Hidden Tiger
Graham Leslie and Rhian Kendall uncover the geology beneath Singapore

ELIZABETH ALEXANDER
Mary Harris on her mother’s pioneering work

TRUST & TRANSPARENCY
Mark Steeves on building public confidence

COAL COMFORT?
Bryan Lovell and Ted Nield on coal, CCS and Germany
BRYAN LOVELL MEETING 2017

Mining for the Future


Confirmed speakers to include:
Daniel Franks (UN Development Programme)
Richard Herrington (Natural History Museum)
Kathryn Goodenough (BGS)
Sarah Gordon (Satarla Ltd)
David Manning (Newcastle University)

Convenors:
Nic Bilham (Geological Society)
Edmund Nickless (Geological Society / IUGS)
Andrew Bloodworth (BGS)
Frances Wall (Camborne School of Mines)
Natalia Yakovleva (Newcastle University)

Further information:
For further information about the conference please contact:

T: 0207 434 9944
E: naomi.newbold@geolsoc.org.uk
Web: www.geolsoc.org.uk/lovell17
Follow this event on Twitter: #lovell17

The mineral resource needs of the future will be different to those of the past and present. Delivering the UN 2030 Sustainable Development Agenda and implementing the COP 21 Paris Agreement to decarbonise the global economy will alter and add significantly to the demand for metals and minerals by both developed and developing countries. Our growing global population rightly expects greater prosperity and more equitable access to resources, and is becoming more industrialised and urbanised.

We are only beginning to understand the challenge of meeting these needs in a way which is environmentally, economically and socially sustainable. Meeting this challenge will depend on cutting-edge research across the geosciences and in other disciplines, including engineering, economics and social sciences – and will require engagement with industry, the financial community, policy-makers and the wider public.

Introducing our Year of Resources running throughout 2018, this meeting will bring together a wide community of geoscientists and others to explore how we can address this challenge, and start to develop a roadmap for this multidisciplinary effort.

It is held in conjunction with the IUGS Resourcing Future Generations Initiative, and will inform the major IUGS conference on this topic to be held in Vancouver in June 2018.

Conference Themes:
- Future Demand
- Where will future resources come from?
- Meeting the resource challenge responsibly
- Who do should we engage in this effort, and how?
ON THE COVER:

10 HIDDEN TIGER
What lies beneath the vibrant city state of Singapore?

FEATURES

16 ELIZABETH ALEXANDER
Mary Harris writes about her mother’s pioneering scientific work in Singapore

REGULARS

05 Welcome Ted Nield on coal, CCS - and Germany

06 Society News What your Society is doing at home and abroad, in London and the regions

09 Soapbox Bryan Lovell thinks CCS could be the last roll for coal

20 Books and arts Six new books reviewed by Catherine Kenny, David Edwards, Nine Morgan, Mark Griffin, Gordon Woo and Rob Bowell

23 Calendar Society activities this month

24 People Geoscientists in the news and on the move

26 Obituary John Baverstock Saunders 1928-2017

27 Obituary Trevor David Ford 1925 – 2017

28 Obituary James Brooks 1938-2017

29 Crossword Win a Special Publication of your choice
**Event Sponsor:**

**Corporate Supporters:**

**Convenor:**

**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 W1J 0BG

Sarah Woodcock, The Geological Society, Burlington House, Piccadilly, London W1J 0BG. T: 020 7434 9944

**Abstract**

Contribution to sarah.woodcock@geolsoc.org.uk by 23 Feb 2018.

**Call for Abstracts:**

- • 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.

- • Reservoir quality and reservoir characterisation
- • Potential of deeper plays and possibilities for oil.

- • 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.

- • The value of surveillance
- • Exploiting difficult fluids
- • Exploiting new technology or first application of technology to the UKCS
- • Enhanced Oil and Gas recovery
- • Decommissioning

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 plays in the region will also 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.

**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

**At the forefront of petroleum geoscience**

www.geolsoc.org.uk/petroleum

---

**FUGRO TECHNICAL COURSES**

Free one-day Cone Penetration Testing (CPT) technical courses presented by specialists from Fugro

<table>
<thead>
<tr>
<th>Course</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil and Rock Logging and Hydrogeology courses presented by First Steps Ltd (£275 + VAT)</td>
<td>3rd November 2017</td>
<td>Wallingford</td>
</tr>
<tr>
<td>Soil and Rock Logging course</td>
<td>8th November 2017</td>
<td>Wallingford</td>
</tr>
<tr>
<td>Physical Hydrogeology course</td>
<td>18th October 2017</td>
<td>Fulham London</td>
</tr>
</tbody>
</table>

To apply for the Cone Penetration Testing (CPT) courses email to: s.poulter@fugro.com
To apply for the Soil and Rock Logging and Physical Hydrogeology book online at:

www.firststeps-geo.co.uk/course-calendar
Two reactions emerged from the editorial Coal is Dust (Geoscientist 27.5, June). One was that, elsewhere in the world, geologists are still helping to find and dig it (Letters, Geoscientist 27.8 September). The other was that, if we can only get our act together on Carbon Capture and Storage (CCS), we might be able to go on using it (Soapbox, this issue). Meanwhile, the geopolitical climate has just become more heated.

In the United States, the Trump administration has indicated its intention to support the domestic coal industry – a major plank in the President’s campaign, not only rolling back progressive environmental measures, but possibly putting the US on a collision course with the United Nations Minimata Convention on mercury pollution, at its first Conference of Parties (COP1) in Geneva this September. But - we have already grown used to the USA resiling from environmental agreements. We hear rather less about the failures of our European partner, Germany.

But - Germany is terribly ‘green’, isn’t it?

Well, no. Coal still provides 43% of its electricity. Coal is cheap, because its huge environmental costs are never factored in. And since Germany is committed to phasing out nuclear power by 2022 – for arguably entirely spurious environmental reasons in the face of the much greater threat posed by CO₂ – it is likely to stay that way.

Germany has pioneered wind turbines, and has many - mostly in the windy, industrial north. The power they generate is often wasted because coal plants burn on, regardless. Wind power works best when decentralised; but old power grids rely on distribution from point-sources. Germany has inadequate grid capacity for getting the north’s green surplus to the south. Meanwhile German emissions are not falling, but rising.

More surprising still, perhaps, Germany’s spending on energy R&D has stagnated for a decade and - according to the OECD - is exceeded in this niggardly short-sightedness only by – the UK.
Research Grants

Applications are invited for the 2018 round of the Society research grants.

Please complete the form which can be downloaded from the Society Awards and Research Grants page at www.geolsoc.org.uk/grants where you will also find information about all the grants. The average award has been about £1000.

The Research Grants committee meets once annually. Applications must reach the Society no later than 1 February 2018 and must be supported by two Fellows of the Society who must each complete a supporting statement form. Only complete applications on the appropriate form will be considered.

Stephanie Jones

Open House 2017

The Society threw open its doors to the general public on Saturday 16 September, writes Dawne Riddle

Over 1100 people chose to visit the Society this year for Open House. In partnership with the Geologists’ Association, who also ran some urban geology tours of the area, visitors were invited to join one of seven guided tours during the day, led by Wendy Cawthorne, Sarah Day, Eileen Jamieson, Caroline Lam and Ted Nield. The Library also operated a ‘pop-up bookshop’ selling a variety of souvenirs and books, taking over £500 – a new record.

LONDON LECTURE SERIES

Why Earth developed into the crucible of life, and Venus into a hostile wasteland
Speaker: Dr Sami Mikhail (University of St Andrews)
Date: 22 November

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/gslondonlectures17. 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

The Royal Commission for the Exhibition of 1851

For reasons lost in the mists of time the President of the Society is an ex officio Commissioner of the Royal Commission for the Exhibition of 1851.

Applications are now open for their various Awards, including Research Fellowships. For further information please go to: W: https://www.royalcommission1851.org/awards/

The Society will be...
(London and Bath) will be CLOSED from 1600 on Friday 22 December and will reopen at 0930 on Tuesday 2 January 2018
Mark Steeves* says oil & gas, and mining, have done much to improve their transparency, but trust comes slowly - and more effort is needed

In April 2017 Geoscientist (27.3) reported on an event that took place on 21 February entitled: Trust & Transparency in the Oil & Gas and Mining Industries. It was organised by the City of London Geosciences Forum, an initiative of the Society’s Corporate Affiliates Committee aimed at building understanding between the Society and the City of London - especially those bankers, insurers, lawyers, Nomads, accountants, brokers, who depend upon the exploration activities of geologists for their business.

