

GEO SCIENTIST

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The Fellowship Magazine of the Geological Society of London

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Arctic Azolla

An event that changed the world, and may again

100 GEOSITES

Nominate your favourite UK and Ireland localities

ORDNANCE SURVEY

Is the UK's mapmaker losing the plot over contours?

EXIT INTERVIEW

David Shilston reflects on two hectic years at the helm

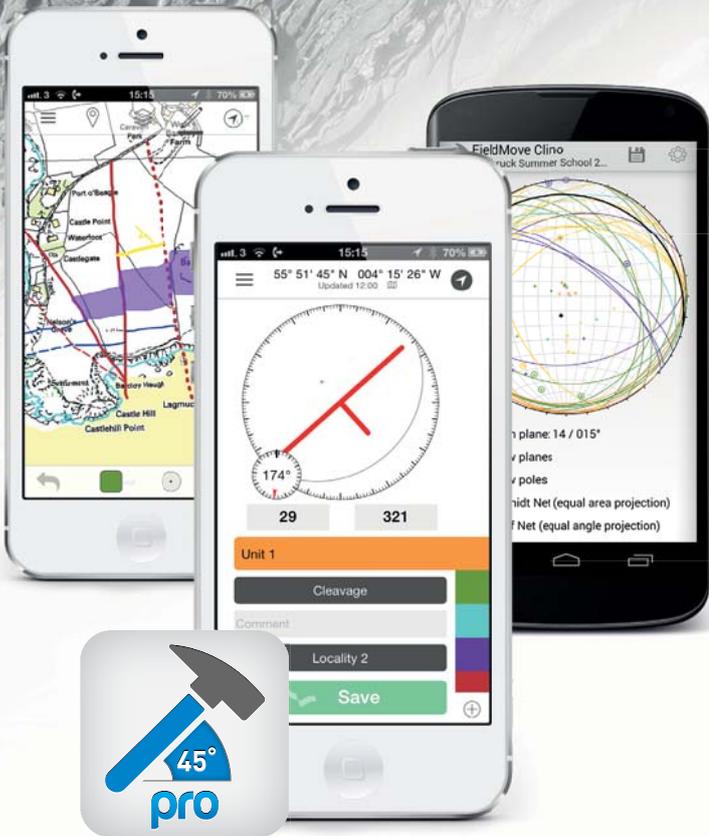
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*Only available in iOS version †Number of downloads during first six months





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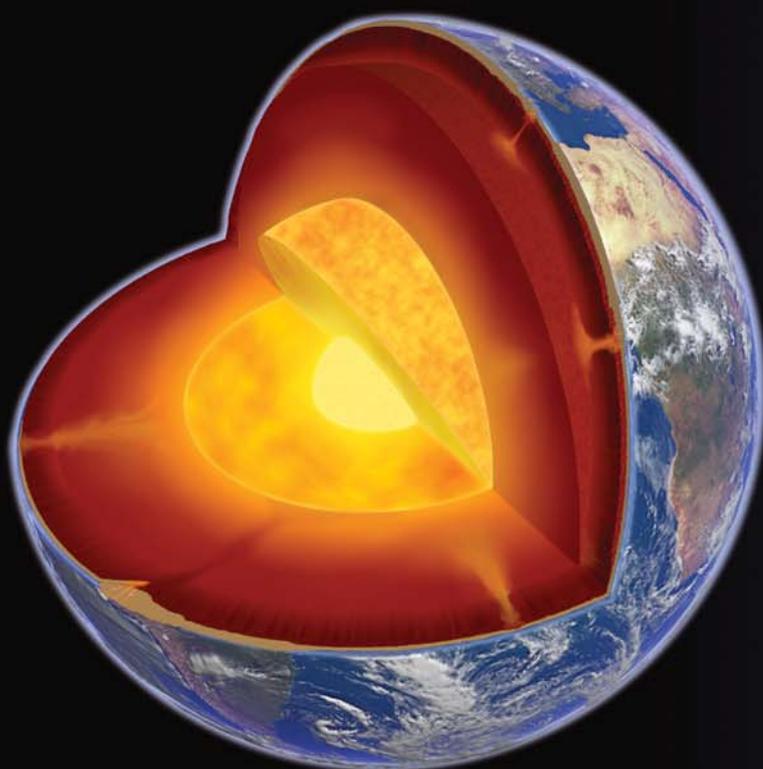
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Deep Earth Processes

