geological Society, Burlington House, London
With 2017 being the "Year of Risk" the Contaminated Land Group are proud to be hosting this year's Janet Watson meeting.
The conference will be exploring emerging science, technologies and guidance in the contaminated land industry, told from the viewpoint of all the key stakeholders: the site owner, consultant, contractor and regulator.
Keynote talks will be provided by accomplished industry leaders and the conference will provide a platform for scientific developments and innovative projects to be presented by the students, academics and early-career professionals working on them.
Conference themes
Innovative investigation and risk assessment.
Understanding, managing and communicating risk.
Emerging remediation technologies.
New guidance, standards, accreditation and the evolving role of the regulator.
The programme will be varied, including workshops, an expert panel discussion and presentations by speakers from a variety of backgrounds. Whilst offering all delegates the opportunity to become up to date with many of the latest technologies and guidance, this conference will also be an excellent opportunity for networking, and particularly beneficial for early-career professionals who are interested in or are currently working towards chartership in contaminated land.
Further information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Call for Abstracts – Deadline: 23 Feb 2018
Eastern Mediterranean – An emerging major petroleum province
29-30 May 2018
The Geological Society, Burlington House, Piccadilly, London
Image courtesy of Chevron
Image courtesy of PGS
Convenor:
Iain Brown
PGS
The objective of the conference is to enhance technical understanding of the status of key plays in this geologically complex region
In recent years the Eastern Mediterranean region has witnessed growing interest from international energy companies. Substantial gas reserves have been found in Egypt's Nile Delta Basin and in the Mediterranean coastal areas since 1995, and in more recent times Noble Energy has discovered a series of substantial gas fields off the Israeli coast. Several countries have been announcing licensing rounds in recent years.
A key objective of the meeting is to seek a strong set of papers to highlight in greater depth recent discoveries such as those of the prolific Pliocene Nile Delta province and the more recent ENI Zohr supergiant carbonate discovery and the successful clastic plays in the Levant Basin. Results from Totals current drilling campaign in Cyprus Blk 11 will also drive interest in the region.
The conference will review exploration activity, as well as challenges to a better understanding of the geology in the eastern Mediterranean, including seismic (and other data) acquisition and imaging. Key geological issues for understanding subsurface risk in the area will be addressed, including but not limited to
Geodynamic Evolution
Pre-salt plays including carbonate build-ups
Source rock distribution and maturity
The importance of regional seismic and refraction data
Sediment provenance studies
Reservoir quality and reservoir characterisation
Potential of deeper plays and possibilities for oil.
Event Sponsor:
PGS
Call for Abstracts:
Please submit abstract contribution to sarah.woodcock@geolsoc.org.uk by 23 Feb 2018.
For further information please contact:
Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG. T: 020 7434 9944
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The Geological Society
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YEAR OF RISK
Ground Related Risk to Transportation Infrastructure
26-27 October 2017
The Geological Society, Burlington House, London
We are pleased to announce a conference for the Society's chosen scientific theme in 2017 (Year of Risk). The meeting will focus on best practice for managing geotechnical infrastructure and is supported by the UK Geotechnical Asset Owners Forum. The conference will provide an opportunity to showcase innovative, industry leading approaches to holistic and tactical risk management across geotechnical infrastructure.
Themes include:
Strategic management of risk for portfolios of geotechnical assets, including policy development, application and use within regulated industries.
Identification, assessment and management of ground-related hazards to transportation infrastructure.
Identification, assessment and management of hazards relating to natural slopes and hazards from third party land in proximity to transportation infrastructure.
Assessment and management of changing risk during asset deterioration, including monitoring procedures and methods.
Operational responses to geotechnical asset failures impacting on transportation infrastructure.
Assessment of Whole Life Cost and Value, including modelling, development of input data and validation of outputs.
Current state of thinking in assessing climate change and dynamic weather events that impact of geotechnical infrastructure.
Keynote Speakers include:
Professor Jean Hutchinson (Queen's University, Canada)
Professor Kenichi Soga (University of California)
Convenors
Simon Abbott (Network Rail)
Chris Power (Mott MacDonald)
Fiona Todd (The Coal Authority)
Ken Gavin (Technical Uni Delft)
Claire Brian (Network Rail)
Tom Berry (Arup)
Jonathan Chambers (BGS)
Verity Smith (Atkins)
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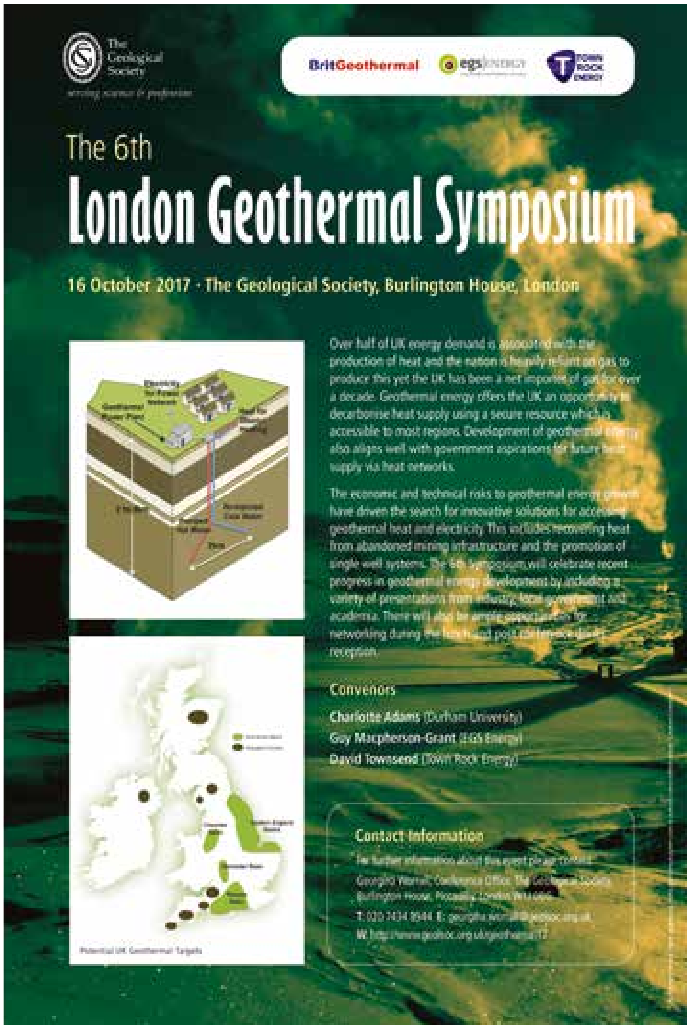
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TOWN ROCK ENERGY
The 6th
London Geothermal Symposium
16 October 2017 · The Geological Society, Burlington House, London
Convenors
Charlotte Adams (Durham University)
Guy Macpherson-Grant (EGS Energy)
David Townsend (Town Rock Energy)
Contact Information
Potential UK Geothermal Targets

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The Geological Society,
Burlington House, Piccadilly,
London W1J 0BG
T +44 (0)20 7434 9944
F +44 (0)20 7439 8975
E enquiries@geolsoc.org.uk
(Not for Editorial - Please contact the Editor)

Publishing House
The Geological Society
Publishing House, Unit 7,
Brassmill Enterprise Centre,
Brassmill Lane, Bath
BA1 3JN
T 01225 445046
F 01225 442836

Library
T +44 (0)20 7432 0999
F +44 (0)20 7439 3470
E library@geolsoc.org.uk

EDITOR-IN-CHIEF
Professor Peter Styles

EDITOR
Dr Ted Nield
E ted.nield@geolsoc.org.uk

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ADVERTISING SALES
Jonny Knight
T 01727 739 193
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> THE QUALITIES THAT MAKE A GREAT SCIENTIST - OR MINERAL PROSPECTOR - MAY NOT SUIT ONE TO ALL THE MANY AND VARIOUS DEMANDS THAT THE WORLD MIGHT MAKE

FROM THE EDITOR'S DESK:

Genius

"And the gentleman in the Chair, who looks a bit like Ronnie Barker, is Professor Sir James Lighthill FRS, Provost of UCL" whispered Miss Crispin, Secretary to Committee A, as she introduced me to the upper chamber of (as it then was) the Committee of Vice-Chancellors & Principals, where I had just been taken on to promote UK universities' scientific research.

"He's a genius, you know!" she added, reverentially.

Lighthill, Hawking's predecessor as Lucasian Professor of Mathematics, was certainly no slouch - a world expert on aeroacoustics and fluid dynamics, who helped design Concorde. This was what university bosses used to be like – great men (sadly, all men then), with minds like steel traps, rounding off distinguished academic careers; all but unknown to those below them, their numinous presence at the helm lending legitimacy to the whole enterprise. These were folk, I thought then, one needn't feel soiled working for.

'How different from the current breed', readers may reflect - as I did, ten years or so later, despite the presence of a few notable exceptions, when I left for the Society. But then, unworthiness in high office is a sad feature of modern life, which favours those with a taste for gold, but no idea how to find it - as our second feature may suggest.

This issue is dominated by two great men and one great woman – people whose minds found gold, through understanding what others did not. If they sought greatness, they hardly needed to; it sought them. Indeed, it used to be said (only half-jokingly) that the only good reason for advertising Vice-Chancellorships was to eliminate anyone who applied. Like being Speaker of the House of Commons, you're not supposed to crave the bauble. You should be called, and put up a token fight (at least) against 'the slippery slope of public life'.

Sir James finally succumbed in 1998, rupturing his mitral valve during an attempt to swim, once too often, around the Island of Sark. The qualities that make one a great scientist - or mineral prospector - need not necessarily fit one to all of the many and various demands that life exacts. Genius, a much overused term, should be reserved for something one might have, but not be - at least, not until death has made you safely invulnerable.

The rest of us may content ourselves that there is more to life than 'genius' – and more yardsticks than one. Even glorified personnel managers in grey shoes have their place, and maybe also their use.

DR TED NIELD NUJ FGS, EDITOR - TED.NIELD@GEOLSOC.ORG.UK @TedNield @geoscientistmag

SOCIETY *NEWS*

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

Council – call for nominations

Membership of Council enables you to influence the role of the Society in acting as a respected voice, serving science, the profession of geoscience and society, writes Steph Jones.

Would you consider standing, to become a member both of Council and one or more of its committees?

You will be able to play an active role in the formulation and delivery of the Society's scientific and professional strategy, and help to facilitate the communication of new scientific findings, engagement with policy makers, the media and the public, and the certification of good practice in education and the profession.

Each of Council's 23 members is a trustee of the Society, accountable to the Fellows and to other stakeholders and regulators, such as the Charity Commission. The prime responsibility of trustees is to oversee Society affairs and to act prudently in the management of its financial resources.

Council meets five times a year, usually on a Wednesday. Four of those meetings take place in the afternoon beginning at 14.00 and finishing at 17.00. In addition there is a two-day residential meeting, usually in late September, to discuss major strategic issues.

All Council members also serve on one of the standing committees (External Relations, Finance & Planning, Professional, Publications & Information and Science). These usually meet three or four times a year, mostly in person but sometimes virtually. Council members are sometimes also asked to join other committees or short-term working groups. The typical time commitment is eight to 10 days annually for ordinary members of Council.

➤ Nominations must be received no later than noon on Friday 5 January 2018. Details of the nomination process are on the form included with this month's *Geoscientist* and also on the Governance section of the website, where you can also see the names of those members of Council due to retire at the AGM in June 2018. W: www.geolsoc.org.uk/elections2018

Fault growth and interactions - implications for earthquake hazard and risk assessment

Speaker: Dr John Walsh (University College, Dublin)
Date: 18 October

Programme

- **Afternoon talk:** 1430pm Tea & Coffee: 1500 Lecture begins: 1600 Event ends
- **Evening talk:** 1730 Tea & Coffee: 1800 Lecture begins: 1900 Reception

Further Information

Please visit www.geolsoc.org.uk/gsllondonlectures17. Entry to each lecture is by ticket only. To obtain a ticket please contact the Society around four weeks before the talk. Due to the popularity of this lecture series, 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**

FUTURE MEETINGS

Dates for meetings of Council and Ordinary General Meetings until April 2018 will be as follows:

- **OGMs:**
2017: 22 November
2018: 7 February, 4 April

- **Council:**
2017: 22 November,
2018: 7 February, 4 April

Lyell Meeting 2019

The Lyell Meeting 2019 is now open to proposals, writes Naomi Newbold.

The Lyell meeting is an annual flagship event for UK palaeontology. It is co-ordinated by the Joint Committee for Palaeontology (JCP), which consists of representatives from the Geological Society (GSL), Palaeontological Association (PalAss), Palaeontographical Society (PalSoc) and The Micropalaeontological Society (TMS). Co-ordination of the Lyell Meeting is open to any member of the four constituent societies.

There is now a call for proposals for the 2019 meeting, which is due to take place in March that year. Those wishing to propose a topic and convene this meeting are invited to submit developed proposals to naomi.newbold@geolsoc.org.uk by Friday 2 February 2018.

The JCP welcomes submissions that are ambitious in scope and trans-disciplinary, which are more likely to attract a larger and potentially international audience. Proposed topics should appeal to a wide cross-section of the geological and palaeontological community. They should have a lead convener and one or two co-conveners. Submitted proposals will be reviewed by JCP, with the successful proposal decided by mid-March next year.