The Rt. Hon. Clare Short, former Labour MP for Birmingham Ladywood (1983-2010) and Secretary of State for the UK Department for International Development (DFID, 1997-2003) opened the meeting. As she explained, her interest in transparency, and her passion for international development had led to her becoming chair of the Extractive Industries Transparency Initiative (EITI, 2012-16).

In an overview of EITI since full establishment in 2006, Ms Short said that the issue of illicit financial flows had quickly risen to the top of the international agenda, where it remained. Of the $3.5 trillion annual gross revenue generated globally by extractive industries, an estimated $1 trillion is lost by producing countries through corruption, illegal resource exploitation and tax evasion.

Trump

While acknowledging that progress had been made, she noted one of President Donald Trump’s early “ominous” actions - to rescind the ‘Dodd-Frank’ provisions requiring extractive companies to report, country by country, what they pay to governments. She accused the American Petroleum Institute (API, and by extension, extractive industries at large, and therefore some in our audience) of having lobbied unrelentingly against those provisions. Some API members, she said, now “sit on the EITI Board - and thus the ramifications could be considerable”.

Ultimately, I think we learnt that our industry today (certainly at the high-end, and in the UK) is actually fairly transparent. Society President Malcolm Brown (Executive VP Exploration at BG until 2016) will have been pleased to hear Peter van Veen say that BG came top among oil and gas companies in Transparency International’s ‘Corporate Political Engagement Index’, which assesses the public reporting of the top 40 companies in the FTSE 100. Moody-Stuart defended Shell’s historic actions, in Nigeria, for instance, reasonably and pretty convincingly; robustly commending Shell’s commitment today to good governance and to EITI. He agreed that Short was rightly critical of API, and deplored US extra-territoriality.

Right thing

Peter van Veen asked – and answered - an obvious but pertinent question about beneficial ownership: “What does happen to the money, after it reaches government? It often ends up in countries where there are no beneficial ownership rules, where you can’t tell who owns assets. Ten percent of Westminster is owned by offshore vehicles from the British Virgin Islands. Why do we allow this? What good reason can there be not to be transparent?” Quite.

A delegate from our hosts, Norton Rose Fullbright, suggested from the floor that corporations couldn’t be blamed if resource-rich host governments are poorly served by their civil service. Clare Short, not interested in apportioning blame, asked rhetorically in reply: “Is it the company’s duty to do a ‘good’ deal, or not?”. Tom Bergin pointedly observed that companies don’t just ‘happen’ on situations, but conspire in creating them; citing the way North Sea bare-boat charters “are clearly structured artificially”. (My early career was spent chartering supply-boats, and I well remember how “imaginative” their ownership structures could be!)

We like to think we’ve done a lot to improve the way we do business, but much remains to be done. Even when we want a ‘good’ - by which I mean a ‘clean’ - deal, we often find ourselves facing competing and conflicting pressures. How ‘good’ is your agent, broker, adviser, operating partner, or legal advice? Consider the advantages of ‘having a good agent’ - and the almost total impracticality of not having one, in some countries. A ‘big brand’ company may have options often unavailable to young entrepreneurs and small businesses; but the big and powerful may not be agile, innovative or responsive - either to clients or civil society.

Mistrust

Public mistrust in the extractive industries, which in the mid-2000s led to EITI being created, has not noticeably diminished. And despite a large number of registrations for our event, the relatively low turnout might suggest that industry professionals and City firms supporting and serving the industry are either uninterested, think they know all there is to know and how to deal with the regulations, or both. Not good.

With the passing of time, it has become clear that this event raised as many questions, as it provided answers. In the future, the CLGF intends to hold more events that bear on what might most broadly be termed ethics, and the expectations and behaviour of the professions operating in and around extractive industries, as well as of the public.

*Clare Short’s full speech is available with the Online version of this article. Editor
* Mark Steeves is founder and director of Samphire & Associates Ltd. He is also a Friend of the Geological Society and sits on both the Corporate Affiliates Committee and the City of London Geoscience Forum Steering Committee.
Honorary Fellowship

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

Min Huh has been a hands-on, field-orientated palaeontologist for more than 30 years and as a leader is energetic and prominent in promoting the Korean geosciences internationally. He continues to publish significant, well-cited papers in his field and at the same time plays important roles in national geoscience outreach and policy, as Director of the Dinosaur Research Centre and as President of the Geological Society of Korea. He led a major initiative to have the Korean Dinosaur Coast nominated as a UNESCO World Heritage Site, in 2009, and it remains on the list to be considered for this status at a later date. In 2016, he led the successful Korean application to host the 37th International Geological Congress in 2024 and is now co-chair of the implementation committee. The Society expects to take an active part in the 2024 IGC and hopes to develop and strengthen links with relevant Korean national organisations in the intervening years.

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: http://bit.ly/2lkAvbd

◆ 6 December Athenaeum (London SW1Y 5ER)

2018
7 February (Gay Hussar) 24 April (Burlington Hse.)
14 June (Athenaeum) 12 September (Gay Hussar)
24 October (Bumpkins) 5 December (Athenaeum)

Geomechanics and Geology


Geomechanics investigates the origin, magnitude and deformational consequences of stresses in the crust. In recent years awareness of geomechanical processes has been heightened by societal debates on fracking, human-induced seismicity, natural geohazards and safety issues with respect to petroleum exploration drilling, carbon sequestration and radioactive waste disposal. This volume explores the common ground linking geomechanics with inter alia economic and petroleum geology, structural geology, petrophysics, seismology, geotechnics, reservoir engineering and production technology.

New Book

Find out more here
www.geolsoc.org.uk/SP458

Latest news from the Publishing House

A new anurognathid pterosaur with evidence of perching behaviour

A new anurognathid pterosaur, Versperopterylus lamadongensis gen. et sp. nov., is erected based on a complete skeleton with a skull preserved. It is characterized by two short distinct ridges present on the ventral surface of the cervical vertebrae; coracoids slightly longer than scapula; humerus, wing phalanx 3 and tibia nearly the same in length; grooves clearly present on the posterior surface of the wing phalanges 1–3; and the first toe reversed. It is the first anurognathid pterosaur from China with a definitively short tail, and the first pterosaur with a reversed first toe. The reversed first toe of Versperopterylus indicates that it had arboreal habitats. The discovery of Versperopterylus lamadongensis from the Jiufotang Formation strongly expands the geological age range for anurognathid pterosaurs.

Read here https://doi.org/10.1144/SP455.16

FUTURE MEETINGS

Dates for meetings of Council and Ordinary General Meetings until June 2017 will be as follows:

◆ OGMs:
2017: 22 November, 2018: 7 February, 4 April

◆ Council:
2017: 22 November, 2018: 7 February, 4 April
One last roll for coal?

Former President Bryan Lovell* says Carbon Capture and Storage is the last roll of the dice for fossil fuels

The June editorial (Geoscientist 27.5 – ‘Coal is Dust’) described a divisive threat to our Society at the end of the last century. Ted Nield illustrated a local story of the gulf between the British coal industry and the environmentalists: ripples at the edge of the pond.

During this century, as the climate ‘sceptics’ have squared up to environmentalists, the Geological Society has remained a unified body. The key to that unity is observational science. We rely on the evidence from the rocks.

We continue to argue with each other about climate change, and much else, in the Lower Library and in Geoscientist. We do so happily, because we know that in the end none of us can argue with the rocks themselves. We will go out in the field, look at the rocks again, and hope to see who was right.

Policy

In 2010 the Society published a statement of policy on human-induced climate change. The report was prepared by a group of Fellows renowned for their knowledge of the record of past climates preserved in rocks and ice. The only guidance provided by Council was that these mighty scholars should stick to those tangible records in assessing whether we really did have a problem requiring attention. We do.

The geological case for concern about human-induced climate change has strengthened since 2010. One example: we have new evidence from the geological record of the Paleocene-Eocene Thermal Maximum (PETM) in Spitsbergen and China. That evidence suggests that the input of carbon that triggered the PETM was an order of magnitude less rapid than our own rate of release of carbon to the atmosphere: disturbance of Earth systems at speed by us.

Challenge

We challenge those at both ends of the public argument on climate change. The climate sceptics flounder when presented with evidence from the geological record. Environmentalists with a general aversion to the fossil-fuel industry fret at geological support for carbon capture and storage (CCS).

That geological contribution to development of commercial-scale CCS becomes ever more significant. Academic and industry scientists work together on successful field trials of storage in conventional hydrocarbon-style traps.