windows on the workings of a planet

15-16 September 2014



**The Geological Society, Burlington House,
Piccadilly, London, UK**

The physical and chemical nature of Earth's deep interior is key in controlling many of the processes that shape our planet: from mantle convection to melting, from volcanism to plate tectonics. Rationalising the latest observations – be they clues revealed in the compositions of mantle melts, diamond formation, seismological nuances, or atomistic scale predictions – requires interaction across sub-disciplines. This international meeting seeks to draw together the latest ideas and results from geophysicists, geochemists, mineral physicists, geodynamicists and petrologists to identify the processes shaping the inaccessible depths of our planet.

Thematic sessions:

- Deep mantle structure
- Composition of the lower mantle
- Core formation, CMB & D"
- Surface expression of deep Earth processes

Convenors:

Sally Gibson, *University of Cambridge, UK*
Saskia Goes, *Imperial College, UK*
Simon Redfern, *University of Cambridge, UK*
Mike Walter, *University of Bristol, UK*

Keynote Speakers:

John Hernlund, *Tokyo Institute of Technology, Japan*
Bernie Wood, *University of Oxford, UK*

Invited Speakers:

Chris Ballentine, *University of Oxford, UK*
John Brodholt, *University College London, UK*
Arwen Deuss, *University of Cambridge, UK*
Dan Frost, *Bayreuth, Germany*
Matt Jackson, *UC Santa Barbara, USA*
Peter van Keken, *University of Michigan, USA*
Mike Kendall, *University of Bristol, UK*
Graham Pearson, *University of Alberta, CA*
Dan Shim, *Arizona State University, USA*

Call for abstracts

There is a call for abstracts and contributions are invited by **30th May 2014**. Further information on submitting an abstract can be found at www.geolsoc.org.uk/deepearth14

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

W: www.geolsoc.org.uk/deepearth14



Follow this event on Twitter #deepearth14

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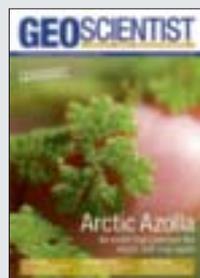
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“ **COULD AZOLLA EXPLAIN OUR PRESENT ICEHOUSE WORLD, AND HELP US SURVIVE THE COMING GREENHOUSE?** ”
 Front cover image

FROM THE EDITOR'S DESK:

Open access

Certain propositions are inherently difficult to counter. Appeals to the market, for example, were particularly hard to counter in the 1980s, and the associated concept of ‘customer choice’ was then applied willy nilly where it has since been recognised as completely inappropriate. It is hard to argue against the democratic principle, even though a majority in favour is no guarantee of anything at all, except possibly the lowest common denominator of understanding.

Is Open Access Publishing one of these? Its very name makes it almost unseemly to oppose. Who would champion the restriction of information? Not I. It is the Government’s view that the results of research for which it has paid should be available to the taxpayers who funded it. It is equally hard to argue against that, though elsewhere, paying for things does not automatically entitle me to access them. Taxpayers fund many things that remain unavailable to them, or even unadvertised to them – for reasons that are sometimes bad, but sometimes conceivably very good.

It is at this point that for me the argument becomes a little confusing. Research paid for by the Government should be published, if it is worthwhile, and therefore made

available – so far, so good. But publishing is not an activity free of investment or labour, or in itself worthless. Rain may fall gently from heaven, but to make it safe and accessible to me in my house, I expect to pay.