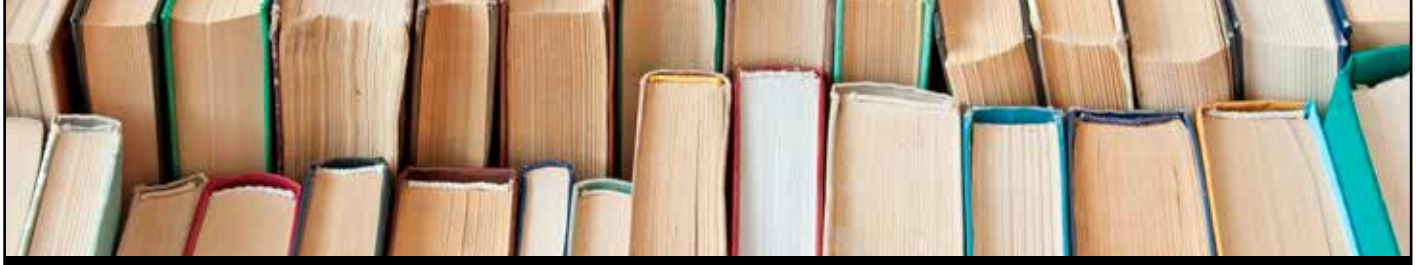
Society Discussion Group

Programme: 2017

Meetings of the Geological Society Discussion Group (formerly the Geological Society Club) are 18.30 for 1900, 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: www.geolsoc.org.uk/Groups-and-Networks/Specialist-Groups/Geological-Society-Discussion-Group.**

- **Thursday 19 October.** Bumpkins Restaurant (London SW7 3RD)
- **Wednesday 6 December.** Athenaeum (London SW1Y 5ER)

➤ Please contact Sarah Woodcock for more information and to make a reservation. E: sarah.woodcock@geolsoc.org.uk



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http://www.geolsoc.org.uk/sponsorabook

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Latest news from the **Publishing House**

Jenny Blythe has the latest from the Geological Society Publishing House

A Cretaceous Pterosaur Embryo Ready to Hatch

Neonate morphology and development in pterosaurs: evidence from a Ctenochasmatid embryo from the Early Cretaceous of Argentina

We report on a diminutive pterosaur specimen (MIC-V246), from the Lower Cretaceous Lagarcito Formation, which has anatomical features and general proportions that agree with those of other juvenile specimens of the filter-feeding pterosaur Pterodaustro guinazui. MIC-V246 is nearly complete, with the majority of its bones in natural articulation. The specimen is preserved within a small oval surface inferred to demarcate the outline of an egg. It includes remains of the skull a...

➤ **To continue reading** ...

view the paper at http://sp.lyellcollection.org/content/early/2017/08/16/SP455.17

Recently in the News: Scientists Discover 91 Volcanoes in Antarctic

A new volcanic province: an inventory of subglacial volcanoes in West Antarctica
By Maximillian van Wyk de Vries, Robert G. Bingham and Andrew S. Hein

The West Antarctic Ice Sheet overlies the West Antarctic Rift System about which, due to the comprehensive ice cover, we have only limited and sporadic knowledge of volcanic activity and its extent. Improving our understanding of subglacial volcanic activity across the province is important both for helping to constrain how volcanism and rifting may have influenced ice-sheet growth and decay over previous glacial cycles, and in light of concerns over whether enhanced geothermal heat fluxes and subglacial melting may contribute to instability of the West Antarctic Ice Sheet. Here, we use ice-sheet bed-elevation data to locate individual conical edifices protruding upwards into the ice across West Antarctica, and we propose that these edifices represent subglacial volcanoes. We used aeromagnetic, aerogravity, satellite imagery and databases of confirmed volcanoes to support this interpretation. The overall result presented here constitutes a first inventory of West Antarctica's subglacial volcanism. We identified 138 volcanoes, 91 of which have not previously been identified, and which are widely distributed throughout the deep basins of West Antarctica, but are especially concentrated and orientated along the >3000 km central axis of the West Antarctic Rift System.

➤ **Read here** http://sp.lyellcollection.org/content/specpubgsl/early/2017/05/26/SP461.7.full.pdf

A community stake in geological disposal

For over 40 years, UK Governments have failed to secure a site for an underground radwaste repository. **Phil Davies*** has a proposal…

A national screening exercise is under way, precursor to new discussions with communities about their geological potential to host a national Geological Disposal Facility (GDF). The Society has established an independent panel to review and evaluate the guidance for national screening.

Solution

A disposal solution needs to be found. While there are opportunities for re-use or conversion of some stockpiled nuclear materials, there is no further use for the majority of the UK waste inventory. Safe, monitored storage of waste is an interim solution, but it isn't sustainable for thousands of years. Nor is such an approach used for other long-term hazardous wastes.

Potential negative impacts will concern members of any community where it is suggested that a GDF might be sited, such as the safety of transporting waste consignments and risk of 'blight' on image and property values. In addition to facing these issues, and most importantly, the aspiring developer will need to satisfy the public that radionuclides that will eventually leak away from the repository will not harm future generations. Experience shows that a hybrid storage/disposal design may be somewhat more acceptable to the public, the waste remaining retrievable 'just in case'.

Host

In current thinking, volunteer host communities will be sought, and presumably communities that appear to be located in feasible GDF locations will be approached. As soon as a location is mentioned, expressions of local concern and opposition will follow. The would-be GDF developer will be cast as the party looking to bring bounty, or detriment - probably both. Local politicians will be in a difficult position – various electors will take a negative view of whatever position they adopt. The seeds are thus sown for yet another failed siting initiative.

Alternatively, we could try to avoid the predictable 'rejection and retreat' scenario. What if the project itself were partly 'owned by' a community, not something 'done to' a community? A special-purpose community stake company could obtain its own independent advice on the feasibility and safety of hosting a GDF. Such a company would be hard-wired to one or more local authorities, thus providing excellent public transparency and accountability.

Dividend

If feasibility and safety studies showed sufficient promise, and political agreement was achieved, the company would continue as a developer partner for subsequent steps. This would allow continuous public scrutiny of feasibility and safety 'from inside the tent'. The company would earn dividend through its evolving engagement in the project, this arrangement supplanting the 'negotiated benefits' model. The dividend income (which would continue right through to facility operation) would be available for local socio-economic investment.

Moving beyond the traditional us-and-them, developer versus community approach, this concept could be applied to other projects where public trust or lack of it is a significant issue… fracking, anyone?

FURTHER READING

- History of nuclear waste disposal proposals in Britain: http://www.no2nuclearpower.org.uk/radwaste/history-of-nuclear-waste-disposal-proposals-in-britain/
- Department for Business, Energy and Industrial Strategy, update 13 April 2017: https://www.gov.uk/government/collections/geological-disposal-facility-gdf-for-high-activity-radioactive-waste
- Department for Business, Energy and Industrial Strategy, annual report published 8 December 2016: https://www.gov.uk/government/publications/implementing-geological-disposal-annual-report-april-2015-march-2016

* **Phil Davies** is a freelance consultant with Westlakes Nuclear Limited. E: phil.davies@westlaesnuclear.co.uk

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 **ted.nield@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).

> "THIS CONCEPT COULD BE APPLIED TO OTHER PROJECTS WHERE PUBLIC TRUST OR LACK OF IT IS A SIGNIFICANT ISSUE… FRACKING, ANYONE?"
>
> PHIL DAVIES

FIFTY YEARS ON

Marking the launch of the new McKenzie Archive, **Sue Bowler** interviews the 1983 Wollaston medallist

Above: The young Dan McKenzie standing in a river bed - taken during an undergraduate field trip, [1960-1962]. The image may have been taken in Scotland, possibly in the North West Highlands North of Ullapool

"The reaction was astonishing. I went from being an unknown graduate student … to one of the people everybody invited to a conference and paid their way … before I had even the most junior position as an academic."

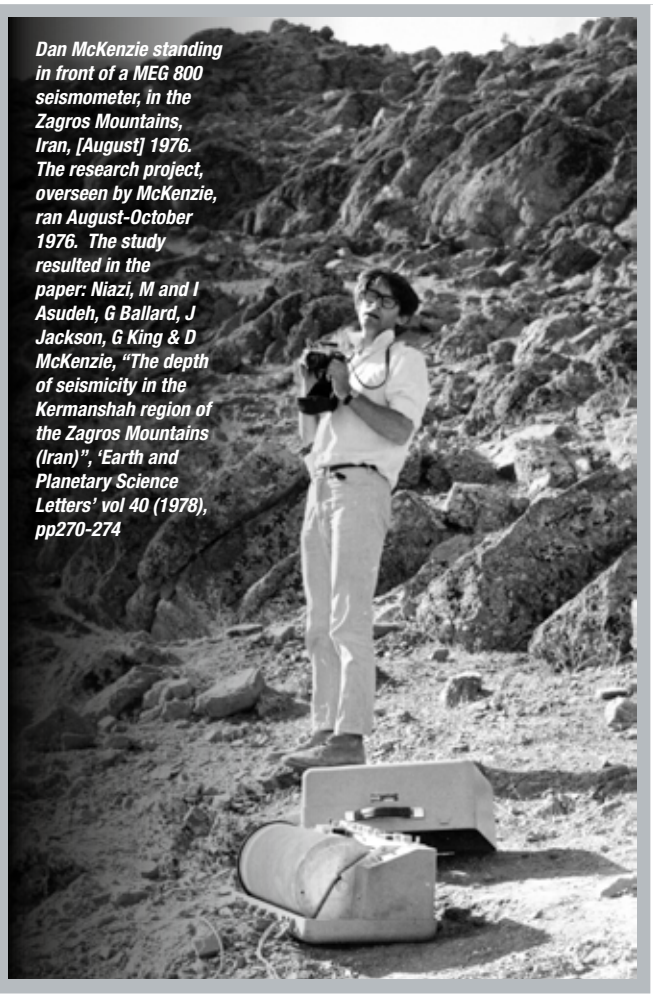
Fifty years ago Dan McKenzie was among the handful of people, worldwide, who brought about the plate tectonics revolution. This new paradigm for understanding the Earth came about because of an explosion in the amount and quality of data, made possible by new technology – a process that continues in Earth sciences today.

Archive

McKenzie's landmark 1967 paper with Robert Parker was the first to describe rigid plate movements, and was one of a flurry of publications in the late 1960s that demonstrated the power of plate tectonics to explain the evolution of the Earth's surface. McKenzie has now donated his extensive archive to the Geological Society of London. His archive has been catalogued and can be searched online; the Society has also established a dedicated website for a wider public audience. McKenzie will give the William Smith Lecture in October this year, the highlight of a William Smith meeting centred on plate tectonics and how the ideas developed then and in the half century since continue to shape modern geosciences.

Back in 1967, however, none of this could have been anticipated. "I wondered for a long time", remembers McKenzie, "whether I was going to be one of these scientists who has one really good idea when they're in their twenties

> MCKENZIE HAS DONATED HIS EXTENSIVE ARCHIVE TO THE GEOLOGICAL SOCIETY OF LONDON. THIS HAS BEEN CATALOGUED AND CAN BE SEARCHED ONLINE



Dan McKenzie standing in front of a MEG 800 seismometer, in the Zagros Mountains, Iran, [August] 1976. The research project, overseen by McKenzie, ran August-October 1976. The study resulted in the paper: Niazi, M and I Asudeh, G Ballard, J Jackson, G King & D McKenzie, "The depth of seismicity in the Kermanshah region of the Zagros Mountains (Iran)", 'Earth and Planetary Science Letters' vol 40 (1978), pp270-274

Top left: Detail from figure showing a reconstruction of the Indian Ocean, 75 million years before present, used in the paper McKenzie, D & J G Sclater, "The evolution of the Indian Ocean since the late Cretaceous", 'Geophysical Journal of the Royal Astronomical Society', vol 24 (1971), pp 437-528

Bottom left: Installing strain meters in qanats at Dasht-e-Piaz [Plain of Onions], c.200 km south of Mashad in north-east Iran. Image shows the field workers lowering a rope down the vertical shaft of a qanat to about 30m deep to access the horizontal tunnel at the base in which the strain meter was placed

and that's it." He needn't have worried: he has gone on to work extensively and successfully in fluid dynamics, continental tectonics, mantle dynamics, melt generation and planetary geology, among other fields.

He was elected a Fellow of the Royal Society in 1976, aged just 34; in 2011 he received their premier award, the Copley Medal. McKenzie has received honours and awards from around the world, including the Gold Medal of the Royal Astronomical Society in 1992 and the Crafoord Prize from the Royal Swedish Academy of Sciences in 2002. And he was in 1983 the youngest recipient of the Wollaston Medal for his career contribution to Earth sciences.

Scripps

In 1963 McKenzie started his PhD in the Department of Geodesy and Geophysics at Cambridge, winning while a research student a fellowship from King's College that gave him the freedom to travel and pursue his own ideas. He headed for the United States, to Scripps Institution of Oceanography at the University of California at San Diego, Lamont Geological Observatory at Columbia University, New York, and the California Institute of Technology in Pasadena, California, in turn. He also attended in 1966 a conference at the Goddard Space Science Laboratory in New York on 'The History of the Earth's Crust'. "It wasn't really about the Earth's crust at all", says McKenzie. "It was all the new stuff from magnetic anomalies, earthquake mechanisms and it was quite clear then that the whole thing was essentially on."

Continental drift had never been taken seriously by most geophysicists; it was these new data from the oceans that changed minds and led to plate tectonics. Technology developed for submarine warfare during the Second World War led to accurate bathymetry, refined in the Cold War. Magnetic methods for tracking submarines picked up remanent magnetism in the rocks of the ocean floor; academic research began to use both methods, and to measure heat flow.