Field trials

I declare an interest, as consultant to BHP, in research sponsored by that company on storage in open systems. This project is now underway at the Universities of Cambridge, Melbourne and Stanford. The aim is to quantify capillary, solution and mineral trapping of carbon dioxide in a range of reservoirs. Successful field trials of trapping by these mechanisms would transform the debate on CCS.

Until this research is complete, it is premature to consign any type of fossil fuel to the scrapheap. We geologists have been set the challenge of finding adequate safe storage for carbon dioxide. If we can’t do that, the fossil-fuel game is indeed up. If we can, we can continue to use coal, gas and oil. We have seldom had a more important job to do.

*Bryan Lovell is at the University of Cambridge

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).

We geologists have been set the challenge of finding adequate safe storage for carbon dioxide. If we can’t do that, the fossil-fuel game is indeed up.

BRYAN LOVELL
The Republic of Singapore is a hugely vigorous and dynamic hub for global finance, commerce, and transport links, and is arguably one of the world’s most competitive countries. The only island city-state on the planet, and frequently cited as the most ‘technology-ready’ nation, Singapore is the world’s third-largest oil refining and trading centre, its second-busiest container port, largest oil-rig producer and a major hub for ship-repair services.

Looking to the future, Singapore today aspires to becoming a ‘smart’ nation – one that integrates transportation, utilities and service infrastructure with information communications technology (ICT), in order to facilitate the sustainable management of its societal assets.

Natural resources
The resulting demand on Singapore’s constrained land and natural resources is high. A growing population of over 5.6 million lives within an area of only 700km², a population density of some 8264 people per km² in an area approximately the same size as Anglesey (Ynys Môn) in North Wales! Although half of Singapore’s land area comprises spectacular nature reserves, parks and gardens, natural outcrop is now extremely rare at surface; and so, getting to grips with Singapore’s geology is always challenging. Despite these challenges however, it is becoming increasingly clear that the story of Singapore’s geological evolution from Carboniferous times on, was diverse, often complex, and rapidly changing.

Graham Leslie* and Rhian Kendall**
explore the geology beneath one of the world’s fastest growing cities - Singapore

Above: Singapore, Asian Tiger City - arguably one of the world’s most competitive places and certainly one of its most densely populated.
Understanding that geological inheritance, and communicating its most significant characteristics to Singapore’s geological community, is vitally important to those responsible for fuelling and sustaining the country’s continued growth.

Taking a long-term view, the Singapore Government has already invested heavily and strategically in the creation of land and space, establishing an Economic Strategies Committee (ESC) in 2009. The Singapore Government is developing an underground master-plan and ‘land bank’, with a view to ensuring that underground and aboveground spaces are better integrated with surrounding developments and infrastructure.

All underground and other geological information that will benefit both private and public sector efforts in underground development has now been collated, and a subterranean land rights and valuation framework is being developed. The British Geological Survey (BGS) has been working with the Geological and Underground Projects Department in of the Building and Construction Authority (BCA) since 2012 to deliver this modern geological knowledge-base. This article tells the story (so far!) of the fascinating geology emerging from beneath the Asian Tiger City.

Reclamation
Since the 1960s, land reclamation projects have increased Singapore’s land area by almost 24% - to c. 720km² in 2015. Its surface area is projected to grow by another 100km² by 2030.

Singapore presently comprises 63 separate islands; some of these reclamation projects involve merging smaller islands to form larger, more functional islands (as has been done with Jurong Island in the south west). In still more ambitious plans, the subsurface is seen as an attractive development space for, among other things, basements, energy production and infrastructure, waste disposal and treatment, groundwater abstraction and water storage, transportation, industrial manufacturing, and logistics.

Planning
Geological and geotechnical understanding of Singapore’s sub-

- at least on a geological timescale.
Although highly built up, it is possible to find outcrops along the foreshores of Singapore’s many outlying islands.

Singapore has taken advantage of the proximity of its outlying islands to, in some cases, join them together. Marina Bay Gardens, Singapore – all on land reclaimed from the busy Singapore Strait.

Marina Bay Gardens, Singapore – all on land reclaimed from the busy Singapore Strait.

BGS’ copy of Mary Alexander’s geological map of Singapore

Surface is critical to planning, design and construction of a future-proof city infrastructure. Very significant parts of that infrastructure will comprise enormous underground facilities, and land-scarce Singapore is already storing some of its military resources in this way. The giant cavern facilities beneath Jurong Island entered service for oil storage in September 2014. This cavern complex lies some 150m below ground, delivering a storage capacity of 1.47 million m³ of liquid hydrocarbon - equivalent to some 580 Olympic-sized swimming pools. This capacity will double when the second phase of the work is completed.

In the last decade, the push to go underground has seen potential uses of cavern space as water reservoirs, power stations, port logistic systems, data centres, warehousing and storage all under consideration. The state-of-the-art underground MRT system for Singapore’s growing population continues to expand rapidly.

Bedrock is now preserved only sporadically at the modern metropolitan surface. Most natural outcrop is confined to coastline and to disused quarries, many of which are now flooded or in varying stages of reclamation.

The present new study is only made possible because of a new and comprehensive ground investigation programme commissioned for the BCA. This includes acquiring drillcore from more than 100 boreholes. Each borehole is typically about 200m deep, extending from
the ground surface to some 70m below the engineered floors of any anticipated cavern storage space designs - totalling approximately 13, 400m of new drillcore. Some 100km of new seismic reflection and refraction data have been acquired in a number of designated development areas; all these new data are having a very significant impact on current understanding of Singapore geology.

None of the geological record that emerges from beneath the modern Singapore cityscape is straightforward. Embedding robust geoscience knowledge in sub-surface planning will help ensure that the future decision-making process will be well informed and so improve urban resilience.

Singapore rocks

Singapore lies at the southern end of Peninsular Malaysia, in a region dominated by the geological history of two continental fragments (Indochina-East Malaya and Sibumasu) that separated from the supercontinent of Gondwana during the Palaeozoic. These fragments are now joined together, along with rocks assigned to the Sukhothai Arc terrain, along the trace of the Bentong-Raub Suture Zone (see map p15).

Singapore’s oldest rocks are thought to be the siliciclastic sedimentary rocks of the Sajahat Formation, which crop out on the island of Pulau Tekong in north-eastern Singapore. Although the Formation’s age is not proven conclusively, these rocks have been thermally metamorphosed by the intrusion of granitic and associated mafic intrusive rocks of Permian to mid-Triassic age. The Central Singapore Granite and Gombak Norite plutons are a conspicuous feature on the geological map.

In western and south-western Singapore the Mid- to Upper Triassic (to earliest Jurassic?) volcano-sedimentary Jurong Formation (which has been assigned Group status in the BGS’s new proposed lithostratigraphical framework) was originally deposited in an active fore-arc basin as a shallow marine to terrestrial succession, broadly contemporaneous with the younger elements of the plutonic rocks. The sedimentary succession is punctuated by volcanogenic deposits that issued from the still-active arc; 240 million year-old tuffs are interlayered with Carnian/Norian fossil assemblages, all pointing to a mid- to late Triassic history.

Now folded, thrust and cleaved, these Jurong strata record deformation and low-grade metamorphism that resulted when the fore-arc sequence became accreted onto Mesozoic Indochina-East Malaya during collision and suturing with Sibumasu across the Bentong-Raub line.

During the earlier stages of that collision, and possibly as the subducting oceanic slab detached, the older inner fore-arc succession was buried beneath a 20 – 30Ma younger fluvial succession laden with volcanic, plutonic and metamorphic detritus. Gradually, that fluvial succession became more tidally dominated again, as relative sea-levels rose in the earliest Jurassic. Terminal collision of Sibumasu and SE Indochina- East Malaya (‘docking’) marked the end of deformation, focused in the Bentong-Raub suture zone. NE-vergent fold and thrust-belt deformation developed on the eastern side of the suture zone, affecting upper Triassic to earliest Jurassic strata.

Deformation ended by about 195Ma and that terminal collision was followed by a long period of deeply penetrative weathering and erosion for c. 50 million years during the later Jurassic. No mid- to upper Jurassic strata are preserved.

Variously cemented Quaternary sands and gravels cover much of eastern Singapore Island. These are thought to have been deposited by braided river systems, flowing broadly southwards into the Straits of Singapore. They are known as ‘Old Alluvium’ in both Johor and Singapore (attributed to the Bedok Formation within the new proposed lithostratigraphical framework).

The youngest part of the succession comprises unconsolidated marine to terrestrial sediments of late Pleistocene to Holocene age, which are assigned to the Kallang Formation (also elevated to Group status in the BGS proposed lithostrat framework).