True, costs are falling with the advent of online publishing. True, much research publishing is highly lucrative to publishers; good research is in demand. True, some publishers are making profits off the back of research paid for by the public, often using some volunteer labour from the very academics who perform it, but who by the process of peer review, give the results dignity. Their validation renders the published results ‘scientific’.

However in going after commercial profiteers, and in so doing further forcing the pace of publishing reform at a time when nobody is really sure if revenue streams will hold up at all, is this process not in danger of confusing baby and bathwater? Learned society publishers plough their surpluses back into fostering new and better science through meetings and research sponsorship. We do not line shareholders’ pockets. Our shareholders are - scientists themselves.

Is it now more than ever timely to issue an appeal to scientists to show a little solidarity with their learned societies and publish with them?

DR TED NIELD, EDITOR - ted.nield@geolsoc.org.uk @TedNield @geoscientistmag

SOCIETY NEWS

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



Policy update

The policy team has been active in environmental policy, carbon capture and storage (CCS) and shale gas, writes *Florence Bullough*.

Issues such as shale gas may grab headlines, but we also aim to communicate an understanding of the importance of geology to inform a wide range of interdisciplinary areas of policy-making. The Society responded to several consultations on environmental management in the first part of 2014, in which we highlighted the vital functions performed by the geosphere within wider natural systems.

Please see the online version of this piece for hotlinks to the policy documents referred to.

Environmental policy

Natural Resources Wales (NRW) launched a consultation on their corporate plan to which the Society responded. We supported their recognition of the importance of geodiversity and geosphere functions, and stressed the need to ensure that these considerations are fully applied in practice in a holistic approach to environmental management and ecosystem service delivery, rather than just focus on air, water and living things. The Society also reiterated its concern at the backlog of Geological Conservation Review sites that are awaiting designation as SSSIs.

The Society also responded to a Welsh Government consultation on the Environment Bill White Paper. Our response again emphasised the importance of the geosphere as a first-order control on ecosystems services and expressed concern that the abiotic elements of ecosystems are often undervalued in policy documents in comparison to biotic elements, and urged the Welsh Government to ensure that the forthcoming Environment Bill recognises the importance (and interconnectedness) of both. In both these responses, we highlighted the importance of retaining geoscience capacity and human capital following the creation of Natural Resources Wales, and the restructuring of policy functions this has entailed.

The Society also responded to the London Geodiversity Partnership, supporting their 2014-2018 geodiversity action plan for London and highlighting the work of our Geoconservation Committee.

Shale gas

The Shale UK 2014 conference, organised by Global Event Partners on behalf of the Society, took place in London on 4-5 March. It presented a state-of-the-art view of the geology of shale gas to a diverse audience of industry decision-makers, policy-makers, regulators, community representatives and others. A wide-ranging and engaging programme of talks over the two days of the conference featured leading experts in many relevant areas of geology from across industry, government and academia, including several from North America, providing an opportunity to learn from experience there.

As well as drawing on expertise on resource exploration and production from the hydrocarbons industry, the conference also featured hydrogeologists, engineering specialists and regulators, who presented a geological view of the potential impacts and environmental management of shale gas extraction. Feedback on the conference was very positive – we succeeded in our aim of delivering something different from other shale gas conferences, of real value to our audience.

We also responded, together with the PESGB, to a House of Lords Inquiry into the 'Economic Impact on UK Energy Policy of Shale Gas and Oil' in addition to the recent DECC consultation on the 'Environmental Report for further onshore oil and gas licensing'.



LONDON LECTURE SERIES

Geology in Space: Meteorites and Cosmic Dust

Speaker: Matt Genge (Imperial College, London)

Date: 18 June 2014

Programme

- ◆ Afternoon talk: 1430 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/gsslondonlectures14. 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: **Naomi Newbold**, The Geological Society, Burlington House, Piccadilly, London W1J 0BG, T: +44 (0)20 7432 0981 E: Naomi.newbold@geolsoc.org.uk

Other activities

In December, as part of the Society's ongoing work on radioactive waste disposal policy, we responded to a DECC consultation on the 'Review of the Siting Process for a Geological Disposal Facility', and have also attended stakeholder meetings in connection with this review.