By the early 1960s, the mountainous mid-ocean ridges, with higher heat flow than their surrounding plains, were well-documented. In 1962 Harry Hess of Princeton University suggested that the ocean floor formed there and spread out on each side. In 1963 Cambridge geophysicists Fred Vine and Drum Matthews combined this idea with reversals of the Earth's magnetic ▶

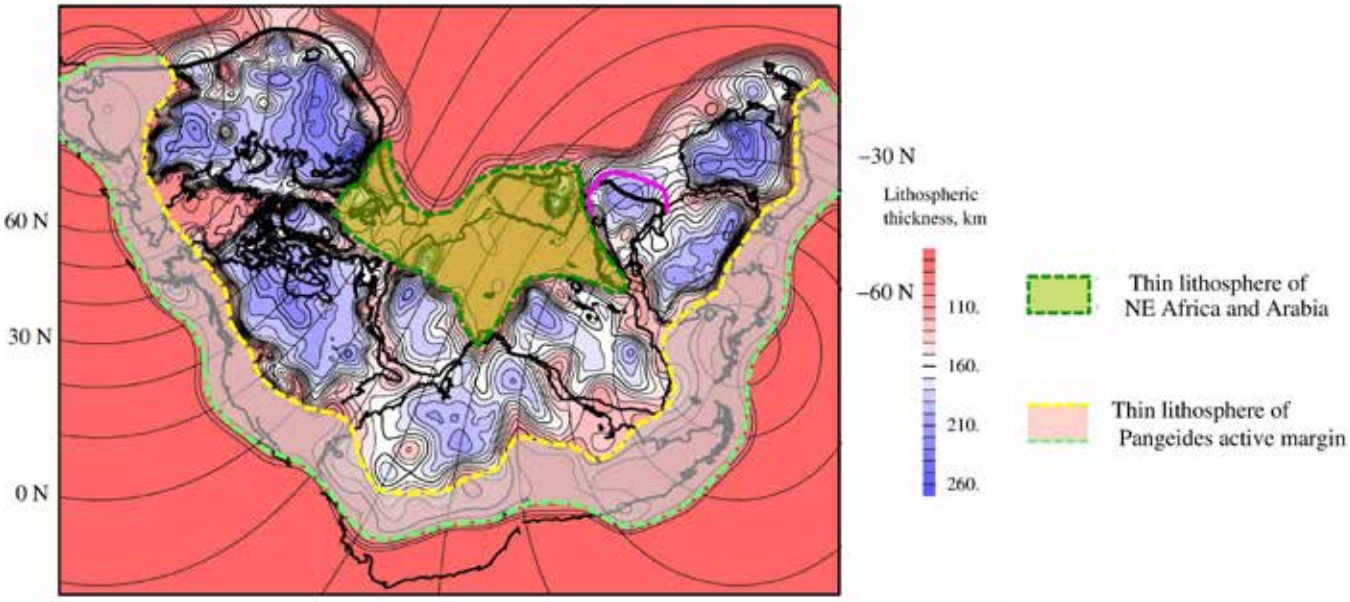
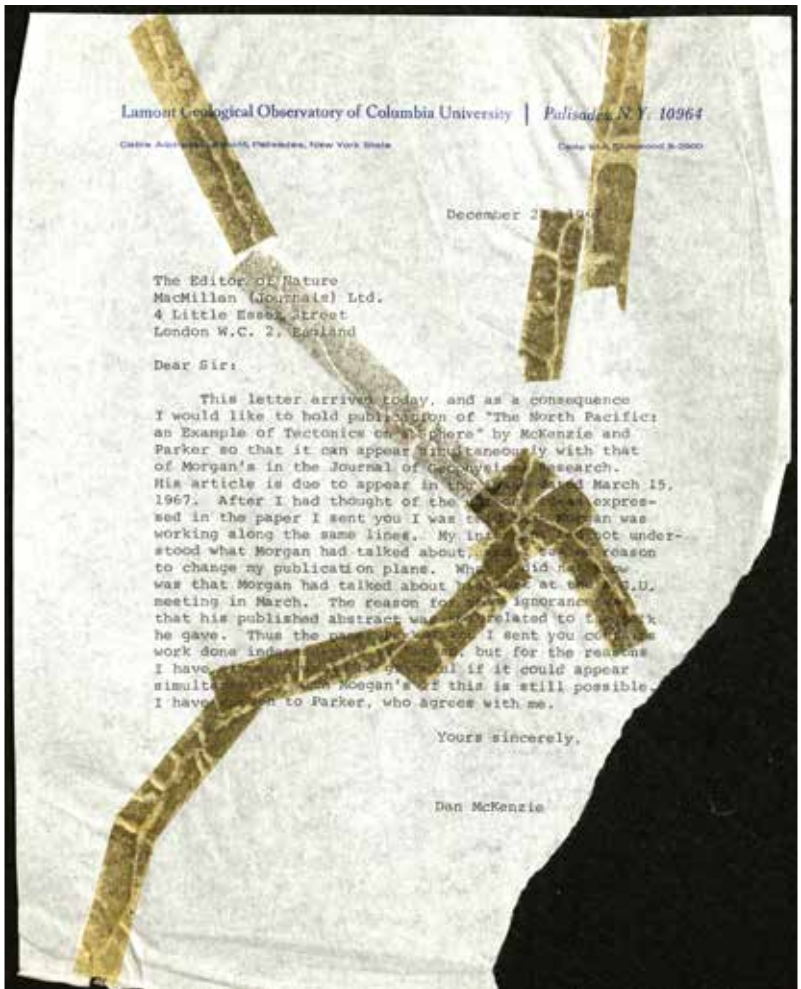


Figure from paper: McKenzie, D and M C Daly & K Priestley, "The lithospheric structure of Pangea", vol 43 (September 2015), pp783-786

Colour photograph, from a 35mm slide, entitled 'Surface break 1971 Gediz earthquake in Turkey', showing Dan McKenzie looking over a surface fault caused by the Gediz earthquake, Turkey, [August-September 1978]. The Gediz earthquake occurred on 28 March 1970



Lamont Geological Observatory of Columbia University | Palisades, N.Y. 10964

December 2[illegible] 1967

The Editor of Nature
MacMillan (Journals) Ltd.
4 Little Essex Street
London W.C. 2, England

Dear Sir:

This letter arrived today, and as a consequence I would like to hold publication of "The North Pacific: an Example of Tectonics on a Sphere" by McKenzie and Parker so that it can appear simultaneously with that of Morgan's in the Journal of Geophysical Research. His article is due to appear in the [illegible] March 15, 1967. After I had thought of the [illegible] expressed in the paper I sent you I was [illegible] Morgan was working along the same lines. My [illegible] not understood what Morgan had talked about, [illegible] reason to change my publication plans. What did [illegible] was that Morgan had talked about [illegible] at the A.G.U. meeting in March. The reason for [illegible] ignorance was that his published abstract was [illegible] related to the work he gave. Thus the [illegible] I sent you contains work done independently, but for the reasons I have [illegible] if it could appear simultaneously [illegible] Morgan's if this is still possible. I have [illegible] to Parker, who agrees with me.

Yours sincerely,

Dan McKenzie

McKenzie's letter to the Editor of Nature, requesting delay in publishing, torn up (and subsequently repaired) by Dan when the request was refused

▶ field to explain symmetrical stripes of normal and reversed rock magnetism on each side of ridges.

Euler

In the 1950s the prospect of underground testing of nuclear weapons by hostile powers led to the US establishing a committee to discover how to detect such tests. The result was a standard seismometer, deployed worldwide in a linked network using the same protocols for testing and with a standardised response. The Worldwide Standardized Seismic Network (WWSSN) produced an immediate improvement in the accuracy of earthquake locations, showing that undersea earthquakes were very tightly clustered along what were later seen as plate boundaries.

As well as location, the WWSSN gave information about the first movements and hence the mechanism of earthquakes, which corresponded to fault movements. This source of information on current Earth movements was essential for McKenzie's formulation of plate tectonics.

"A lot of earthquakes had been studied in the North Pacific by, particularly, Father William Stauder in the Mid-West," recalls McKenzie. "He actually listed the slip vectors of these earthquakes all around the North Pacific." McKenzie examined the data around the north Pacific, and found large areas with no seismic activity – plates – surrounded by narrow bands with consistent movements – plate boundaries. He saw that the plates themselves were rigid and did not deform; their movement on the Earth could be simply described using Euler's

theorem, which McKenzie's PhD supervisor Teddy Bullard had used to fit together the continents across the Atlantic (Bullard Everett and Smith, 1965). "So I then plotted that up … plotted is too fancy a word," says McKenzie. "I took a National Geographic globe with its cap and drew with a marker pen lines on the globe and fiddled with the cap until I could see where the pole was for the motion of the Pacific [with respect] to North America."

In 1967 McKenzie was at Scripps, as was Bob Parker who had written a mapping programme – HYPERMAP – that was ideal for presenting these ideas. Together they wrote a paper and posted it off to *Nature*. "I remember very clearly when I posted it. I thought 'yep, that's going to cause me to be elected to the Royal Society'" he says, "which was an arrogant thing to say but I was perfectly well aware of how important this was going to be when we did it".

Lamont

Later in 1967, McKenzie moved to Lamont, where he discovered that Jason Morgan at Princeton had been working along very much the same lines. He also found out that Morgan had spoken about his work at the American Geophysical Union Spring Meeting that year, which McKenzie had attended. McKenzie wrote to *Nature* to try to delay publication of his paper, to no avail – and he tore up his letter to the Editor (picture).

'McKenzie and Parker' was published in the final issue of *Nature* in 1967; Morgan published in 1968. "I was completely unaware, until I got to the East Coast, what had happened, and that was why I tried to delay the publication of the Nature paper," says McKenzie. "Jason certainly has priority, but he did it in a completely different way. He didn't use the earthquakes at all - he used the magnetic anomalies."

McKenzie feels that this was one of those times when ideas leap out of the data, if you are looking at them in the right way. "As soon as I saw the slip vectors around the north Pacific and could describe that by a single pole, for me, that was it; I didn't have to look at every other bit of the Earth. With Jason I think it was exactly the same. It was so obviously straightforward and the key piece of the whole story was that the plates were rigid."

But McKenzie and Parker (1967) was not McKenzie's first work on plate tectonics nor, arguably, his most significant. In 1966 he had returned to Cambridge to complete his PhD thesis, *The Shape of the Earth*. While waiting for his examination, he thought about ridges. Seafloor spreading was accepted, but the ridge was seen as part of a convection cell in the mantle, with the up-welling driving the two halves of the ocean apart. But McKenzie saw that the plates need not have any deep structure, they could be like ice floes moving apart, with magma welling up to fill the gap as a consequence of the movement. When next at Caltech, he modelled the process by computer, using heat flow and ocean floor elevation; his models matched the observations far better than those tying ridges to deep-seated convection (McKenzie, 1968).

Triple junctions

In the late 1960s, ideas were moving quickly. McKenzie together with Morgan published in 1969 a vector analysis of the evolution of triple junctions. And in 1968 he and John Sclater embarked on a project to survey the Indian Ocean, deriving the geological history of the ocean basin (McKenzie and Sclater 1971). McKenzie saw this extraordinarily successful result as a reason to move on. "I thought this was really just turning the handle … everything worked, which was really frustrating to me," he says. "I then really stopped working on marine geology and geophysics, because I thought - gosh, we're done."

He then went back to mantle convection. He applied what was becoming his trademark, of picking out the fundamental physical considerations and testing them in the simplest possible numerical models. "All the geophysicists are busy trying to model the Earth putting in every sort of complication you can, what I call kitchen sink modelling," he says now. "I don't think you learn anything. What I want to do is numerical experiments and see how these things behave." His fluid dynamics work in the 1970s showed that mantle convection would produce a measureable gravity signal, testable by observation.

At the same time, he was working

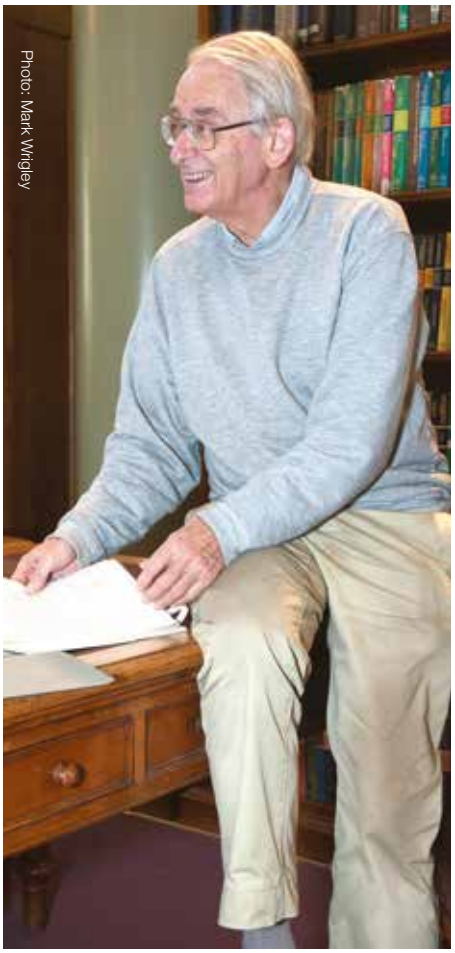


Photo: Mark Wrigley

***Above:** Dan McKenzie, pictured in the Geological Society Library*

> "I REMEMBER VERY CLEARLY WHEN I POSTED IT. I THOUGHT: 'YEP, THAT'S GOING TO CAUSE ME TO BE ELECTED TO THE ROYAL SOCIETY'" HE SAYS, "WHICH WAS AN ARROGANT THING TO SAY BUT I WAS PERFECTLY WELL AWARE OF HOW IMPORTANT THIS WAS GOING TO BE WHEN WE DID IT"

on the continents, where plate tectonics did not apply. "It was clear that the deformation was distributed, and you couldn't really talk about plate tectonics in many of the areas on land," he says. "But there were regions inside the continents which really didn't have many earthquakes, which were moving rigidly."

In 1967, while based at Lamont, he had started work on the area from the Azores to eastern Iran, which he thought large enough and seismically active enough sort out what was happening in the Mediterranean. The region's politics meant that he moved to fieldwork in the Aegean; this is what led McKenzie to his 1978 model of extensional basins.

Model

The McKenzie Model applies to basins such as the North Sea, formed by extension of continental crust and characterised by the accumulation of thick sedimentary deposits, all formed more or less at sea level, with the first extension by faulting. This was the pattern emerging from seismic exploration of the North Sea in the 1970s, but neither industry nor academic researchers could produce an adequate model of how it happened.

"What caused the penny to drop with me was that I'd known for a long time that the whole of the Aegean, the north and the south, from east to west, was all being stretched," he said. "If you're stretching something which is 400 km by 400 km, you can't just be stretching the crust. You must be stretching the mantle."

The McKenzie Model has its roots in the mid-ocean ridge modelling he had done a decade before: stretch the lithosphere, then track the thermal consequences. Fault-controlled subsidence is thus followed by thermal subsidence. "I wrote a short paper … after I'd moved to Lamont," recounts McKenzie. "That was then picked up by their Industrial Associates before it was published and all the oil companies just like that said 'this is correct, this is what we're going to use'". And they did, helped by the fact that computing power had advanced to the extent that the models could be written and run on desktop PCs.

McKenzie's further work with Andrew Mackenzie of the University of Bristol demonstrated how this model could predict maturation within the source rocks of a basin. After some difficulty in publishing the paper – neither author had a track record in geochemistry – McKenzie and Mackenzie (1983) was awarded a prize as the best paper in organic geochemistry that year.

At the same time, McKenzie continued to think about the driving mechanisms of plate tectonics. "Plate tectonics works on the surface but clearly the Earth is not a rigid enterprise. So what went on below? It was clearly some form of thermal convection … but the rest of it was unknown." Isotope geochemistry is a source of data on the mantle, and one that McKenzie went on to learn and use. This set him thinking about how a melt separated from its residue. To his surprise, this process was not covered in the literature.

"I thought well, this is a branch of fluid mechanics; I understand fluid mechanics; why don't I sit down and see whether I can actually see how to set up this problem from the conservation laws of mass and energy?" He could, launching a new field in petrology with the novel fluid dynamics equations now called the McKenzie Equations. McKenzie went on to test them with data collected around Theistareykir in Iceland. The results answered petrological questions, but posed more.