Pioneer

It is important though to acknowledge that our work did not start from
nothing. One of the first geological maps for the whole island of Singapore was created by Dr Elizabeth Alexander and published in 1950. Frances Elizabeth Somerville Alexander (1908-1958) was a pioneering scientist (see this month’s second feature, p17). She was awarded a PhD from Cambridge University in 1934 with a thesis on the main outcrop of the Aymestry Limestone (Silurian, Upper Ludlow Shales Group).

After her marriage the couple moved to Singapore in 1936, where they had a family of three children. Alexander worked for the Royal Navy on radio direction-finding, during which time she held the rank of Captain. She is, arguably, most well-known as the first female radio astronomer, discovering in 1945 the ‘Norfolk Island Effect’ - the connection between an increase in radio noise associated with the sun (solar radio emissions).

In 1942, with the threat of Japanese invasion looming, Alexander fled with her children to safety in New Zealand. Believing her husband to be dead (he was actually a prisoner of war at Changi), she remained there, and was appointed head of the Operations Research Section of the Radio Development Laboratory. After they were reunited, the couple returned to Singapore in 1947. Alexander became a geological consultant and in 1949 was appointed Geologist to the Government in Singapore.

Her main task was to make a survey of the islands resources of granite and other useful stone - one conclusion of which being that the island’s granite resources should last for 500 years. Alexander died in 1958, a few months short of her 50th birthday. Her contribution to geology and radio astronomy is extraordinary, considering her short life, detailed knowledge of two disciplines, and the traumatic circumstances in which she made it.

Our present work on Singapore’s subsurface geology rests on the pioneering work carried out by Alexander, often in the most difficult of circumstances. It is with a certain pride that by building on what she achieved, we are able to draw attention to this sadly neglected figure, whose daughter is currently engaged in writing her biography. The Asian Tiger City owes her a very great debt indeed.
Top left: Singapore lies at the southern end of Peninsular Malaysia, in a region dominated by the geological history of two continental fragments (Indochina-East Malaya and Sibumasu) that separated from the supercontinent of Gondwana during the Palaeozoic. These fragments are now joined together, along with rocks assigned to the Sukhothai Arc terrain, along the trace of the Bentong-Raub Suture Zone. Permian to mid-Triassic granitic and mafic intrusive rocks from that arc dominate central Singapore. In western and south-western Singapore a mid- to uppermost Triassic (to earliest Jurassic?) volcano-sedimentary succession was originally deposited in an active fore-arc basin as a shallow marine to terrestrial succession, broadly contemporaneous with the younger elements of the plutonic rocks of Singapore. After Metcalfe (2011) and Hall (2009).

REFERENCES


* BGS Scotland, The Lyell Centre, Edinburgh EH14 4AP: E: agle@bgs.ac.uk ** BGS Wales, Cardiff University, Main Building, Park Place, Cardiff CF10 3AT, Wales. Published with the permission of the Executive Director, British Geological Survey.
*Mary Harris* recounts her mother’s role in investigating the geology of Singapore

Much of the current geological work in Singapore has developed from the work of Dr Elizabeth Alexander: particularly from that published in her Granite Report of 1950 with its enfolded map. She had come to Singapore in 1936 with her husband, New Zealander Norman Alexander, Professor of Physics at Raffles College, but began research on the island’s geology under her own initiative almost as soon as she arrived.

Malay States

In the colonial era, Singapore was included with Malaya in a complicated organisation of Federated and Unfederated Malay States and Straits Settlements, and the only comprehensive publications on the geology of the region were those of John Brooke Scrivenor, appointed first Director of the new Geology Survey Department of the Federated Malay States in 1927. He had worked in Malaya since 1903 with a small and fluctuating staff, from headquarters in Kuala Lumpur; but by the time Elizabeth arrived, the Department’s headquarters was in Batu Gajah, near Ipoh - accessible from Singapore by road and air - where it remained until after the end of colonial times.

Scrivenor’s publications had been accessible to Elizabeth in Cambridge University Library, (where her 1935 PhD in geology is archived) in the Raffles Museum and Library in Singapore, and through the Geological Survey, headed by Eric Willbourn following Scrivenor’s retirement in 1931. Elizabeth developed a particular interest in erosion under the warm and humid climate of Singapore, finding that under certain circumstances, iron, aluminium and silica were mobile and were involved in the formation of new rock at unexpectedly high speed.

Mangrove swamp

By 1940, she had buried some rock samples in mangrove swamp, to compare some years later with controls in the lab which she had set up in her own home. She was still freelance as a geologist, but by 1938 had begun war work at the Singapore Naval Base, where she was employed in Radio Direction Finding (RDF). At that time the Admiralty was setting up a network of long-range, high-frequency, radio direction finding stations, with Singapore as their control centre. Singapore had particularly close links with New Zealand, whose Navy was still a squadron of the Royal Navy and which, as a country, was well advanced in wireless technology.

Invasion

The Japanese Army invaded Malaya in December 1941 and advanced rapidly down the peninsula. Elizabeth was ordered to take her three children to safety with her husband’s family in New Zealand, and to return to the Naval Base with specialist equipment then being manufactured in Sydney. But she was overtaken by events. Singapore fell, and she found herself stranded with no income and no news of her husband and needing to find work so that she could rear her children.

Through contacts with colleagues from Cambridge University days who were by then working in radar (not yet called that, but disguised under the name of ‘RDF’) and her Singapore Naval Base link with the New Zealand part of the RDF network, she was invited to set up and run the Operational Research Section of New Zealand’s Radio Development Lab, the secret radar research department of New Zealand’s Department of Scientific and Industrial Research.

During her four years there, she was responsible not only for the operational effectiveness of New Zealand’s own radars (thrown into prominence in the South Pacific theatre, following Pearl Harbour), but also for two major pieces of research, which faded from history until the very recent publication of New Zealand’s WWII Radar Narrative. One became the beginning of the science of radio astronomy in Australia and the other the Canterbury Project.

Elizabeth could proceed with neither...
of them herself because her contract with the New Zealand government ended with the end of the war. Her husband re-appeared from internment in Singapore in 1947. It is relevant to note however, that her work as Head of Ops Research in New Zealand, in which she was employed as Senior Physicist, was as significant to the development of radio science as her work in the science she loved best was to become in the development of the geology of Singapore.

**Recovery**

In Singapore in 1947 the priority was recovery from occupation. Continuation of her own research was made impossible because her house, which included her lab, had been looted to complete emptiness by the British Army of Reoccupation. Instead, she worked to help re-establish Raffles College, in various consultancies concerned with Singapore’s neglected or damaged infrastructures, and in acting as Temporary Registrar for the new University of Malaya while preparing specimens and slides for teaching in a geology department there as soon as it opened.

In 1949 she was commissioned by the Singapore government to survey the Island for sources of granite for reconstruction and to publish the Granite Report named above. Her attempt to restart her own weathering research was further obstructed because, during some road building, the occupiers had sliced the top off a hill which bore a triangulation point, crucial in locating her buried basket of rocks. Then, her husband was head-hunted to Ibadan, Nigeria where University College Ibadan (then an internal college of London University) would need its physics department upgraded in time to undertake ionosphere research for the International Geophysical Year of 1957/8.

Elizabeth was unhappy to leave her own Singapore geology research for a second time, but her husband, affected like all internees by his experience, needed her help and she put him first. At University College Ibadan, she took a junior post in the Agriculture Department under the rule that wives of expatriate staff could not undertake employment if a qualified Nigerian was available, and attempted to start some weathering research again. Meanwhile Michael Tweedie of Raffles Museum, a naturalist with great experience of and fondness for mangrove swamps, found one of Elizabeth’s baskets of rocks and had it sent to the Rothamsted Research Station, just outside London, where she could examine the rocks during annual leaves from Nigeria.

**Stroke**

Her paper was read at the Geological Society, shortly before she died and published posthumously. During an unsuccessful argument with the College Principal at Ibadan for the development of a geology department which she had already set up at her own expense, she suffered a cerebral haemorrhage and died a week later. She was not quite 50 years old, but in her short life, hampered by war and its lasting effects, she had changed thinking in two separate sciences. Then she disappeared from both sciences until, with the publication of the New Zealand Radar Narrative and renewed geological research in Singapore, people began asking who this remarkable scientist was. My forthcoming biography intends to try to explain.