Following the launch of our major report on 'Geology for Society' at the Southern Wales Regional Group's event 'Geology and the Welsh Economy' (reported in the April *Geoscientist*), the report is continuing to attract considerable interest, both in the UK and more widely.

In April, we hosted the third in a series of conferences held jointly with AAPG on CCS entitled 'Geological Carbon Storage: Meeting the Global Challenge', a two-day programme of research and field experience relating to the development of geological storage. This concluded with discussion on wider economic, commercial and policy issues, at which conference delegates were joined by parliamentarians, officials, and representatives of environmental NGOs and other scientific societies.



PERC Committee: L-R: Carlos Almeida, Steve Henley, John Clifford, Gordon Riddler, Graham Woodrow and Markku Iljina

NEWS IN BRIEF

Future meetings

The dates for meetings of Council and Ordinary General Meetings until June 2015 will be as follows:

- ▶ OGMs 2014:- 18 June; 25 September; 26 November.
- 2015:- 4 February; 8 April
- ▶ Council 2014:- 18 June; 25 & 26 September (residential); 26 November. 2015:- 4 February; 8 April.

Research Grants, 2014

Stephanie Jones writes: The RGC recommended to Council that £22,761 be awarded to 15 applicants, which Council approved at its 2 April meeting.

The Jeremy Willson Charitable Trust and Novas Consulting Ltd. continued their generous support, and this year the Society has been able to do even more because of the additional gift in memory of Robert Scott which will fund Lisa Mol's project.

The Society is most grateful to CASP for this endowment, which was facilitated by Gary Nichols. A complete list of the approved projects, with sums awarded, is available in the online version of this article.

New CGeol logo

The Professional and Chartership Committees have agreed this Logo for use by CGeols on letters, reports etc. It will be provided free in electronic form and CGeols will personalise it by the addition of their Fellowship Number. The logo will also be available for purchase as a stamp from the Fellowship Office. We hope it will be widely used by CGeols on all business correspondence to raise the profile of the qualification among clients and other geologists.



Chartership news - PERC up your ears

News from the Pan European Reserves and Resources Reporting Committee (PERC).

PERC was set up in 2006 in order to formalise a European Standard for reporting (as an update to the IMM Reporting Code of 1991 and "The Reporting Code" of 2001), equivalent to the Australian JORC, South African SAMREC and Canadian CIM NI43 101, and others from the USA, Chile and Russia in the international CRIRSCO (Committee for Mineral Reserves International Reporting Standards) family of reporting codes/standards.

It was founded by collaboration between the Geological Society of London (GSL), the Irish Geological Institute (IGI), the Institution of Materials, Minerals and Mining (IMMM) and the European Federation of Geologists (EFG) and replaced the defunct IMM Reserves Committee and an ad hoc European working group. The Committee has four members from each of the founding organisations, and at present eight co-opted members representing various other European national professional geological and mining organisations and industry sectors. The Chairman of the Committee is Eddie Bailey who is one of the GSL representatives.

The latest version of the PERC Standard was published on March 16th 2013 and is a principles-based standard providing Transparency, Materiality and Competence. Please see online for further details.

The Committee met in Dublin on 29 March for its second AGM. Promotion of the PERC Standard, to make it the reference standard for European reporting, is the main aim. In particular we hope that the European Securities and

markets Authority (ESMA) might be persuaded to specify PERC for reporting to European Stock Markets. This is particularly important as the UK Stock Exchange has over 40% of the world investment in resources and, together with the other European Exchanges, comprises well over 50% of the global total.