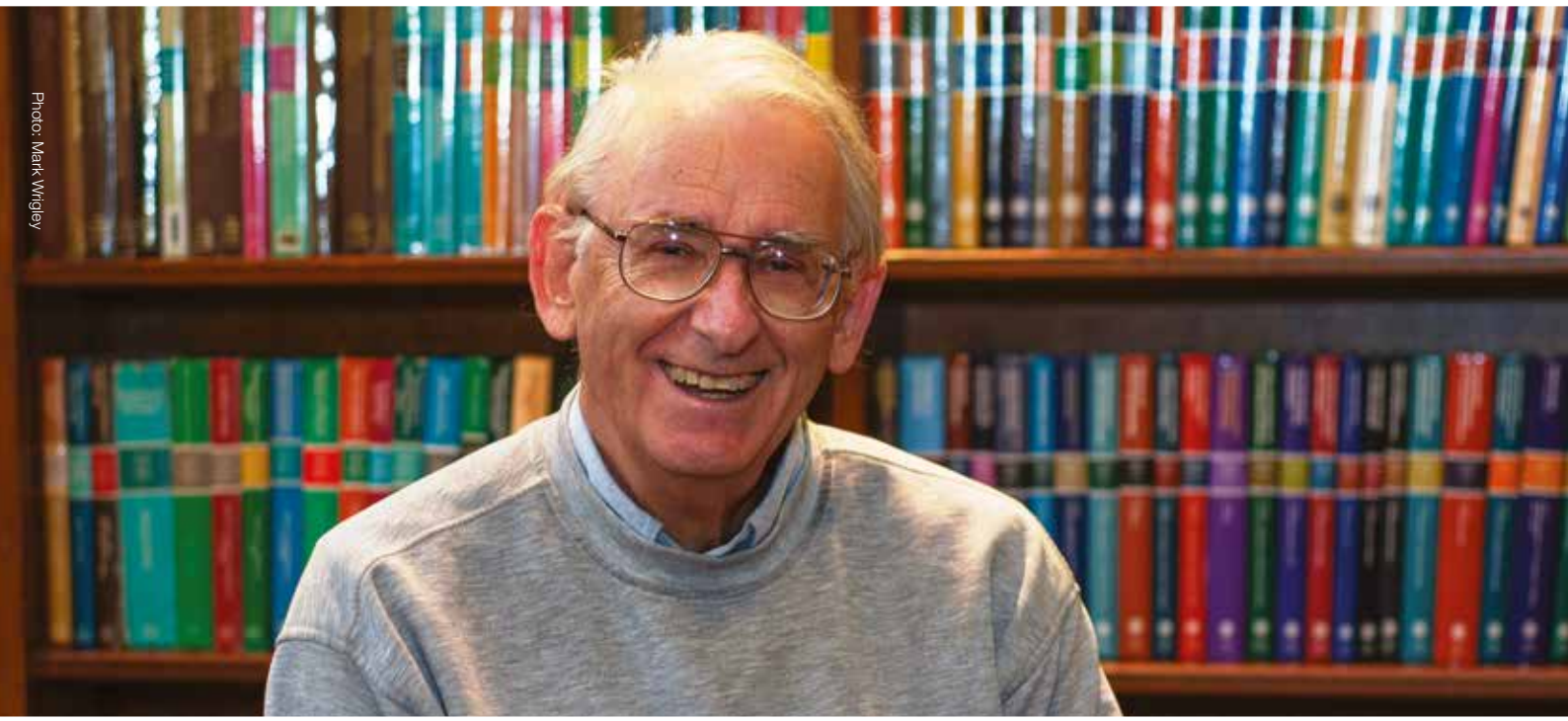


Photo: Mark Wrigley

Professor Dan McKenzie, pictured in the Geological Society Library

"Yes the mantle is very well stirred, but it isn't well mixed because the material doesn't diffuse; it's just like Brighton rock - it's streaked," he says. "In some way that we still don't understand, the melt can be extracted from those streaks without interacting with any of the rest of it. How that works is still quite mysterious."

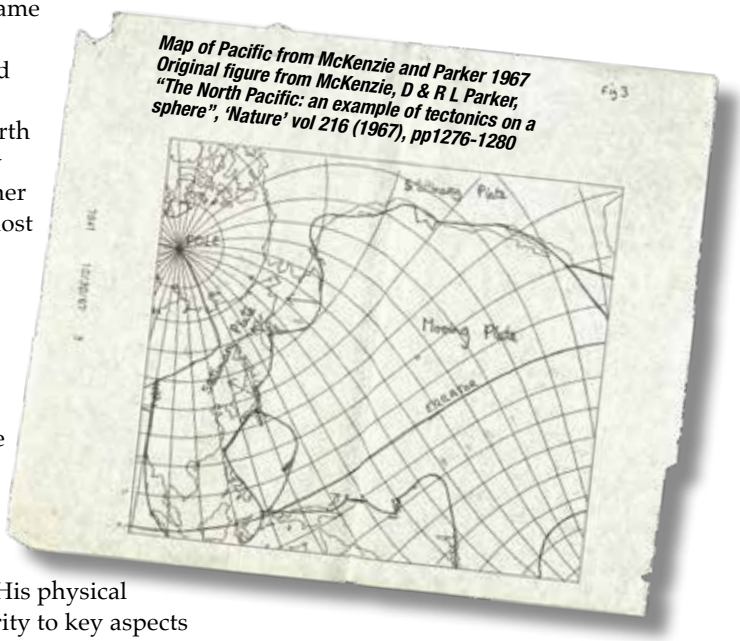
Diverse

McKenzie's career has covered diverse fields across Earth and planetary sciences. What they have in common is a focus on observations and the application of fundamental physical reasoning. Throughout his career, McKenzie has used, developed and adapted new technologies and sources of data. Earthquake seismology provided the key to understanding plate movements 50 years ago; now surface wave tomography, for example, makes possible reconstruction of continental lithosphere, such as Pangea, using surface wave tomograhy (McKenzie, Daly and Priestley 2015).

For the future, McKenzie sees progress made possible by better technology, especially seismology. "Anyone who's interested in any part of the interior of the Earth is in the end going to use full waveform inversion whether they're interested in mantle convection, whether they're interested in finding oil in sedimentary basins, whether they're interested in the interior structure of the inner core – all of these things are going to be done with this technology in just the same way as all astronomers use big telescopes." And he sees stronger links developing between Earth sciences and astronomy over planets around other stars, but regrets that most observations are going to be about planetary atmospheres – not planetary interiors – in the medium term.

McKenzie's success has come about because he has kept a sharp eye on the data and how it can illuminate the workings of the Earth. His physical insight has brought clarity to key aspects of how the Earth works, and, in turn, highlighted new questions. And, above all, he has stuck to the facts, in the lab, on the computer and in the field.

"You've got to be helped by making observations and decide whether you believe the observations or not on the basis of the observations themselves, not on the basis of theory. I feel that all very strongly now." ◆



Map of Pacific from McKenzie and Parker 1967 Original figure from McKenzie, D & R L Parker, "The North Pacific: an example of tectonics on a sphere", 'Nature' vol 216 (1967), pp1276-1280

Editor's Note: All papers referred to in this article can be read on the McKenzie Archive website, at **W: www.mckenziearchive.org**

McKenzie kneeling over photograph on ground, 'Sept 18 Central Japan 1971, trying to see an active fault on a stereo pair of aerial photos by its effect on paddy field boundaries'

THE TRANSLATORS

Ted Nield on the first English translation of the first ever mining textbook – Agricola's *De Re Metallica*, 1556

On 20 December 1907, a young American couple – Bert and Lou - moved into Red House, Hornton Street, in the Royal Borough of Kensington, not far from Holland Park - the sort of area where a modest flat can now set you back £2 million. It was a rambling, old (1835) eight-room, two storey dwelling with a huge garden and high walls all around - the site now occupied by Kensington Town Hall. They were in their early 30s, and had met as students at Stanford University. They were intellectual, athletic, and both geologists. They were also very rich.

Like many geologists in the extractive industries, they had already circumnavigated the world. Bert had spent much time in Western Australia and both had spent years in China, where they had weathered the Boxer Rebellion (guns in hand) and learned Mandarin (which they spoke together whenever they needed to keep things from the servants).

Stanford

Bert was a little older - one of Stanford University's very first student crop, and a Senior when they had met. They had married as soon as Bert got his transfer from the Australian goldfields to his new posting in China. He was by that time a fully-fledged mining engineer, partner in prestigious London Wall firm Bewick Moreing, and a man of impressive industrial and academic credentials. She, meanwhile, had developed her remarkable facility with languages, mastering not only Chinese but also Latin.

Neither had 'come from money', though Lou's modest banking background was more well to-do than Bert's; he had been born in a two-room weatherboard cottage in Iowa, to a blacksmith father who sold farm tools. All their money was their own - built through workaholic Bert's considerable geological, mining and business acumen. Their uncomfortable years were now over; but despite his success, something gnawed at him.

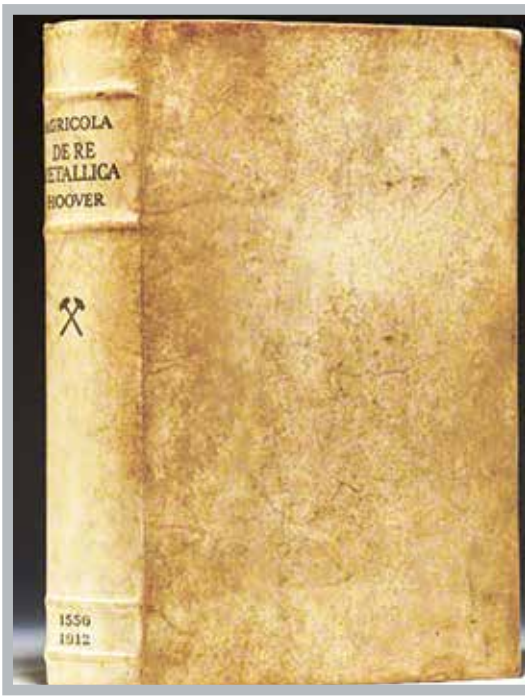
Bert and Lou both knew that before it can be found in the ground, wealth must first be found in the mind, by applying our understanding of the Earth to find, win and refine the useful minerals on which civilization depends. For the successful, this might lead to great personal fortune – and by 1914, Bert could lay claim to an estimated $4 million - quite a lot of money, even today. But what mattered to them, now they were established, was respect.

Like many men and women whose scientific work allies them to the ancient occupations of mining and building, Bert felt his industrious tribe had never really enjoyed the respect it properly deserved. 'Mining' was brutish, manual, labouring - trade. 'Engineering' evoked the grease-monkeys of heavy industry, wielding the wrenches that the class-ridden British (among whom Bert now resided) scornfully named after them. Yet it was precisely such people who made wealth, and hence advanced society, possible. Living in Britain's snobbish Imperial capital undoubtedly strengthened these feelings in the patriotic Republican; whose initials 'HC' had long ago earned him the nickname 'Hail Columbia'.

Rational basis

Mining had long embraced the scientific revolution. Geology provided it with a rational basis for improving prospectors' chances of success, and boosting their confidence. Yet unlike petroleum, whose industrial exploitation began in the later 19th Century, metal mining was immeasurably older, and its culture very different - emerging from the Middle Ages with deeply ingrained traditions of occult knowledge and protective secrecy. Yet, such an ancient heritage should, they thought, only enhance the regard in which the profession was held – if only it were better known.

Older by far than the scientific tradition, mining's know-how had been ▶



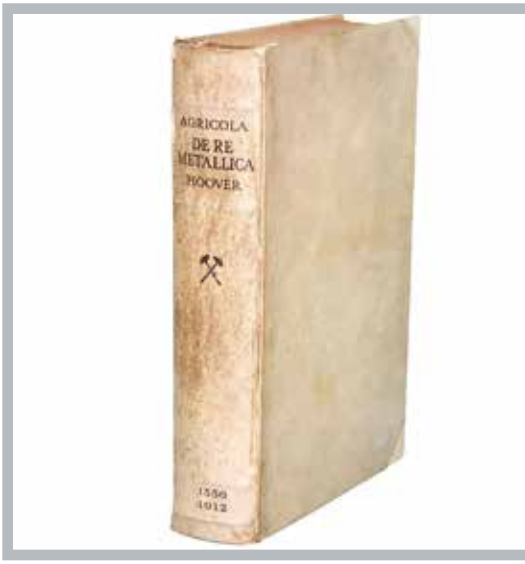
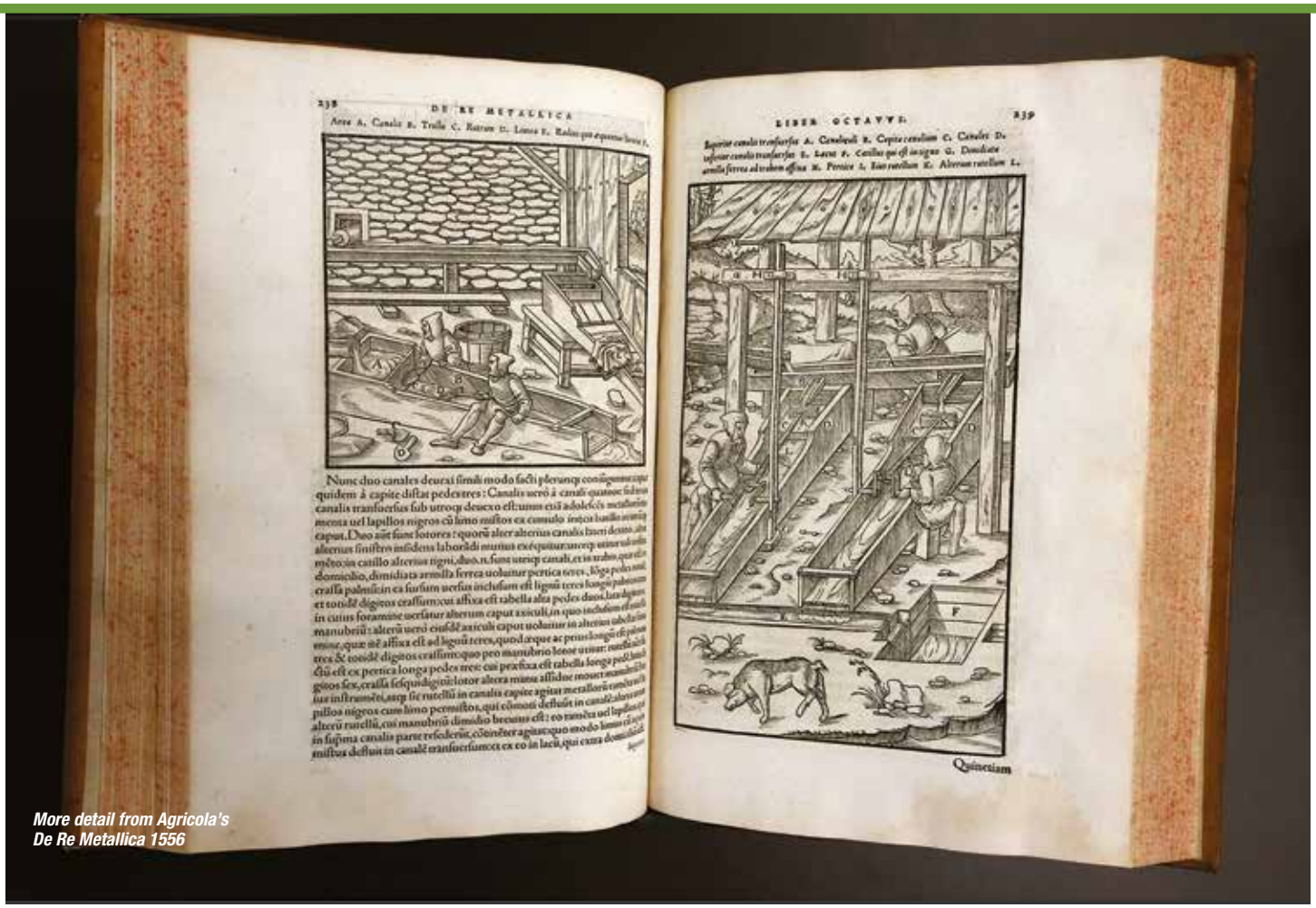