Elizabeth Alexander would have been particularly pleased to see the lasting effects of her Singapore work both in Singapore and in England. The second edition of The Geology of Singapore by Lee Kim Wee and Zhou Yingxin, was published in 2009 by Singapore’s Defence Science and Technology Agency in collaboration with the Building and Construction Authority of Nanyang Technological University, and made available online through researchgate.net by author Professor Zhou in 2016. Her work is cited, discussed and developed throughout the book as new generations of Singapore geologists work collaboratively with government departments which need to use it. At the same time, the British Geological Survey is working collaboratively in Singapore in building its three-dimensional model of the island. At a time when so much of Singapore’s land has been bulldozed and built on, Elizabeth’s 1950 report, map and photographs are the only record of earlier, more accessible geology.

At the same time, her posthumously published paper on tropical weathering in SE Asia has significance for recent work on the Hertfordshire Puddingstone. Lovell and Tubb (2006) suggest that cementation of this famously hard rock took place “… beneath a 55Ma land surface that enjoyed
a climate closer to that of present-day Penang (in Malaysia) rather than that of Puckeridge.”

ACKNOWLEDGEMENT

I am grateful to Professor Yingxin Zhou and Marcus Dobbs for personal communications about the significance of Elizabeth’s legacy in their current work.

* Mary Harris is writing the biography of Elizabeth Alexander. E: mary@maryharris.plus.com

FURTHER READING

3. Harris, Mary (forthcoming). Rocks, Radio and Radar: the extraordinary scientific, social and military history of Elizabeth Alexander, to be published by Imperial College Press.
Gold Rush – how I found, lost and made a fortune

It was a pleasure to meet geologist and former parachute regiment solider Jim Richards when he delivered a lecture to the North West Regional Group of the Geological Society on this, an autobiography of his career in gold mining and an epic geological tale of rocks, survival and endurance at the most inhospitable ends of the Earth.

This is a no-holds-barred account of life at the sharp end of the exploration industry and, much like the man himself, it comes across as genuine and honest. The people are real, and the situations Jim vividly describes are as raw and real as they can get.

Jim tackles the thorny issue of providing accounts of events in which real people do not always display themselves in the best light with tact and diplomacy, and isn’t afraid to share his own mistakes. As a former gold miner myself, it rang true on so many levels and brought back many happy (and somewhat dusty) memories of rock logging. There is plenty of geological description in here, and so much to be learnt from Jim’s long field experience.

Along with thoroughly entertaining and informative anecdotes of gold, diamonds, oil, iron and more gold, there’s a whole lot of guns, greed, sex, terrorism, corruption, disease and politics thrown in to boot. A representative of seemingly every corner of the animal kingdom has a go at him at one time or another, providing nightmarish encounters with rats, vampire bats, mosquitos, leeches, snakes, and perhaps the deadliest animal of all: the investment banker.

Jim’s geological knowledge and his belief in his dream pull him through: he never gives up, and it is his tenacity of spirit and enthusiasm for geology that bring forth a tale of triumph in the face of adversity, the true possibilities of human achievement in the worst of circumstances and with the smallest of resources, for those who dare to walk the path. There’s many genuine laugh-out-loud moments too. The encounter with Mitch The Canadian’s handover notes had all of us rolling in the aisles.

An absolute must-read for any aspiring exploration geologist, it’s also thoroughly digestible for non-geologists and a handy sized and nicely bound book complete with an interesting set of colour photo illustrations. If you like to read about genuine adventure and survival, then this is for you. AND it has rocks in it. What more could one ask?

Reviewed by: Catherine Kenny

GOLD RUSH - HOW I FOUND, LOST AND MADE A FORTUNE
List Price: £10.99
W: www.septemberpublishing.org

Volcanoes: Encounters through the Ages

Even if you didn’t think you had any interest in either volcanoes or historical geological documents and references, a visit to the Volcanoes exhibition which was held at the Weston Library in Oxford from February to May 2017 will surely have changed your mind.

The exhibition, based on original materials, documents and volcanic phenomena, and even old film posters designed to fire the public imagination. The text descriptions that accompany the illustrations seem to expand on the original exhibition captions and are informative and fascinating.

But the book also attempts to serve as an introduction to volcanology for the general reader, and this, I feel, is its weak point. Admittedly, it’s not easy to explain the complexities of volcanoes to non-specialist readers. However, in contrast to the generally stylish and informative writing about the historical context, the science writing often seems clumsy and occasionally unintentionally patronising – an impression not helped by the excessive use of explanatory phrases in parentheses.

My advice: skip the Introduction, skim through the other ‘science textbook’ sections and focus instead the historical sections and wonderful illustrations. You’ll be in for a fascinating, enjoyable and informative read and a feast for the eyes.

Reviewed by Nina Morgan

VOLCANOES: ENCOUNTERS THROUGH THE AGES
List price: £20/US$35.00

A History of the Solar System

This an unusual book, packed with information, and a difficult one to review. Rather than discuss the evolutionary history of the solar system (as I expected), Vita-Finzi chooses to talk about the history of some ideas that have come about and developed through the study of our planetary neighbours. Each idea is assigned a chapter followed by a list of references.

To explain what the author’s approach is all about, we must go back to 1584, when
Giordano Bruno first suggested our planets revolved around the sun. Now, we know there is a multitude of planets orbiting similar stars to ours in our galaxy. That’s a pretty good, and relevant, idea!

In another chapter, the author explores the idea that the solar system is still changing. External ingresses must have had an influence. Vita-Finzi discusses a variety of potential influencers and our present ability to measure their effect.

This is a challenging read. Long sentences are common. They are replete with subsidiary clauses, which make parts of the text difficult to absorb. I often found I had to read a sentence several times to fully understand the gist. And, sometimes a word had obviously been dropped, which made me feel uneasy about my comprehension overall. Such blemishes are irritating and detract from the underlying value.

Despite these problems with editing, the book is cleverly conceived and a useful addition to any scientists bookshelf. It should provide a challenging read to students and graduates alike. Many seasoned scientists may enjoy taking a stab at it too.

In many ways, I understand and admire this brave attempt to conjure up a fresh and more interesting way to examine our local system. I hope there are better books to come.

Reviewed by David Edwards

Radioactive Waste Confinement: Clays in Natural and Engineered Barriers

The current scientific consensus for the safest long-term management of higher-activity radioactive wastes is through geological disposal in engineered facilities constructed at an appropriate crustal depth, within stable geological formations (the geological disposal facility or ‘repository’). Repository development on a specific site requires the integrated and systematic analysis of the characteristics of the waste to be ‘emplaced’, the enclosing engineered barriers and the site’s host rock and its geological setting. Three main host rock types are usually considered for geological disposal: crystalline rocks, evaporites (salt) and clays.

This GSL Special Publication concentrates on the importance of clays and other argillaceous materials in the development of geological disposal systems. Characteristically, clays display properties which can be exploited both as host rock and material for engineered barriers (as buffer, backfill or sealing material). Properties include low permeability, diffusive transport, retention capacity, buffering effects, self-sealing capacity, stability, vertical homogeneity and lateral continuity, which make clays significant barriers to radionuclide and chemical contaminant migration towards the surface environment.

Based upon the 6th International Clay Conference hosted by the Belgium National Radioactive Waste Management Agency (ONDAF/NIKAS) in 2013, the volume contains 25 papers grouped into six interrelated and multi-disciplinary topic areas: large-scale geological characterisation, general strategy for clay-based systems, geomechanics, mass transfer, bentonite evolution and gas transfer. These topic areas demonstrate the diversity of current geological repository research. Clay characterisation studies relevant to the confinement of radionuclides range from the fundamental process level, to the overall understanding of the performance and safety at geological and repository scales. Emphasis is placed on the modelling of processes operating at the mineralogical level within the argillaceous barriers.

The contributions are well-written and edited, complemented with appropriate figures, photographs and data-tables. A minor presentational criticism is that several data graphs are difficult to discriminate, reproduced as grey-scale images in the print copy - unfortunately distracting from the details described. Overall, a recommended read and valuable reference work for practising geoscientific professionals within the radioactive waste management sector.

Reviewed by Mark Griffin
relating the hydrocarbon production of world-wide sedimentary basins to their geology.

As an Imperial College lecturer in the Applied Geochemistry Research Group, he researched the application of statistical and computing methods to mapping and interpretation of regional geochemical survey data for mineral exploration, geological and epidemiological purposes. Howarth’s broad experience in industry and academia qualifies him as much as anyone else to produce his dictionary of mathematical geosciences, but inevitably some subjects are treated in greater depth than others. His personal interest in the history of the development of quantitative methods is evident throughout, with abundant references to geoscientists who have made substantial contributions. Some readers may be disappointed that their own particular field of geoscientific enquiry is not as well represented as those with which Howarth is most familiar from his own career. Hopefully, this disappointment will be compensated by the reward of finding new nuggets of information and insight that may prove very useful. Some readers may be delighted to find some topics treated in considerable detail, bordering that of a basic mathematical dictionary. Being expensively priced, this volume should be often browsed. (though an e-book is available); but there it should be often browsed.