A training workshop entitled 'Best Practice for the Assessment and Reporting of Exploration Results, Mineral Resources and Mineral Reserves', was presented by Dr Edmund Sides (AMEC). PERC has plans to develop further training in good practice for geologists and others in the Mineral Exploration/Mining area.

Further information on PERC can be found at www.percstandard.eu.

CGeol in Hong Kong

We hear from Mr Sam Ng that CGeol has been adopted by the Civil Engineering and Development Department (CEDD) for Civil Service recruitment of Geologists, and that the Accredited Training Scheme has also been adopted by the Civil Service for training of Geologists.

This is the first time that CGeol's effective equivalence to 'MHKIE' has been put in writing in an official government document. In practice, since the 1980s the Geotechnical Engineering Office (GEO) of CEDD has accepted CGeol, and MIGeol before it, as equivalent to MHKIE - but that was decided ad hoc by the GEO without there ever being official written acceptance.

The important step forward is that 'Chartered Geologist' is now the *de facto* qualification for professional geologists in Hong Kong.

SOCIETY NEWS...

Scrutineers

Over 40 attended a Scrutineers' Information, Consultation & Training Day at Burlington House, writes **Bill Gaskarth**.

Attendees heard Mike De Freitas speak on Duty of Care and the Code of Conduct, David Norbury on what is expected of Candidates for CPD records, Supporting Documents, and the types of material that may be used as such.

The Chartership Officer offered an outline of what scrutineers are sent, and what is expected of them before interview. We held breakout-group discussions on what information should be provided on a scrutineers' Page on the Website, the design and use of the Post-Interview Report form, and common reasons for deferring recommendations. Further detail of the discussion can be found in the website version of this article.



Image: Aarion Amari / Shutterstock.com

The Society has 366 scrutineers on its list, and of these some 242 are aged between 40 and 60. Eighty-nine scrutineers are now in their 60s. The low number of scrutineers under 40 is to be expected, but CGeols aged 35-40 are particularly encouraged to apply, so that we can replace scrutineers who retire and no longer retain their Chartership.

The Geological Society Club

The Geological Society Club, successor to the body that gave birth to the Society in 1807, meets monthly (except over the field season!) at 18.30 for 19.00 in the Athenaeum Club, Pall Mall, or at another venue, to be confirmed nearer the date.

Once a year there is also a buffet dinner at Burlington House. New diners are always welcome, especially from among younger Fellows. Dinner costs £57 for a four-course meal, including coffee and

port. (The Founders' Dinner, in November, has its own price structure.) There is a cash bar for the purchase of aperitifs and wine.

◆ **2014:** 24 September; 15 October.

▶ Fellows wishing to dine or requesting further information about the Geological Society Club, please email **Cally Oldershaw** (Hon Sec) at cally.oldershaw@btopenworld.com or **T: 07796 942361**. DR



Image: David Jiffi via Wikimedia Commons

The Athenaeum Club, Pall Mall



FROM THE LIBRARY

“THE GEOLOGICAL SOCIETY LIBRARY IS A RESEARCH LIBRARY WHICH OFFERS ITS FELLOWS THE BEST OF BOTH WORLDS: RICH HISTORICAL AND ARCHIVE COLLECTIONS AS WELL AS THE MOST UP-TO-DATE INFORMATION RESOURCES IN PRINT AND ELECTRONIC FORMATS”

Improving remote services to Fellows In April, Council approved the five-year Library Strategy, writes **Fabienne Michaud**.

The Strategy has at its heart the necessity to evolve and adapt to a fast-changing library and information environment, and the research needs of its users.

The Geological Society Library provides a wide range of resources such as electronic journals, document supply, postal loan and enquiry and literature searching services on-site, in Burlington House. As well as being available in London these services are also accessible off-site. In 2013, some of the Library's most popular services were largely used remotely and more Fellows each year are taking up the opportunity to access its collection of over 90 electronic journals via Athens. In the last five years, the number of Athens registration has risen by 57%, and in 2013:

- ◆ 20,299 articles were downloaded
- ◆ 3,803 enquiries were made**
- ◆ 605 documents were supplied

With 85% of the Fellowship based in the regions and overseas, one of the Library's key objectives is to deliver better electronic and remote services, while simultaneously, working to develop, preserve and promote its collections and improve their content findability online. The Library Strategy provides the basis upon which this will be achieved within the next five years.