Photo: Wikimedia Creative commons

***Top:** The translation and facsimile edition produced by Bert and Lou in 1912, together with faux calfskin binding*
***Middle:** A copy of De Re Metallica may be inspected on request in the Society Library (Rare Book Collection).*
***Below:** Agricola's De Re Metallica 1556, showing typical page with woodcut illustrations, the large number of which delayed publication until after the author's death*

***Left:** The slippery road to public life - the translators make a 'whistlestop', 1928*



More detail from Agricola's De Re Metallica 1556

▶ assembled by professional guilds, jealously guarding their secrets, mostly in continental Europe. Nobody seemed to appreciate (thought Bert and Lou) quite how ancient this understanding was - how much lore had come down from time immemorial, much of it trial-and-error knowledge that had now, belatedly, received the endorsement of scientific understanding (plus much that did not).

However, luckily, one single source-work had preserved all that accumulated knowledge of the ancients; one compendious manual, covering prospecting, mining, refining and smelting and providing a snapshot of everything that men of the 16th Century knew - or thought they knew - about wresting wealth from the Earth's grip. This was the book that gave the science of mineral exploitation *pedigree*.

It was also a summary of geological understanding - at least, of that part of it which concerned winning useful minerals. It was the miner's Bible. And yet, almost nobody paid it any attention. There was not even an English edition.

Georg Bauer

The book was *De Re Metallica*, by 16th Century German scholar Georg Bauer (1495-1555) - more widely recognised by his Latinized byline, Georgius Agricola. His last, enormous work had had to wait until 1556 - a year after his death - to be published, so numerous (289) were the woodcut illustrations it required.

Lou had first had the idea, in 1906. In London, centre of world metals and minerals trading, with great libraries all around them, why should they not embark upon a long-overdue English translation of Bauer's seminal masterpiece?

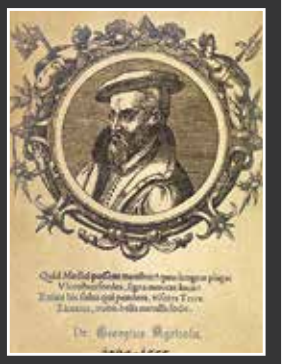
They were, after all, eminently qualified. Lou was now a first-rate linguist. Both were geologists. Bert had by now compiled his early lectures, given in Columbia and Stanford universities, into a book entitled *Principles of Mining* (1909), which was becoming the standard textbook. Both were fully experienced in prospecting, mining, refining and smelting. Far from needing permission - who better was there to do this? Neither was easily daunted; though had they known more (as many before and after them have said) they might never have even begun.

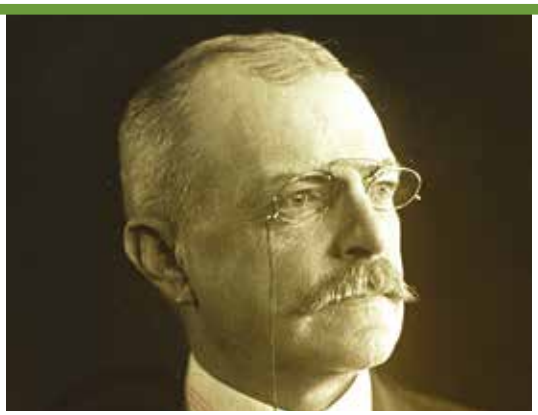
Translating Agricola proved a Herculean task. Bauer, knowing words in his native tongue for the tools, techniques and rock features he needed to explain, had no Latin vocabulary with which, writing as 'Agricola', he could express himself. So he had coined new Latin words; words that occur nowhere else but in *De Re Metallica*. To figure out what they meant, the translators had to back-translate from Bauer's Latin neologisms into Middle High-German mining jargon, and then from there, into English.

Beginning in earnest in 1908, the job took the couple four years. But how was it to be published, and by whom? And who was to pay for it? By the time they were ready to go to press, Bert had garnered subscriptions from his industrial and financier friends to pay for the project, even before publication became an issue. The project by then had grown in Bert's mind far beyond a mere translation of the original. He now envisaged a full-sized (and fully annotated) facsimile - right down to original typefaces and hand-made paper. They had taken on staff to help. It was monumental.

Slippery road

But Bert was an astute and persuasive financier, and after years of arm-twisting, Bert and Lou finally succeeded in bringing one of the great scientific works of the late Mediaeval period from out of the shadow. Their 1912 rendition remains the one authoritative version of *De Re Metallica* in English today, and its clarity of expression (and extensive learned footnotes and





Left: Portrait of Herbert Hoover (1874-1964), 'Hail Columbia', at about the time his translation of De Re Metallica appeared. Wikimedia Creative commons

Top middle: Portrait of Georg Bauer, 'Agricola'

Top right: Waldemar Lindgren FGS (1860-1939), pictured in 1912. Lindgren gave the young Hoover his first geological job, working for USGS. From the Society's archives

Bottom right: Lou Henry Hoover (1874-1944), geologist and linguist. Translating Agricola's great work was originally her idea

annotations, putting Agricola into the context of world mining history) mark it as a true classic of translation.

Two years after it appeared, War broke out in Europe. From their home in London, Lou and Bert worked 14-hour days organising relief work in France and Belgium, repatriating 120,000 Americans stranded by the war. He didn't know it yet, but Bert's glittering geological and mining career was over. He had, as he put it, set foot "upon the slippery road of public life".

In 1929, 31st President Herbert Clark Hoover with his First Lady, Lou Frank Hoover, forsook the Red House for the White House.

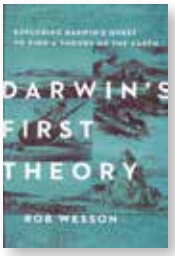
Wisely, Bert and Lou kept up the habit of conversing privately in Chinese. ◆

Ted Nield is Editor of Geoscientist

FURTHER READING

- Nash, George H, 1983: *The Life of Herbert Hoover (Vol 1), The Engineer* 1874-1914. W W Norton & Co., New York ISBN 039301634X 968pp.

Darwin's First Theory - Exploring Darwin's quest to find a theory of the Earth



I have never passed up the opportunity to remind the world that Darwin was, primarily, a geologist, nor that he owed his biological insight to the unique world view of a geologist, who sees objects – be they landforms or species - not as perfect objects, but as the end result of historical processes. And lo, on the very day I write this review of Rob Wesson's admirable and hugely enjoyable examination of Darwin's geological researches, my colleague Oliver Morton at *The Times* writes (in a box-text about the great man): *"Charles Darwin - A geologist by training..."*.[1]

Clearly, the message is getting through, and this hugely readable book will ensure it is heard more widely – especially perhaps across the Atlantic. Wesson has made it his task to examine Darwin the geologist, from 'training', at the hands of Adam Sedgwick, to his many significant geological contributions, notably on the uplift of the Andes, the subsidence of Pacific coral islands, and his less successful brush with glacial theory, which eventually trumped his eustatic explanation for the Parallel Roads of Glen Roy.

Wesson, a geophysicist with USGS who (we gather) was 'seduced' by mathematical modelling early on and spent much of his life since in front of a computer, traded all that for some camping equipment and a trenching tool to get back in the field, retracing Darwin's extensive footsteps in company with field geologists. Thus we encounter him - from Cwm Idwal to Glen Roy, Patagonia to the Isla Santa Maria, where Darwin and Fitzroy noted the abrupt raising of the shoreline following the 1835 earthquake which destroyed Concepcion and Valparaiso during the Beagle voyage. This event, life-changing for Darwin, was paralleled by the 2010 Chilean earthquake, which thus enables the author to compare, contrast and fit both events into a modern plate tectonic framework, excitingly interlacing his dual narratives as he goes. It is a compelling tale, engagingly told.

Away from tectonics and seismology, Wesson occasionally finds himself on shaky ground - notably in palaeontology, over-egging the asteroid strike at the end of the Cretaceous, which progressive opinion now views as one factor among many - no mass extinction ever having a single cause - and prime importance in that case resting instead with the Deccan Trap eruptions.

I could have done, too, without all the trade-names (I won't mention them again, but the repetition of various brands of outdoor gear and motor vehicle brought out the Lord Reith in me). Nor did I see the reason behind granting any publicity oxygen to those pernicious young-Earthers who masquerade as scientists and seek to portray 'Darwin's first theory' as his 'first big mistake', for their own fraudulent purposes.

But these blemishes, if such they are, are minor. Others may not even find them so. Although it can and should be read for pleasure and profit by all, principally this is a book for Americans - 42% of whom, it seems from a recent survey, prefer believing their Bible over what geologists say about the age and origin of the Earth; a lamentable fact that reduces the human race's already slim chance of escaping its own imminent extinction even further, Wesson concludes.

Reference

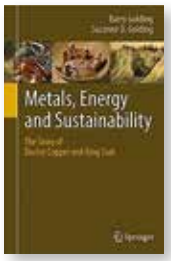
1. Morton, O: 'Class of 2017 dumber than Victorians'. The Times July 18, p15

Reviewed by: ***Ted Nield***

DARWIN'S FIRST THEORY - EXPLORING DARWIN'S QUEST TO FIND A THEORY OF THE EARTH
by ROB WESSON 2017 Pegasus Books
ISBN 978-1-68177-316-2 457pp (hbk)
List Price $29.95 W: www.pegasusbooks.com

Metals, Energy and Sustainability - the Story of Doctor Copper and King Coal

In our era, as global challenges rightly take centre stage, this book is very timely. The imperative to confront human-induced degradation of climate, soil fertility, ecosystems and freshwater resources must be reconciled with the need to provide the burgeoning human



population with sustenance, shelter, healthcare and other means of comfort and pleasure. The scale of these challenges can feel overwhelming. Yet this highly readable book, of only four chapters, provides a worked example of how much insight can be obtained by rigorous scrutiny of the interdependencies between just two Earth resources.

Having worked in and around coal and copper mines for decades, I imagined I would learn little from this book. I was very much mistaken. I soon realised I was learning something important on every other page.

The first chapter gives an engaging explanation of how and why, among all the world's mined commodities, copper and coal remain pre-eminent in social and economic importance. The second chapter is essentially geological, summarising the principal economic occurrences of copper and coal deposits. The third chapter provides a historical overview of the technology and economics of exploitation of both commodities – over seven millennia in the case of copper, and over several centuries in the case of coal. The final chapter considers the future of both commodities, examined quantitatively within a framework of holistic sustainability.

The narrative confounds the customary over-simplifications which dominate the qualitative literature on sustainability. For instance, renewable energy technologies use far more copper than conventional fossil-fuel technologies. So to advocate massive expansion of renewable energy use is to demand an expansion and intensification of copper mining and refining.

The lively prose and striking colour illustrations make for an enjoyable read. Quibbles are few and minor. I spotted just two minor typos (of the 'to/too' variety), and in chapter three, I missed scale-bars on ore specimen photos, and would have liked more thorough labelling. These pale into insignificance alongside the depth and breadth of this volume. It is essential reading for anyone interested in the contemporary interface between economic geology and sustainability debates.

Reviewed by ***Paul L Younger***

METALS, ENERGY AND SUSTAINABILITY - THE STORY OF DOCTOR COPPER AND KING COAL
by BARRY GOLDING & SUZANNE D GOLDING, 2017.
Published by Springer, Cham (CH).
ISBN (print) 978-3-319-51173-3,
ISBN (electronic) 978-3-319-51175-7. 196pp
List price: Hbk £44.99. e-book £35.99.
W: www.springer.com/gp/book/9783319511733

Crust-Mantle Interactions and Granitoid Diversification – Insights from Archaean Cratons

Based upon contemporary (2011-2015) research from the UNESCO-IGCP project 'The Changing Early Earth', this GSL Special Publication documents the evidence for fundamental change in the tectonics and magmatism on the Archaean Earth. Initial mafic magmas (erupted as oceanic crust, island arcs or plateaus) evolved through to the calc-alkaline Tonalite – Trondhjemite – Granodiorite (TTG) rock suites of accreting microcontinents, to the diversity of late Archaean granitoids generated at thick convergent continental margins.

An overview paper introduces the research context, including an essential background section on the specific terminology associated with the geochemical (compositional) nomenclature and classification, characteristic features, age relations and temporal – spatial patterns of Archaean granitoids. The volume contains three main regionally-based thematic sections of seven papers: Mesoarchaean Volcanic Supracrustals from Greenland, Mantle-derived Alkaline Rocks from Western Karelia (Fenno-Scandian Shield) and Mantle to Crustal Melting in the Indian Shield. A final section of three papers presents current insights derived from associated studies in metamorphic petrology.