Some readers may be disappointed that their own particular field of geoscientific enquiry is not as well represented as those with which Howarth is most familiar from his own career. Hopefully, this disappointment will be compensated by the reward of finding new nuggets of information and insight that may prove very useful. Some readers may be delighted to find some topics treated in considerable detail, bordering that of a basic mathematical dictionary. Being expensively priced, this volume should be often browsed. (though an e-book is available); but there it should be often browsed.

Soda Lakes of East Africa

There are many reasons for writing and publishing a book, but I suspect the best and most satisfying is ‘fun’. Having now read this latest multi-author publication I firmly believe the 30 different authors had this as their primary motivation.

This book is probably not the last word on the subject of soda lakes, but it is certainly a milestone in characterization and understanding. Covering geology, geochemistry, limnology, zoology, microbiology, environmental and cultural assessment of the soda lakes of East Africa, particularly those of Kenya, this volume provides comprehensive coverage.

The editor, Michael Schagerl (who is also a contributor), has done an extremely good job of assembling like-minded enthusiasts. Starting with an assessment of the physiochemical environment of the lakes, their formation, hydrology and geochemistry, the book then moves to their associated fauna and microfauna. The final chapters cover issues of conservation and environmental assessment, the challenges in managing the lakes, and potential future scenarios. Despite the comprehensive nature of the chapters, the volume ends with a ‘shopping list’ of issues that still need resolution in our understanding of these unique environments.

The book would seem, at first glance, to be aimed at a highly specialized audience; but if you take a step back from the title, you realise on reading it that the volume is a blueprint for how one should assess an ecosystem - from understanding its geological formation and characteristics, to the micro and macro fauna (and looking to the future to assess potential conflicts and knowledge gaps). I would therefore recommend this book to any geoscientist. It allows the reader to see how our science interplays with other natural sciences, and the close interconnection between geosphere and biosphere. The book is extremely well edited and the chapters well written: a lasting testimony to the considerable effort the editor and authors have applied. Strongly recommended for anyone who thinks about our natural world.

Reviewed by Rob Bowell

DICTIONARY OF MATHEMATICAL GEOSCIENCES WITH HISTORICAL NOTES

SODA LAKES OF EAST AFRICA

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! Water Resources - a new water architecture, by Alexander Lane, Michael Norton and Sandra Ryan. 2017 Wiley Blackwell 526pp hbk


◆ NEW! Proterozoic Orogens of India - a critical window to Gondwana by TRK Chetty. 2017 Elsevier 405pp, stbk

◆ Sedimentology of Paralic Reservoirs - recent advances by Hampson, G J et al., (eds) Geol Soc Publishing House 2017 SP #444 (hbk)

◆ The Message - a novel by Jan Vana. Fandelance press 199 pp stbk

◆ Monogenetic Volcanism by Németh K et al. (eds), 2017 Geol. Soc. pub. Hse., SP #446 32pp hbk


◆ Subterranean Norwich - the grain of the city, by Matthew Williams. Lasse Press 160pp stbk

◆ Principles of Radiometric Dating by Kunchtia papad Gopalain Cambrige UP 2017 207pp hbk

◆ Geochemistry and Geophysics of Active Volcanic Lakes by Olha et al. GSL Publishing SP#437 295pp, hbk

◆ Salt Tectonics - principles & practice by Jackson PA and Huden MR. Cambridge University Press 2017 439pp, hbk

◆ Chesapeake perspectives - decoding the deep sediments: Ecological History of Chesapeake Bay by Grace Brugh. 2017 Maryland Sea Grant 62pp stbk

◆ Tectonics of the Deccan Large Igneous Province by Mukherjee et al. (Eds), 2017. Geol Soc Spec Pub #445 363pp, hbk

◆ Sedimentology of Paralic Reservoirs - recent advances by Hampson, G J et al., (eds) Geol Soc Publishing House 2017 SP #444 (hbk)

◆ Land Surface remote Sensing, by Baghdadli N and Zribi M (eds). Elsevier 2017 342pp hbk


◆ Waves, Particles and Storms in Geospace by Balasis et al. 2016 Oxford University Press 448pp hbk

◆ Lake Pavin - history, geology, biogeochemistry and sedimentology of a deep meromictic maar lake, by Sime-Ngando et al., (Eds) 2016 Springer. 421pp, hbk
## ENDORSED TRAINING/CPD

<table>
<thead>
<tr>
<th>COURSE</th>
<th>DATE</th>
<th>VENUE AND DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoding Eurocode 7: Ground Investigation &amp; Testing: Session 1</td>
<td>2 November</td>
<td>Accessed online over 5 90-minute sessions on 2, 6, 9, 13 &amp; 20 November. Fees apply. See Website for details and booking. Venue: Higham Hall College, Bassenthwaite Lake, Cockermouth, Cumbria. Led by Dr Annette McGrath. Fees apply. See website for details and booking.</td>
</tr>
</tbody>
</table>

## 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

<table>
<thead>
<tr>
<th>COURSE</th>
<th>DATE</th>
<th>VENUE AND DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cainozoic Clays of South East England South East Regional</td>
<td>6 September</td>
<td>Venue: Capita House, Wood Street, East Grinstead, West Sussex RH19 1UU. Time: 1800 for 1830. Contact: Simon Holt E: <a href="mailto:Simon.Holt@btp-hyder.com">Simon.Holt@btp-hyder.com</a></td>
</tr>
<tr>
<td>Risk and Uncertainty in Exploration for Oil and Gas East Midlands Regional</td>
<td>7-8 September</td>
<td>Venue: Derby University DE22 1GB. Speaker: Malcolm Brown (President) Time: 1830 for 1900. Contact Jessica DeFreitas E: <a href="mailto:jessica.defreitas@aecom.com">jessica.defreitas@aecom.com</a></td>
</tr>
<tr>
<td>18th Glossop Medal Lecture Engineering Group</td>
<td>13 September</td>
<td>Venue: Royal Institution &amp; Burlington House. Time: 1715 – 1800 (Reception @ BH) Charges apply for Reception. See website for details. Speaker: Jackie Skipper. Contact Georgina Worrall E: <a href="mailto:georgina.worrall@geolsoc.org.uk">georgina.worrall@geolsoc.org.uk</a></td>
</tr>
<tr>
<td>GSL Nottingham Careers &amp; Industry Day 2017 Geological Society</td>
<td>13-19 September</td>
<td>Venue: BGS, Keyworth. An essential meeting place for geoscience students and the geoscience industry. Includes career and industry presentations covering different areas of geology and academia. See Website for details and registration. Contact: Naomi Newbold E: <a href="mailto:naomi.newbold@geolsoc.org.uk">naomi.newbold@geolsoc.org.uk</a></td>
</tr>
</tbody>
</table>

---

**Sticks and Stones**

**Do you, today’s task, is to make a geologic map of the area. There’s a lot to get through in one day...**

**But with careful orienteering and judicious observation of the outcrops you can elucidate the contact between the slates and the limestone.**

**Or you could save yourself a few hours and look which rocks the drystone walls are made of.**
The Society and Publishing House were saddened to learn of the sudden and untimely death of Kurt Kyser, writes Angharad Hills. Fellow of the Royal Society of Canada and pioneering geochemist, Professor Kyser died while teaching in Bermuda on 29 August. Professor Kyser worked at the Department of Geological Sciences and Geological Engineering at Queen's University, Kingston Ontario. He was Chief Editor of the journal Geochemistry: Exploration, Environment, Analysis, which the Society co-publishes with the Association of Applied Geochemistry. The Society would like to extend its sincere condolences to his colleagues, friends and family.

The appearance of war memorials marked one of the many changes to the British landscape brought about by the First World War. Bodies of the fallen were not repatriated, so many bereaved families were denied even the small comfort of a nearby grave on which to focus their grief. Instead, local groups formed committees to create war memorials to commemorate their dead. There are thought to be around 100,000 war memorials in Britain, around two-thirds of them from the First World War.

As geologist and science writer Nina Morgan discovers some of the most moving war memories are set in stone

Local initiatives
In contrast to the war cemeteries established by the (then) Imperial, (now, Commonwealth) War Graves Commission, where the design of the memorials and headstones was strictly regulated (see War Graves Design by Committee got it Right, Geoscientist, 24.10, November 2014), decisions about erecting local war memorials was left to local committees. It was perhaps this outpouring of local grief and unregulated design initiatives that prompted the geologist Archibald Geikie [1835 – 1924] director of the Geological Survey from 1882 – 1901 and then retired and living in Haslemere, Surrey, to write to the Editor of The Times on 10 June 1919.