The contributions chronicle the development of crust-forming magmatism from minor early Archaean (Eoarchaean) crust-mantle interactions to the appearance of extensive multisource granitoids, exhibiting crustal recycling (via mantle and intra-crustal reworking) at the end of the Archaean. These insights significantly expand the debate on the origin of Archaean igneous rocks and their role in deciphering Archaean crustal evolution and tectonics, providing new evidence for increasing crust-mantle interactions, granitoid diversification and the changing plate tectonic 'style' operating towards the end of the Archaean. The overall conclusion is the pre-eminence of convergent tectonic regimes over plume tectonics as the main crustal growth mechanism since the Eoarchaean.

The volume provides an excellent overview of the recent interdisciplinary geoscientific developments within this important and evolving field. The contributions are well-written and edited, complemented with appropriate figures, photographs and data-tables, features that one has come to expect from the GSL Special Publication series. A minor presentational criticism is that a couple of field photographs appear to have colour 'bled' in the print copy obtained by this reviewer, unfortunately distracting from the feature details described.

In summary, the editors and contributors are to be congratulated. An informative and recommended read.

Reviewed by ***Mark Griffin***

CRUST-MANTLE INTERACTIONS AND GRANITOID DIVERSIFICATION – INSIGHTS FROM ARCHAEAN CRATONS
by HALLA, J, WHITEHOUSE, M J, AHMAD T AND BAGAI, Z (editors). Geological Society of London Special Publication No 449. 2017. Geological Society of London. ISBN 978-1-78620-280-2. Hbk. 256pp. ISSN 0305-8719.
List Price: £110.00, Fellows' Price £55.00.
W: www.geolsoc.org.uk/SP449

Unearthed: Impacts of the Tellus Surveys of the North of Ireland

Low-flying (56m) aircraft criss-crossing the country, soil augers and waders were the order of the day. The Tellus project itself is described in the Foreword as a 'land and air offensive'. It was 10 years of geophysics and geochemistry costing €15 million that systematically covered the land of a nation, and a bit of its neighbour.

It is ground mostly covered with the thick debris of the last glaciation so, with excellent surface geological maps the geophysics takes the reader to a lower level, literally unearthing the rocks. Measured from the air are the magnetic field, electrical conductivity and gamma radiation; and the results can only be described as spectacular, as demonstrated by the many colourful illustrations.

The geochemistry is based on systematic sampling of soils and stream sediments. The list of elements detected and quantified includes not just the likes of gold, silver and lead but dozens of others some of which would help on BBC's 'Pointless'. The rarer elements can just as easily effect the health of agricultural livestock as the obvious ones like arsenic.

The book advertises the fact that an enhanced national framework of environmental information is established - and the 30 sections, written by 69 authors, show how the data is already being used in spin-off research. Some is pure research, like the study of the Newry Igneous Complex and that of the Mourne Mountains. Others suggest new targets for mineral exploration, while a large number look at health issues of the environment (pollution/wetlands) and people. The combination of environmental and medical data is discussed, suggesting links with cancer, renal and other diseases; and there is a section on in-house radon measurements. The discussion of geoforensics, where soil on a suspect's shoes might lead to an area where the swag or the body is buried, smacks of Sherlock Holmes.

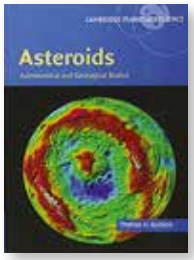
It is a book that most people will not read throughout, but will dip into according to their interests. It is well laid out and early on gives detailed information about how to engage potential stakeholders and communicate with the public; critically important these days. Flick through the pages and you will see from the small maps that 'a picture paints a thousand words'.

The cutting-edge methodologies and statistics point to areas of potential interest or problem rather than closely identifying them. As such it will long continue to stimulate research, be of practical value and generally fascinate.

Reviewed by: ***Tony Bazley***

UNEARTHED: IMPACTS OF THE TELLUS SURVEYS OF THE NORTH OF IRELAND
edited by MIKE YOUNG, 2016. Published by: Royal Irish Academy 423pp ISBN:978-1-908996-87-9
List Price: €30 W: www.ria.ie

Asteroids: Astronomical and Geological Bodies



For most of the time since the discovery of (1) Ceres in 1801, asteroids, those enigmatic lumps of rock (?) mostly condemned to wander the Solar System between the orbits of Mars and Jupiter, have been little more than flecks of light on a photographic plate or CCD detector. How things have changed! Spurred on by the realisation that asteroids can deal life-extinguishing hammer-blows to the Earth, truly stupefying advances in the technology of detectors (including their use in automated discovery and photometric systems) and (since 1991) the attention of robotic spacecraft, the nature, diversity and significance of these bodies are now major areas of intense study.

Burbine's book is intended as '...a reference book for anybody wanting to learn more...' about the smaller bodies of the Solar System (which term now includes, controversially at least in the popular eye, Pluto – or should I say (134340) Pluto?. I believe it succeeds in this objective. Its best feature is the comprehensive coverage of the subject it provides. All the arcana needed to understand asteroids is here, everything from the history of discovery, orbital mechanics, spectroscopy, photometry and more to the threats these bodies pose to the Earth's ecosystems.

The main classes of objects (of which there now seems to be a bewildering variety) are described and there are also competent introductions to the supporting cast of meteorites, comets and related bodies. All of this is commendably up to date, with the initial results of the latest spacecraft missions (Rosetta/Philae, New Horizons) included. The duplication of many of the more complex illustrations as colour plates is to be commended.

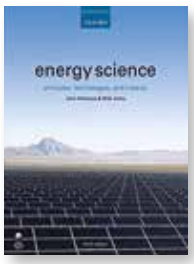
However, the desire to cover so much background material is also, perhaps, the book's one failing. Some of the explanations, for example those of orbital mechanics, are somewhat cryptic and often become little more than jargon. Though I consider myself reasonably well-versed in some of these subjects, I did find such material difficult to follow in places. In Burbine's defence he does suggest that the reader should have a 'college-level knowledge' of physics, mathematics, chemistry, geology and astronomy…'! Phew, who said the age of the polymath was dead?

Overall, this is a book to be recommended. As a 'one-stop shop' on all matters asteroidal it could hardly be bettered. Those wanting to know more about the geology of these bodies will have to look elsewhere, but they can start with this book's excellent reference list.

Reviewed by: ***Trevor F Emmett***

ASTEROIDS: ASTRONOMICAL AND GEOLOGICAL BODIES
by T H BURBINE. Cambridge Planetary Science Series no. 17. Cambridge University Press 2016 ISBN: 9781107096844. 394 pp (hbk)
List Price: £49.99
W: http://bit.ly/2vDWD6H

Energy Science: Principles, technologies, and impacts



It was not entirely coincidental that this book dropped through my letterbox a day after the latest G20 conference ended. I was already in need of a reliable scientific update on where we stand on global warming. The situation changes fast, these days.

And here I have it, with a cover displaying a brick wall (of solar panels) leading up to a bare, mountainous horizon. An implication of global extinction, I assume. Inside, a framework of physics, mathematics and financial analysis delivers a heady excess to the brain. The book is well laid out, dressed with the latest statistics and each chapter embalmed with a short summary, recommendations for further reading and a set of exercises (answers at the back). Compared with the 2013 edition, this new edition has been comprehensively revised and is 100 pages (20%) longer.

The authors' terminal sentence is disturbingly vague. It reads thus: 'Currently, the rise in long term temperature may be limited to 2.7 degrees C by 2100, but only by enacting all the intended contributions of the nations announced in the Paris Agreement in 2015'. That is a hefty ask, particularly as these nations need to deal with a whole range of other (often unpredictable) issues as well. And decidedly more difficult to do now that a new inward-looking, unpredictable, US president has refused to reaffirm that 2015 agreement.

The content of this book is focused on a minority group: scientists. For me, reading it was like ploughing through a field of glutinous mud, full of sticky formulae and arresting acronyms (a loose page re-expanding all those puzzling acronyms would help). Cutting a satisfactorily straight comprehension furrow is tricky and tiring. It's worth the effort in the end, but it's no more accessible to the general public than the man in the moon.

That means we must do more to win over the public and their political representatives, and lead them to understand our logical, scientific, point of view. Just replacing the cover design with a copy of Edvard Munch's dramatic 'The Scream', is tempting, but simply won't do. We need to re-express the essence of this work in simpler language. The matter is too important to permit uninformed dissent. Perhaps, like Mrs Bucket (sorry, 'Bouquet'), we should sing more at the unconverted than with them. Short of creating a scientific meritocracy, that's all we can do.

Reviewed by: ***David Edwards***

ENERGY SCIENCE: PRINCIPLES, TECHNOLOGIES, AND IMPACTS
by JOHN ANDREWS & NICK JELLEY (3rd Edn). 2017. Oxford University Press. ISBN-13: 978-0199281121 344pp (sbk).
List Price £39.99. W: http://bit.ly/2xMi9XA

BOOKS FOR REVIEW

Please contact **ted.nield@geolsoc.org.uk** if you would like to supply a review. You will be invited to keep the review copy. See a full up-to-date list at **www.geolsoc.org.uk/reviews**

- **NEW! Proterozoic Orogens of India - a critical window to Gondwana** by TRK Chetty. 2017 Elsevier 405pp, sbk
- **NEW! Risks, Rewards and regulation of Unconventional Gas - a global perspective** by Grafton , Quentin et al (eds)2017 Cambridge University Press494pp, hbk

READERS' LETTERS

Geoscientist welcomes readers' letters. These are published as promptly as possible in Geoscientist Online and a selection printed each month. Please submit your letter (300 words or fewer, by email only please) to **ted.nield@geolsoc.org.uk**. Letters will be edited. For references cited in these letters, please see the full versions at **www.geolsoc.org.uk/letters**

Hutton owes no debt to Browne

Sir, Historical myths are hardy perennials, and myths about Hutton continue to be propagated in the media, in blissful or perhaps wilful (chauvinistic?) ignorance of a body of historical research that sets his ideas in their contemporary context. Briefly, the very words of Hutton's famous "vestige... prospect..." quote show what he himself was open about: that he was an 'eternalist' - a position antithetical to modern geology's developmental model of the history of the Earth (and of the cosmos).

The Browne "but five days" quote shows equally clearly that his cosmology was, within the limited time frame of his generation, a developmental one from start to finish ('alpha' to 'omega'). By Hutton's time, geologists had adopted Browne's kind of model, having simply expanded it into a far longer - but still 'finite' - time dimension. Hutton's contemporaries criticised him for his eternalism, not his lengthy time. Modern geology therefore stems far more from them than from him.

This conclusion is now obvious to historians of geology, backed by a large body of historical research. Among many books that summarise this work, I dare to cite my own 'Earth's Deep History' (Chicago 2014) because it gives a brief bird's-eye-view all the way from Browne (and Ussher's 4004BC) to the present, and includes a further reading section that gives references to a lot of other historians' work. A fuller evaluation of Hutton is in my 'Bursting the Limits of Time' (Chicago 2005), pp. 158-172, with detailed footnoted references to primary and secondary sources to back it up.

MARTIN RUDWICK

Mike Leeder replies:

Sir, Martin Rudwick seems to miss the point of my article, which simply proposes that Hutton adapted Browne's beautiful words in the coda to his own opus. Nothing more, nothing less. I made no novel interpretations, simply stating what each quote might imply to any intelligent modern reader. The essential part of the longer quotation is: "…but to retire so farre back as to apprehend a beginning, to give such an infinite start forward, as to conceive an end".

I would disagree with Rudwick's assessments of both Browne and Hutton. The former seems against 'alpha and omega'; as the quote I unearthed emphasises, and as does the rest of Section 11 of 'Religio Medici'. I would differ also from his opinion of Hutton's 'eternalism': the qualifier '...we find', which precedes his quoted aphorism, is surely quite enough to negate this view.

It is not enough to show that others misinterpreted Hutton's careful delineations of his position as 'eternalism'. To my mind, modern geology (in its fundamental 'planetary recycling' essence) stems far more from Hutton than anyone else among the 'savantiers', up until the times of Wegener and Holmes (the great modern 'savants' of physical geology).

MIKE LEEDER

IN MEMORIAM WWW.GEOLSOC.ORG.UK/OBITUARIES

THE SOCIETY NOTES WITH SADNESS THE PASSING OF:

Absolom, Sydney Stuart *
Armitage, John *
Atkinson, Keith *
Ayers-Morgan, Christopher *
Butcher, Norman Edward *
Chillingworth, Patrick Cecil Hamilton *
Drysdall, Alan Roy *
Elueze, Anthony Azbuike *
Evans, Anthony Meredith
Gardener, Roger *
Geddes, James D*§
Ginsburg, Robert Nathan
Howell, Frank Travis *
Howells, Malcolm Fletcher
Jenner-Clarke, Hugh Clifford David *
Laws, Michael James *
Leighton, James *
Macchi, Louis
Marshall, Mr John A *
Matthews, Peter Elvor *
Merriam, Daniel Francis
Needham, Clive
Palmer, Stephen J *
Pipes, Kenneth P *
Rawcliffe, Eric *
Robson, David *
Shingleton, Sam *
Whitlow, Roy *
Young, Paul Ivor

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 ted.nield@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**.

PEOPLE NEWS

CAROUSEL

All Fellows of the Society are entitled to entries in this column. Please email ted.nield@geolsoc.org.uk, quoting your Fellowsip number.

◆ Chris Eaton

has been appointed Associate Director at RSK responsible for development of their geotechnical expertise within their Midland and Northern offices having spent over 35 years within the geotechnical industry.

◆ John Edward Guest

(1938-2012) has been honoured by the International Astronomical Union's formal approval to name a crater on the far side of the Moon after him. John was a volcanologist and planetary scientist who inspired generations of students at UCL over half a century. The crater is c. 20km in diameter, just west of crater Tsiolkovsky, first seen by the Soviet Lunar 3 mission in 1959. Guest wrote a classic paper on the geology of Tsiolkovsky in 1971.

◆ John Warburton

has been appointed Visiting Professor in the School of Earth & Environment at the University of Leeds where he currently serves on the External Advisory Board for Petroleum Leeds. Dr Warburton continues in his Sydney-based role as Chief Geoscientist with Oil Search Ltd and as Non-Executive Director of Senex Energy Ltd and of Imperial Oil & Gas Ltd. W: www.see.leeds.ac.uk/people/j.warburton

DISTANT THUNDER

Poetry and Geology

Geologist and science writer Nina Morgan relishes some 19th Century geological rhetoric in rhyme

In 2010, Bryan Lovell, President of the Geological Society 2010 – 2012, suggested bringing together scientists and poets to explore the links between their disciplines and to celebrate poetry and geology. This inspiring event took place on 10 October 2011 – and earned a permanent place on the Society website, where the poems can still be viewed (W: www.geolsoc.org.uk/geopoetry)

As Lovell himself would be the first to observe, links between geology and poetry are nothing new. But even so, the idea that hard-core geologists in the 19th Century might want to rush to a bookshop to snap up the latest volumes of verse was considered a strange one.

Open mind

An anonymous reviewer writing in the February 1872 issue of the Geological Magazine urged his readers to keep an open mind on seeing a review of a book of poetry in this serious scientific magazine. But he assured them that the book in question, *Gaudeamus!* Humorous Poems by popular German poet, Joseph Victor von Scheffel [1826 – 1886] translated from the German of by the American humourist, writer, and folklorist Charles Godfrey Leland [1824 – 1903], was an essential addition to every geologist's field kit.

"The English edition being small" the reviewer advised, "it can conveniently be put into every geologist's pocket or knapsack. Then, when the way proves long, and the load of rocks or fossils wearisome, he will find it is good to sit down on the first convenient seat by the wayside, and having taken out his pipe and his *Gaudeamus*, he will follow Mr [sic] Leland's directions, and say to his companion if he have one – or to himself if he have none – 'Let us be jolly'."

In addition, the Geol. Mag. reviewer notes, the book's geological content is also very relevant.

"...these ballads... form in their connexion a droll history of the world and of humanity – advancing from the early outburst of Granite and Basalt, through the boulder of Gneiss to the Ichthyosaurus and Megatherium."

The poems were written in response to a course of lectures on geology delivered in Heidelberg by Pastor Schmezer. Scheffel regularly attended these lectures, and, as the translator Leland reports:

"the latter was certain to find as regularly on the following morning of his lecture a poetical resume of it on his desk, in the form of a humorous poem."

Scheffel's take on Ichthyosaurus is a typical example:

The rushes are strangely rustling,
The ocean uncannily gleams,
As with tears in his eyes down gushing,
An Ichthyosaurus swims.

He bewails the frightful corruption
Of his age, for an awful tone
Has lately been noticed by many
In the Lias formation shown.

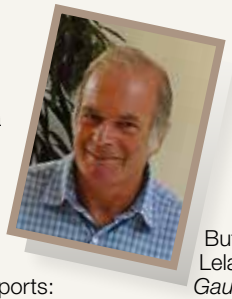
The Plesiosaurus, the elder,
Goes roaring about on a spree;
The Plerodactylus even
Comes flying as drunk as can be.

The Iguanodon, the blackguard,
Deserves to be publicly hissed,
Since he lately in open daylight
The Ichthyosaura kissed.

The end of the world is coming,
Things can't go on long in this way;
The Lias formation can't stand it,
Is all that I've got to say!

So the Ichthyosaur went walking
His chalks in an angry mood;
The last of his sighs extinguished
In the roar and the rush of the flood.

And all of the piggish Saurians
Died, too, on that dreadful day;
There were too many chalks against them,
And of course they'd the devil to pay.



And this petrifideal ditty?
Who was it this song did write?
'Twas found as a fossil album leaf
Upon a coprolite.

But 'education' aside, Leland suggests that *Gaudeamus* is all the more notable because Scheffel "manifests a remarkable insight into the inner real life of the past."

With such verses as:

In stocks I would gladly grow wealthy
But exchange is not yet understood:
A good glass of beer would be healthy,
But never a drop has been brewed.

Leland might also have claimed that Scheffel also showed remarkable insight into the real life of the present.

Some things never change!

Acknowledgement
Sources for this vignette include: An anonymous book review that appears on pages 85 – 86 of the February 1872 issue of Geological Magazine; the full text of Gaudeamus available from W: www.gutenburg.org; the Wikipedia entries for Charles Godfrey Leland and Joseph Victor von Scheffel; and the article Poetry Day 2011 by Bryan Lovell available at W: www.geolsoc.org.uk/Geoscientist/Archive/March-2012/Poetry-Day-2011

* **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**

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

ENDORSED TRAINING/CPD

COURSE	DATE	VENUE AND DETAILS
Lapworth's Logs	n/a	'Lapworth's Logs' is a series of e-courses involving practical exercises of increasing complexity. **Contact:** info@lapworthslogs.com. Lapworth's Logs is produced by Michael de Freitas and Andrew Thompson.

DIARY OF MEETINGS 2016/2017

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

COURSE	DATE	VENUE AND DETAILS
William Smith Meeting 2017: Plate Tectonics at 50 Geological Society	3-5 October	Burlington House. Registration Closed. The meeting, to coincide with the launch of the Dan McKenzie Archive, will however be live streamed. See website for details. W: www.geolsoc.org.uk/wsmith17
A Brief History of Construction Monitoring in England Engineering Group	11 October	Burlington House. **Speaker:** Peter Hewitt - Laing O'Rourke. Time: 1700 for 1800. **Contact E:** Contact email address engineering.group@geolsoc.org.uk
Earth Science Week 2017 Schools Event: Plate Tectonics & Mineralogy Geological Society, 2017 Year of Risk, Earth Science Week 2017	12 October	Burlington House. Open Day. **Presenter:** Dr Matt Loader. **Contact Amy Ball E:** amy.ball@geolsoc.org.uk. See website for details.
GSL 6th UK Geothermal Symposium Geological Society	16 October	Burlington House. Fees apply – see website for details and registration. **Contact E:** georgina.worrall@geolsoc.org.uk
Getting the best out of geotechnical sampling and laboratory testing Thames Valley Regional	18 October	**Venue:** Jacobs Office, Wokingham RG41 5TU. **Speaker:** Dr John Powell (Geolabs). **Time:** 'Evening meeting'. **Contact: E:** tvrgsecretary@gmail.com
Fault growth and interactions - implications for earthquake hazard and risk assessment Geological Society	18 October	London Public Lecture. **Speaker:** Dr John Walsh. See p. ?? for details. See website for registration. Burlington House. **Time:** 1645-1900. **Contact Amy Ball E:** amy.ball@geolsoc.org.uk. See website for details.

OBITUARY George Williams 1917-2016

Shell geologist who foresaw the hydrocarbon potential offshore Brunei and beneath the northern North Sea

George Williams was born on 6 August 1917, attended Truro School, and read for the Natural Sciences Tripos at St John's College, Cambridge, majoring in geology. He was due to join Shell on 5 September 1939 but war was declared two days earlier. On 4 September Shell suspended the job offer with the assurance that it would be honoured after the War. George was commissioned in the Royal Air Force. In June 1944 he was promoted Wing Commander and appointed to command No. 36 Squadron flying Wellington XIVs on anti-submarine patrols. He held this position until the end of the war. In later years, George served as President of the No. 36 Squadron Association.

Shell

In 1946 George became a Shell geologist. After assignments in British Somaliland and Indonesia, he was appointed exploration manager with Shell D'Arcy Petroleum in Nigeria. He was in the team that made the country's first oil discovery, the Oloibiri Field in the Niger Delta, in January 1956. This event started a pattern that was to continue.

In late 1957 George joined the recently formed Brunei Shell Petroleum (BSP) initially as exploration manager and ultimately as managing director. The major milestone was Brunei's first offshore discovery, by the Southwest Ampa-1 well, in 1963. In recognition of his service to the protectorate, the Sultan of Brunei conferred on George the honorary State title 'Dato'.

> "HIS VISION MATERIALISED WITH THE DISCOVERY AND SUBSEQUENT DEVELOPMENT OF THE AUK, BRENT, CORMORANT AND DUNLIN FIELDS."

Following his return to the UK in the spring of 1964, George became managing director of Shell UK Exploration and Production. He oversaw the development of southern North Sea gas fields and pursued oil exploration on the UKCS north of 54 degrees. His vision materialised with the discovery and subsequent development of the Auk, Brent, Cormorant and Dunlin Fields. George was appointed OBE by Her Majesty the Queen in 1968.

UKOOA & beyond

After leaving Shell in 1973, George became Director-General of the UK Offshore Operators Association (UKOOA). This allowed him to promote cooperation between North Sea operators and to represent the views of the upstream petroleum industry to the British government. George served on NERC from 1976-1983. George was awarded an honorary DSc by Heriot-Watt University in 1979 and was appointed CBE by Her Majesty in 1983. He retired from UKOOA in 1986.

George retained a keen interest in geology throughout his retirement years. In 2006 he made a return visit to BSP. Our latter-day discussions included how to prevent geology from becoming subordinate to the computer and whether geological data are being used to the full in contemporary subsurface studies. He was an FGS for seven decades.

George lived in Ascot for many years. He died on 1 December 2016 after a brief illness, eight months before his 100th birthday. His life was one of seeing opportunities and bringing them to fruition for the benefit of people. George leaves his wife, Annick, his daughter, Susan, and his two grandchildren.

By Paul F Worthington

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 Ted Nield at the Society.

OBITUARY John Mendum 1945-2016

Structural geologist with BGS who specialised in the geology of the NW Highlands and Islands of Scotland

John was an active field and structural geologist who spent the greatest part of his career ranging widely, and with long strides, across the Highlands and Islands of Scotland as a geologist with the British Geological Survey (BGS). In many ways, he followed in the footsteps of geologists whom he greatly admired and whose Survey and academic careers he studied closely; Geikie, Peach and Horne, and Clough. Through his many seasons of mapping the Lewisian, Moine and Dalradian successions across Scotland, John achieved an encyclopaedic knowledge of these rocks and their geological evolution, a knowledge that he was happiest sharing with all who would spend time debating in the field with him, professional and amateur alike. John passed away on 8 December 2016.

Middlesbrough

John was born on 10 January 1945, the middle child of three, on the outskirts of the expanding industrial town of Middlesbrough with farmland at the other end of the road. Family holidays that explored the mountainous regions of the Alps in the 1950s and 1960s established a pattern for John's life in geology. After studying at Leeds University, where he met his wife Mary through the University Caving Club and from where he graduated in 1967 (BSc Geology), the couple travelled to Australia. John began work mapping for the Bureau of Mineral Resources in the Northern Territory (1967-1971).

Returning to the UK, John studied for the MSc in Structural Geology and Rock Mechanics at Imperial College, London (1972), and then moved to Edinburgh to undertake his PhD. John's research into the Structure & Metamorphism of the Tonale Pass area involved three seasons of detailed mapping in the mountains of Northern Italy. Edinburgh University awarded his PhD in 1976.

> "JOHN LISTENED CAREFULLY TO THE ROCKS ... AND RECORDED IT WITH CARE (AND IN FAULTLESS ENGLISH)"

Hebrides

John had a very active career with BGS, starting in November 1974; he was always very directly involved in the detailed mapping of large tracts of the Outer Hebrides, Northern Highlands and Grampian Highlands of Scotland (sometimes with family in tow). A contemporary described John the field geologist as one who listened carefully to what the rocks had to say, and recorded it with care (and in faultless English); another that John seemed to have a special insight when he looked at the rocks and that his enthusiasm never waned. That was why he was always last to get back on the coach!

John led, contributed to, and participated in much of the modern published mapping output in the Highlands and Islands of Scotland by BGS, most notably completion of the NE Grampians mapping that delivered at least 16 1:50k map sheets between 1992 and 2002. In particular, John's knowledge is the thread that runs throughout the Geological Conservation Review Series Volume 34 (2009), Lewisian, Torridonian and Moine Rocks of Scotland. Along with its companion volume for the Dalradian Rocks of Scotland (published as Vol. 124 of the Proceedings of the Geologists' Association, 2013), these two volumes stand testament to John's contribution to the geology of Scotland.

Retirement

Formal retirement in June 2006 came and went for John, as he continued as an Honorary Research Associate with BGS, seemingly always present as a respected mentor and sounding-board for all of his colleagues. Retirement did allow John to become a much sought-after excursion leader in the Highlands for a wide range of international groups and geological societies, especially but not exclusively the Edinburgh, Glasgow, and Open University geological societies. Though he never worked formally in academia John held his own with, and was greatly respected by, all who engaged with him, often the perfect bridge between the very different perspectives of geological survey and university research – and a bridge of immense benefit to both sides.

John's active retirement (running, yoga, gardening and bridge are only part of a long list) did allow him time to further expand his knowledge and appreciation of the world's wines. This was always to the fore in the field excursion dinners and evening discussions that John and his many contemporaries and fellow geologists shared, usually with a bottle or two.

John is survived by his three children Tom, Neil and Josephine and by his four grandchildren, Ben, Arun, Summer and Sam.

By Graham Leslie

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 Ted Nield at the Society.

OBITUARY Hazel Margaret Prichard 1954-2017

Expert on the Platinum Group Elements and tireless champion for the importance of minerals and mining

Professor Hazel Prichard passed away on New Year's Day 2017, following a 27-month battle with cancer. Hazel grew up in Gravesend with a passion for geology. While studying A-level geology she attended a lecture by Professor Ian Gass, followed by a fieldtrip to Cyprus, which was to have a profound influence on her future career choice.

Hazel studied Geology with Geomorphology at Hull University, graduating with First Class Honours in 1976. She initially read for a PhD at the University of East Anglia, but moved with her supervisor Joe Cann to Newcastle. Her PhD thesis focused on the composition of sea-floor rock samples collected from dredging.

Platinum

Hazel's overarching research passion was the platinum-group elements. She devoted herself to these fascinating metals for 40 years and made numerous fundamental contributions to our understanding of them over her career. Hazel was awarded two fellowships by the Royal Society; an individual University Research Fellowship held first at the Open University and then at Cardiff, plus the Senior Brian Mercer Award for Innovation.

Hazel's research revealed unknown concentrations of Platinum in Shetland's ophiolites. She was UK Representative and Project Secretary for three major IGCP Projects on magmatic ore deposits and co-edited the landmark Geo-Platinum conference volume in 1988 that did so much to expand PGE research out of the narrow confines of layered intrusions and turn it into the field of research that we recognise today.

> "HAZEL WOULD BE FIRST OFF THE BUS IN THE MORNING AND BE FULL OF ENTHUSIASM UNTIL THE LAST OUTCROP IN THE EVENING"

Cardiff

In 1992 Hazel transferred to Cardiff University and in 2000 worked on an industrial fellowship with mining companies in Brazil. In 2004 Hazel became the course director of the Exploration Geology degree at Cardiff University with great enthusiasm, which was manifest in running field courses to Cornwall and Cyprus. Hazel would be first off the bus in the morning and be full of enthusiasm until the last outcrop in the evening. Cardiff students will always remember her enthusiasm for the harzburgite outcrop at Kennack Sands on Lizard and the Umber deposits below Theotokos Monastery on Cyprus.