In the course of his fieldwork in Scotland, Geikie became interested in gravestones as means of studying weathering in stone, and was appalled at the speed with which certain stone types degraded (see The Wasting of Time, Geoscientist 25.9, October 2015).

In a letter to the Editor, headed Whiite Marble Unsuitable, Geikie wrote: “Sir, As so many monuments are about to be erected all over the country in memory of those who have fallen in the war, it may be useful to give a word of advice as to the material that should not be chosen in the construction of them.

“No account should white statuary marble be employed in any structure in the open air. Even the purest air of the country contains carbonic acid, which, dissolved in falling rain, acts on the stone as a solvent. In our rainy climate only a few years suffice to remove the polish from the surface, which gradually becomes rough and granular, so that one can wipe off the crumbling powder with the hand. In the air of large towns other acids, produced from the burning of coal are added to the atmosphere and increase the solvent action of the rain.

“Many years ago I studied this process of decay among graveyards in towns and in the country and as a the result of my observations I found that in town air a marble monument freely exposed to air, rain, wind, and frost will seldom last as much as a hundred years ... Of course, a cynic may say that in the great majority of cases it will be no great matter if, at the end of a hundred years or less, a marble monument has fallen into ruins ... But our war memorials are meant to outlive generations, it is surely desirable that care should be taken to construct them of the most durable materials that can be obtained.”

Circumstantial evidence
The date of the letter, combined with personal connections, all suggest Geikie may have had something to do with the erection of the magnificent Grade II listed war memorial that graces the High Street in Haslemere. The gable-topped cross that tops the memorial was designed by the country house architect, garden designer and author, (Henry Benjamin) Inigo Triggs [1876 – 1923]. Triggs was also the designer of Broad Dene, a wonderful Arts and Crafts house situated near Geikie’s own home in Hill Road, Haslemere.

Given his interests, Geikie may well have influenced the choice of stone. But what is the stone? From pictures, only two stone types degraded (see The Wasting of Time, Geoscientist 25.9, October 2015).

The Grade II listed war memorial, Haslemere

The Grade II listed war memorial, Haslemere

Permanent memorials

The Grade II listed war memorial, Haslemere

The Grade II listed war memorial, Haslemere

Acknowledgement
I thank Julia Tanner, curator of the Haslemere Educational Museum for making local enquiries about the origin of the Haslemere war memorial on my behalf and passing on the helpful responses. Other sources include: a letter from Archibald Geikie to the Editor of The Times published on 10 June 1919; the websites www.learnaboutwarmemorials.org and www.warmemorialsonline.org.uk; and the Wikipedia and Dictionary of National Biography entries for Inigo Triggs.

* 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
Saunders was born on 3 November 1928. He attended the Tiffin School in Kingston-upon-Thames and read geology at University College London, graduating with honours in 1951.

In the same year he took up an appointment with Trinidad Leaseholds Limited as a field geologist. In 1952 he was transferred to the geological laboratory in Pointe-a-Pierre. This proved an important career move as it brought him into contact with Hans Kugler, ‘Father of Trinidad Geology’ and who was instrumental in encouraging the use of planktic foraminifera for stratigraphic control. These studies were spearheaded by Hans Bolli and Walter Blow. Saunders was an enthusiastic addition to this team. These pioneering studies were among the earliest demonstration of the value of planktic foraminifera for stratigraphic correlation and later confirmed in other parts of the world. In 1959 John was promoted to Senior Stratigrapher.

Saunders’ contribution to the geology of Trinidad over almost 25 years, was finally acknowledged by including his name in the Government’s Roll of Honour, which recognises those who have made an exceptional contribution to Trinidadian life and called ‘CARIBBEAN ICONS’. John was a worthy recipient.

Trinidad

As a consequence of the Suez Crisis, Texaco acquired Trinidad Leaseholds in 1956 and John spent the remainder of his working career with Texaco, retiring as Chief Stratigrapher in 1975. His responsibilities while initially confined to Trinidad later were extended to Texaco’s exploration activities in Latin America. During this period he began a revision of the Kugler map, which was finally published in 1997. In 1975 he spent time as the co-chief scientist on Leg 15 of the Glomar Challenger deep sea drilling project.

Other ‘extracurricular’ activities included producing a stratigraphic lexicon for Trinidad and Tobago, he co-coordinated the work of the Ministry of Energy who were ultimately responsible for publishing the revised geological map of the island. He was an honorary member of the Trinidad & Tobago Geological Society. In 1966 Saunders led excursions for the Canadian research vessel ‘Hudson’ on their visit to Trinidad and Barbados. He gave generously of his time to other things, including lecturing to university engineers. He was technical secretary for the 4th Caribbean Geological Conference, and chaired the local branch of the Institute of Petroleum.

He took a keen interest in the Trinidad Field Naturalists’ Club and was a Field Warden, and lectured to schools on their behalf. A keen ornithologist and a skilled pilot he was able to contribute material for ffrench’s book Birds of Trinidad & Tobago and to photograph the island’s mud volcanoes.

Basel

Saunders retired in 1975, and accepted a position as curator of the micropalaeo collections in the Natural History Museum in Basel. This brought him, once again, in contact with his old mentor and colleague Hans Bolli, who was attached to the Federal School of Technology in Zurich. Here he co-curated the museum’s micropalaeo reference collections. He led a government funded expedition to the Dominican Republic between 1978 and 1980. A major contribution whilst in Basel, was to co-edit with Bolli and Perch-Nielsen the two volume book on Cretaceous–Tertiary planktonic foraminifera and also to co-author (with Bolli) the chapters on Oligocene–Holocene planktonics.


By Griff Cordey, with acknowledgement for material from Sally Radford and James Robson
Trevor David Ford 1925-2017

Trevor Ford, one of the giants of traditional British Geology and Senior Lecturer in the Department of Geology at Leicester University until he retired in 1987, died on 22 February aged 91.

Essex

Trevor was born 19 April 1925 at Westcliffe-on-Sea in Essex. At 22 he went to Sheffield University to study geology, following his BSc with a PhD on the Ingleton and Stainmore Coalfields before coming to Leicester.

In 1952 he was appointed as an Assistant Lecturer at University College, Leicester to join Mac Whitaker. Between them they taught all branches of Geology up to the standard required by London University External Honours Regulations. As the department grew and the University was granted its Royal Charter, enabling conferment of its own degrees, his teaching was mainly in stratigraphy, palaeontology, micropalaeontology, map interpretation, quaternary geology, economic geology (mainly coal, oil and water-supply), environmental geology and the history of geological science.

Charnia

Trevor was well known internationally for his tremendous output on Derbyshire and elsewhere, but the aspect of his work that enjoyed greatest international impact concerned his description of the Precambrian fossil Charnia. This frond-like organism was found by a Leicester schoolboy, Roger Mason (himself later a well-known geologist), and described by Trevor in 1958. It was one of the first convincing organisms to be described from rocks that were incontestably Precambrian. Charnia and its relatives are now renowned as members of the enigmatic Ediacaran biota.

Trevor supervised 22 research students and examined a similar number of PhDs. He held visiting Professorships in both US and Australian Universities. He published over 500 papers, books, guides and reviews. He was promoted Senior Lecturer in 1980 and retired from the University in 1987, after 35 years’ service. He was then given the title ‘University Fellow’ and maintained links with the department, continuing his work on local geology, mining history, and caving.

Senate

Trevor’s achievements were recognised by a number of awards culminating in an OBE in the 1997 Queen’s Birthday Honours List, for ‘Services to Geology and Cave Science’. In 1974 he was awarded a moiety of the Lyell Fund by the Geological Society of London. In 2016 an honorary DSc was conferred upon him by the University of Derby in recognition of his contributions to the geology and landscape of Derbyshire.

Honours

Trevor’s first wife Ann (née Thornhill) died in 1956. In 1958 he married Betty (née Thomas) who died in 2006. He is survived by his two daughters, Alison Tagg and Janet Baxter and his granddaughter, Kirsty Baxter.
James Brooks, known as Jim, was as proud of his Saltaire, Bradford, and Yorkshire upbringing and schooling (Salt Grammar School 1950–58) as anyone could be; but he was actually born in Co. Durham. Football and cricket, both playing and watching were life-long passions.