Hazel developed the exploration placement component of the degree scheme, providing valuable industrial experience for many students who went on to work in the industry. Cardiff University honoured Hazel for her efforts with an Enriching Student Life award in 2014.

Gender equality

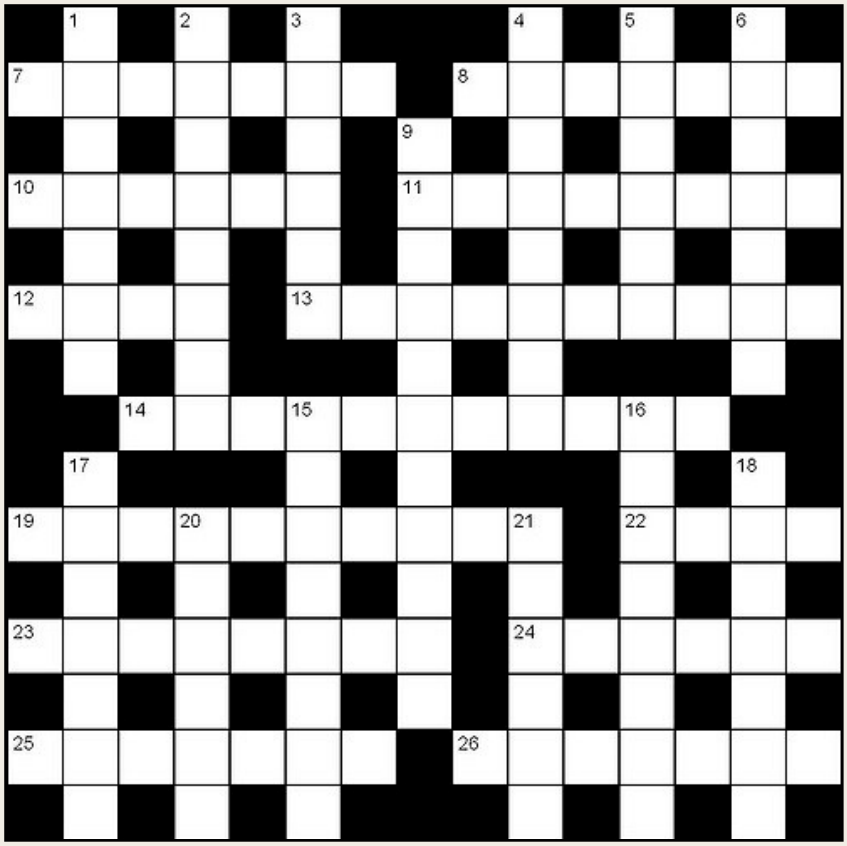
Hazel was a tireless champion for the importance of minerals and mining and for an acceptance among both government and the general public that a modern economy requires a secure supply of minerals. She lobbied Parliament and published reports on metal scarcity that led eventually to the current research initiative on the Security of Supply of Mineral Deposits programme funded by the NERC. As a woman in a male-dominated sector of academia (and an even more male-dominated industry), Hazel was a constant champion for gender equality and for female students to succeed in Economic Geology.

Hazel will be greatly missed by her academic colleagues as her passion for exploration geology was unrivalled and their thoughts lie with her husband David. Hazel was laid to rest overlooking St Brides Bay, Pembrokeshire.

By Peter Brabham

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 Ted Nield at the Society.

CROSSWORD NO.215 SET BY PLATYPUS



ACROSS

7 Biozone in which particular species/genus finds maximum abundance (7)
8 One who brings something into being (7)
10 Erosional pediment in arid regions (6)
11 Any ion containing AsO4 (8)
12 Opposite of floods (4)
13 Delta city where it was discovered how well libraries burn (10)
14 Fragmenting into smaller, hostile, regions or states (11)
19 Craftsman in stone (10)
22 Founder of the SA, assassinated in the 'Night of the Long Knives' (4)
23 Long bone between shoulderblade and sternum (8)
24 Black, Fe-rich tourmaline (6)
25 Sporty type (7)
26 Cut by discontinuity surfaces of tectonic origin (7)

DOWN

1 Group of Permian age in NW England succeeded by Cumbrian Coast Group (7)
2 X axis (8)
3 North Slope State (6)
4 Solids with a highly ordered microscopic structure (8)
5 Classical raver, mad, frenzied, drunk, or all at the same time (6)
6 Channel of the nose (7)
9 Our Father, Latinly, and for some also 8a (11)
15 Meteoritic iron-nickel alloy (8)
16 Tusked whales (8)
17 Ear-stone, important in balance (7)
18 The Society's dates from 1825 (7)
20 Extended fictional narratives (6)
21 Rare feldspathoid found in phonolites (6)

WIN A SPECIAL PUBLICATION!

The winner of the August Crossword puzzle prize draw was **Robert Dawson of Amersham, UK.**

All correct solutions will be placed in the draw, and the winner's name printed in the December/January issue. The Editor's decision is final and no correspondence will be entered into.
Closing date - October 20.

The competition is open to all Fellows, Candidate Fellows and Friends of the Geological Society who are not current Society employees, officers or trustees. This exclusion does not apply to officers of joint associations, specialist or regional groups.

Please return your completed crossword to Burlington House, marking your envelope "Crossword". Do not enclose any other matter with your solution. Overseas Fellows are encouraged to scan the signed form and email it as a PDF to **ted.nield@geolsoc.org.uk**

Name .....

.....

Membership number .....

Address for correspondence .....

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SOLUTIONS AUGUST

Across:
7 Primary **8** Maxilla **10** Runoff
11 Mutation **12** Yeti **13** Saturation
14 Aerodynamic **19** Accredited **22** Opal
23 Barbican **24** Y-Shear **25** Fillies **26** Saurian

Down:
1 Grouted **2** Ammonite **3** Drifts **4** Bacteria
5 Diktat **6** Alcohol **9** Amethystine **15** Obducted
16 Isotherm **17** Oceanic **18** Bahamas
20 Rubble **21** Dry Gas

THE JANET WATSON MEETING 2018

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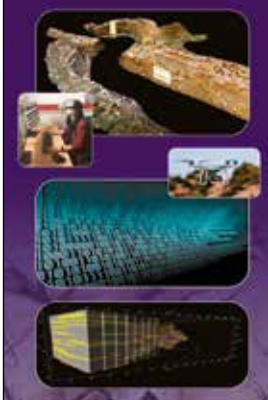
A Data Explosion: The Impact of Big Data in Geoscience

27 February – 1 March 2018

The Geological Society, Burlington House, London



The rise of 'Big Data' has been characterized by a rapidly increasing availability and diversity of data that will play a role in shaping the future of Geoscience Research and the Hydrocarbon Industry. The Geoscience community has been slow to embrace the Big Data technologies that are revolutionizing other sciences such as the pharmaceutical industry and medical research. Where advances in data acquisition and interpretation technologies are being made in academic Geoscience, progress in uptake has been hampered by unstructured data, stored in silos.

This three day meeting will bring together early career geoscientists with leading industry and academic experts to discuss the opportunities and challenges of Big Data and showcase advances in data collection and interpretation technology. It will present an opportunity to learn and collaborate between Geoscience and Computer Science on the subject of Big Data. This will be an excellent forum for networking and an opportunity for graduate students and young professionals to present their research. The conference offers more experienced hydrocarbon geoscientists new research, ideas and concepts and the chance to add their experience to a panel discussion.

Conference themes

- Opportunities and Challenges associated with Big Data in Geoscience
- Data standards, storage and security challenges
- Novel Approaches to data collection
- Technology Advances in interpretation and reservoir characterization, e.g. virtual geoscience
- The future role of Big Data in academic and industry Geoscience

The final day of the conference is dedicated entirely to workshops and demonstrations of technology advances in Big Data on a variety of scales, from regional subsurface interpretation, to virtual fieldtrips and virtual outcrops, with special sessions on automated interpretation and artificial intelligence.

A panel discussion on "The Future of Big Data" will be held at the close of the second day.

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 naomi.newbold@geolsoc.org.uk by 31 October 2017. The abstract should be approximately 500 words and include: a title and acknowledgement of authors and their affiliations where possible.

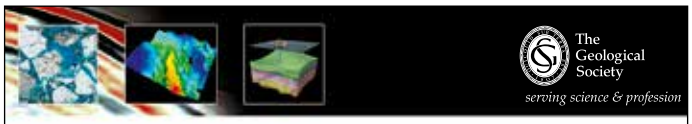
Further information

For further information about the conference please contact:
Naomi Newbold, Conference Office,
The Geological Society, Burlington House,
Piccadilly, London W1J 0BG
T: 0207 434 9944
E: naomi.newbold@geolsoc.org.uk
Web: www.geolsoc.org.uk/janetw18
Follow the event on Twitter: #janetw18

Convenors:

Nicole Duffin (Shell UK) — Helen Smyth (Halliburton)
Caroline Gill (Shell UK) — Isabel Sykes (Halliburton)
John Underhill (Heriot Watt University of Aberdeen)

YEAR OF RESOURCES



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Confirmed Keynote Speaker:

Al Tucker
Brent Asset Manager, Shell

Call for Abstracts – Deadline 15 December 2017

Advances in Production Geoscience as an enabler for maximising economic recovery and ensuring a future for the UKCS

5-7 June 2018

Robert Gordon University, Aberdeen

Out of adversity comes opportunity. A significant change is required in the North Sea petroleum industry to keep it profitable and growing, and geoscience has the opportunity to lead the way in delivering this change. New plays, fields, technologies and alliances are required in order to increase recovery and reduce the cost of delivering hydrocarbons. In 2014 the Maximising Economic Recovery UK report suggested that 12-24bn barrels of oil equivalent remained to be produced from the North Sea. This conference aims to show how geoscience is helping to develop and recover as much of this remaining hydrocarbon as possible. It will showcase the range of solutions maximize economic recovery from the UKCS.

Specific themed sessions may include:

- Near Field Exploration
- New field developments
- Short radius sidetracks
- Infill drilling
- Production from secondary reservoirs
- The value of surveillance
- Existing infrastructure - hosts for new opportunities, making it last longer, novel maintenance, alternative uses (wind/CO_2 disposal)
- Shallow gas (fuel source) and water (for injection)
- Novel drilling technology as an enabler for difficult geology
- Exploiting difficult fluids
- Use of new technology or first application of technology to the UKCS
- Enhanced Oil and Gas recovery
- Adding value from co-produced fluids
- Decommissioning

The focus of the meeting will be on Geoscience, Reservoir Engineering and Petrophysics with the recognition that successful integration across the subsurface and surface disciplines is at the heart of a successful shift in future fate of the UKCS.

Call for Abstracts:

Please submit paper contribution to abstracts@geolsoc.org.uk and copied to caroline.gill@shell.com by 15 December 2017.

For further information please contact:

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

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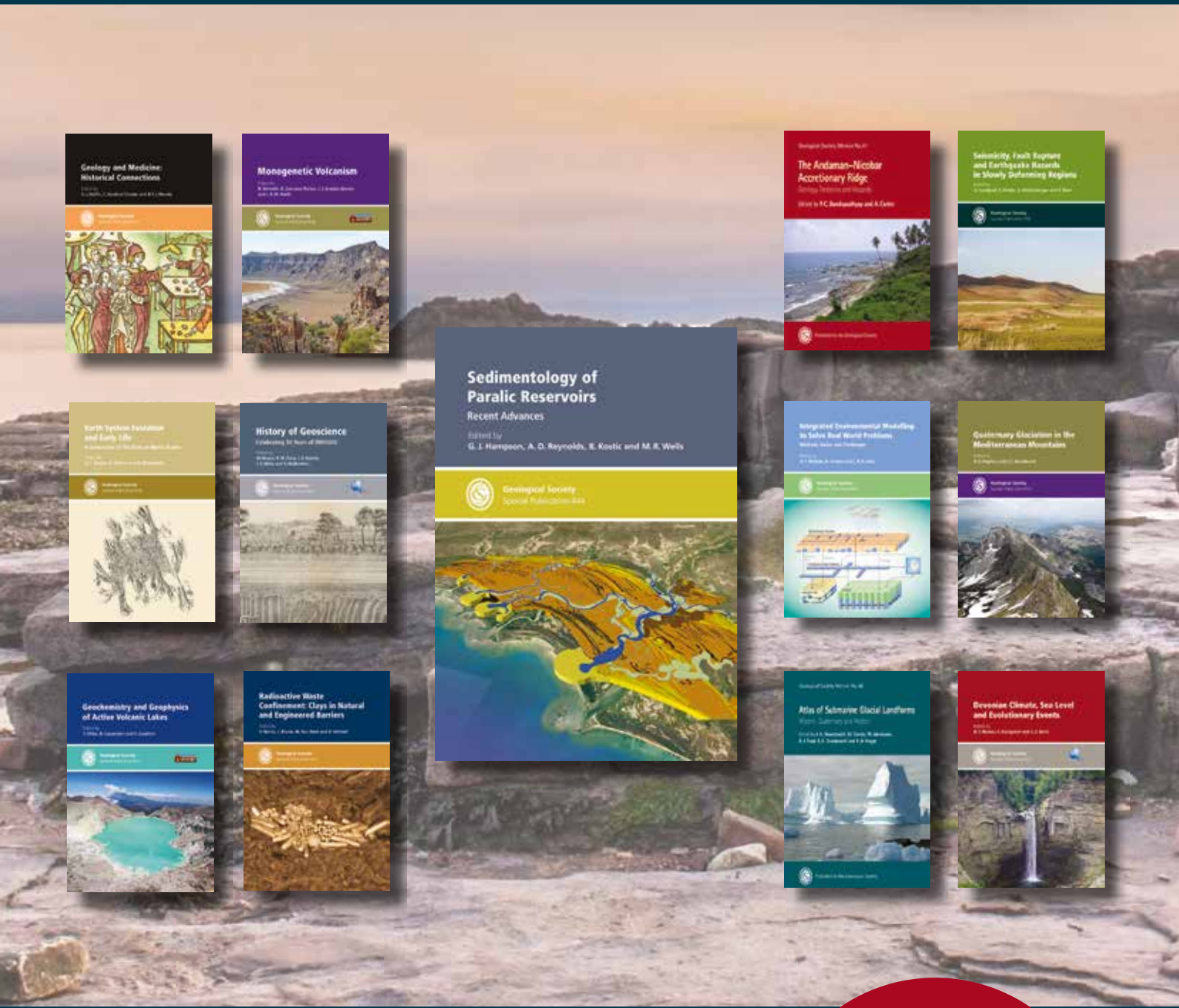

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