After a year working for ICI in Billingham, in 1959 he entered the Industrial Chemistry Honours course of what became Bradford University in 1966. His interest in organic chemistry began with an undergraduate BTech study of the chemistry of wool grease, followed by an MPhil on wool wax and then a PhD (Bradford, 1969) on the chemistry of sporopollenin (on which he became an authority) which makes the highly resistant walls of pollen, spores and microorganisms and is the commonest fossil even in the Precambrian.

Chemical palynology

He became a research chemist in chemical palynology with BP (1969–75), including exploration work on samples from the North Slope, Alaska and the North Sea. He became FGs in 1974. He returned to Bradford University as a Senior Research Fellow (1975–77), working on extant and geological organic materials before joining the British National Oil Corporation in Glasgow in 1977 as Head of Geochemistry, leaving as Senior Scientist in 1986 to form Brooks Associates as a consultant.

Outstanding organic geochemist and lecturer, who founded the Society’s Petroleum Group

By then he had researched organic matter in meteorites and the origin of life, published over 50 papers and six books, and lectured and consulted through the UK, Europe, North America, India and USSR - being UK Exchange Scientist to USSR (1971) and Royal Society Visiting Scientist to India in 1977.

From 1986 he gave short courses literally all over the world because Jim was a superb lecturer, giving an annual organic geochemistry course to Glasgow University geologists (1978–98) but he also teaching Glasgow Chemists and Strathclyde Applied Geologists. He was AAPG Distinguished Lecturer to North America (1989–90).

Petroleum Group

The Society remembers him for founding the Petroleum Geochemistry Group in 1979 which, in 1981 became the enormously successful Petroleum Group with Jim as Founder and First Chairman. He initiated the Society’s agreement with the AAPG to mutually sell each other’s publications and played a leading role in the Petroleum Geology of NW Europe Barbican conferences and resulting books.

He was elected to Council in 1984, was a Vice President, and then Secretary from 1987–90. He received awards for Distinguished Achievement from the AAPG (1993) and Service from the Society (1999) and a Bradford University DSc (2001).

Faith

Jim’s Christian faith and church-led community service was at his core, whether in Yorkshire or Glasgow and he became a near full-time Secretary of the burgeoning Queens Park Baptist Church, Glasgow, for a decade ending in 2002–3 when he was the last President of the Baptist Union of Scotland. He was utterly reliable, good company and splendid teacher.

He retired to Cumnock, Ayrshire, and wrote a 725 page 2013 autobiography The Full Spectrum which is in the Society’s library. He leaves Jan, his wife of 43 years, Naomi, Daniel, and four grandchildren.
CROSSWORD NO.220 SET BY PLATYPUS

ACROSS

1 Turn terrifyingly to rock (7)
2 A cartilaginous fish related to sharks, in the suborder Myliobatoidei (8)
3 In consequence; goes a bit ballistic (6)
4 Jonquils named for Housman’s Grecian lad (8)
5 Basic eruptive (6)
6 Arthur’s seat. Or possibly JFK’s. (7)
7 Type selected subsequently to the description, to replace another (7)
8 GSL founder who invented the cage, among other leccy things (7)
10 Adjustable monkey, pipe or torque (6)
11 Hemlock-drinkibng corrupter of youth (8)
12 Triangle a long way from anywhere (4)
13 In consequence; goes a bit ballistic (6)
14 Water-loving chemical species (11)
15 Science of non-Newtonian fluid flow (8)
16 Line of equal-drilled thickness of a rock unit (8)
17 Drives to frenzied anger (7)
18 Hibernating rodents much eaten by fancy Romans (7)
19 Not your immediate forebear’s sister, but one who came before at least (10)
20 ‘Dawn of the recent’ (6)
21 Basal, asymptotic portion of cross-lamination (6)
22 Double-reeded wind instrument of the orchestra (4)
23 Fish-like marine chordate of the order Amphioxiformes (8)
24 Dig up a Scottish enlightenment philosopher (6)
25 ‘Difficult’ years (7)
26 Under the drift (7)

DOWN

1 Leipzig
2 Silicone
3 Slates
4 Leapfrog
5 Chisel
6 Ingrate
7 Cephalopods/a
8 Methane
9 Spherulite
10 Uplift
11 Exposure
12 Miro
13 Sphairolite
14 Meteorologist
15 Landscapeed
16 Agar
17 Halogen
18 Portland
19 Ablate
20 Peonage
21 Diapir
22 Agar
23 Portland
24 Ablate
25 Peonage
26 Pinnate

WIN A SPECIAL PUBLICATION!

The winner of the September Crossword puzzle prize draw was Conor O’Malley of Cambridge.

All correct solutions will be placed in the draw, and the winner’s name printed in the February 2017 issue. The Editor’s decision is final and no correspondence will be entered into.

Closing date - December 8.

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 ..............
...............................................................
...............................................................
...............................................................
...............................................................
Postcode .............................................

SOLUTIONS SEPTEMBER

Across:
7 Vesicle 8 Methane 10 Uplift
11 Exposure 12 Miro 13 Spherulite
14 Meteorologist 19 Landscapeed 22 Agar
23 Portland 24 Ablate 25 Peonage 26 Pinnate

Down:
1 Leipzig 2 Silicone 3 Slates 4 Leapfrog
5 Chisel 6 Ingrate 9 Cephalopods/a
15 Recharge 16 Scabland 17 Halogen
18 Cantata 20 Dating 21 Diapir
Career & Industry Days 2017
The Geological Society

Wednesday 8 November 2017
Venue: BSi, Keyworth, Nottingham, UK
The Geological Society Career & Industry Days is an essential meeting place for geoscience students and the geoscience industry, and is the most recognised geoscience careers brand in the country. The day will include short career and industry presentations covering different areas of geology and geoscience, and there will be an exhibition consisting of industry and professional bodies, and higher education institutions promoting MSc and PhD opportunities. There will also be a wide range of employer workshops running alongside the talks.

Wednesday 22 November 2017
Venue: Old Station, Edinburgh, UK

Lyell Meeting 2018
Mass extinctions: understanding the world’s worst crises

7 March 2018
The Geological Society, Burlington House

The study of mass extinctions is one of the most interdisciplinary research areas within Earth and environmental sciences. Major extinctions have come from a broad spectrum of events, including atmospheric, volcanic, and oceanic, and the understanding of the causes and consequences of these events has advanced significantly in recent years.

The 2018 Lyell Meeting aims to highlight these achievements and showcase the improved understanding and new avenues of research by both geoscientists and palaeontologists.

Contact Information
The Geological Society, Burlington House, Piccadilly, London W1J 9HN
Tel: 020 7594 2700
Email: events@geolsoc.org.uk

Call for Abstracts:
Bibliographic and poster abstract submissions for the meeting and/or which could be used in the final conference report should be e-mailed to info@geolsoc.org.uk by December 8, 2017.

Geoscience Jobs

Geoscience Jobs is the official jobs platform for the Geological Society. Whether you are searching for a new role, or in a managerial position keen to advertise a new vacancy, you will be able to access and use jobs.geolsoc.org.uk knowing it is tailored to a broad spectrum of specialist earth science professions.

Geoscience Jobs is an essential resource for any earth science professional looking for the next step in their career.

NOW LIVE
REGISTER NOW AND BROWSE THE LATEST ACADEMIC AND COMMERCIAL ROLES FROM LEADING RECRUITERS IN THE UK AND FURTHER AFIELD
jobs.geolsoc.org.uk

IF YOU HAVE A JOB VACANCY TO ADVERTISE CALL 01727 893 894
New publications to add to your bookshelf

Browse the Online Bookshop for these and other titles from the Geological Society and other earth science publishers, www.geolsoc.org.uk/bookshop

Special Publications and Memoirs are also available as an electronic version in the Lyell Collection, as part of the Full Book Collection (for subscribing Fellows). Find out more at www.geolsoc.org.uk/fellowsaccess##fullbookcollection
Why Exhibit?
Promote your licences by exhibiting at the UK’s largest prospects fair organised in cooperation with the OGA. PROSPEx regularly features industry operators, service companies, regulators from UKCS and beyond.

Some of the main benefits include opportunities to:
♦ Attract investment
♦ Meet decision-makers
♦ Promote your opportunities

Why Sponsor?
PROSPEx is the key show in the UKCS for promoting your brand. Get in front of over 900 decision makers, prospectors, financiers and consultants.

For further information on exhibition and sponsorship opportunities, please contact events@pesgb.org.uk

PESGB and OGA bring you the 15th show in their highly successful series of Prospect Fairs - the UK’s leading networking event for exploration and development.

Registration now open at pesgb.org.uk/prospex-2017/

Member
One day £100 / Two day £140

Non Member
One day £130 / Two day £195