*Library Strategy, approved by Council 2 April 2014.

**Library staff responded to a total of 8,885 enquiries in 2013.

▶ You can read the Library Strategy online at www.geolsoc.org.uk/LibraryStrategy

Losing the plot?

David Nowell* wonders why the Ordnance Survey is restricting sales of its own products when people want to buy them

I recently overheard a bizarre conversation. Apparently, the Ordnance Survey (OS) no longer allows retailers to sell contoured 1:10,000 to 1:5,000 printouts to the general public. Chatting to their topographic IT expert, I discovered that this has left customers puzzled and confused, because the OS patronisingly presumes that people fit neatly into their inflexible user-groups.

Contours

Even if geologists can afford their eye-watering prices, this causes immense problems, as fieldwork often requires contours. And, where recent mapping has been completed, the British Geological Survey must sell their 10k geological maps with OS base maps for £80 each, so that even professionals balk at using them.

In contrast, German regional surveys produce cheap 5k maps, including annotated contoured aerial photographs with invaluable coverage within quarries and spot heights on rivers. Even on some 100k maps you can see how the river Rhine steepens going through the Lorelei Gorge. In France the IGN sells *géorando* disks with enlargeable 25k mapping and aerial photography, which yield stunning 3D block-diagrams to look in detail at the geomorphology of a selected area.

Even without mildly jingoistic assumptions about our beloved OS maps (France was mapped in great detail in the late 18th Century) things could be improved.



David Nowell

If the residents of Ventnor on the Isle of Wight can be trusted with complex mapping, zoning the risks to their homes from landslips, why can't we add spot heights to rivers? Surely the Environment Agency can tie them in to local flood gauges, to benefit residents who are sometimes unfairly blighted by their insurers. And in flatter areas, is it asking too much for their cartographers to look at continental maps and plot intermediate 2½ m, if not 1¼ m contours, as many countries do?

Explorer

Instead, there is a great temptation to fall back on the 25k 'Explorer' series and scan an enlargement for detailed contours. Just like the music industry mishandling new technology, the OS should not be surprised if this results in lost revenue. Successive governments have failed to grasp the wider benefits of affordable mapping by ensuring that economic gains were picked up by effective corporate taxation. Before mapping was considered *passé*, the BGS published some innovative 50k posters of Anglesey, using Lidar images as base maps to reveal the geomorphological grain of the glacial landscape, and the outstanding 625k bedrock geology (5th edition) maps used a rival cartographer as the kilometre national grid is out of copyright.

These 25k maps could have limited tidal information, like the levels stated on some BGS 50k coastal sheets: many educated people wrongly assume Ordnance Datum is synonymous with spring high tide - actually, over seven metres above OD in places along the Bristol Channel. Furthermore, since the Explorer series has ensured that fewer topographic maps are being sold, by covering much larger areas than before, why can't the OS produce a third 1:50,000 series on new sheet lines? These could be printed on bigger sheets of paper: their bilingual maps of Wales already extend to an extra ninth fold, and a tenth would be quite feasible.

* David Nowell is a freelance geologist whose publications include over 120 geological map and book reviews

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).

“ THERE IS A GREAT TEMPTATION TO FALL BACK ON THE 25K 'EXPLORER' SERIES AND SCAN AN ENLARGEMENT FOR DETAILED CONTOURS... THE OS SHOULD NOT BE SURPRISED IF THIS RESULTS IN LOST REVENUE ”
David Nowell

THE ARCTIC AZOLLA EVENT



**Jonathan Bujak
and Alexandra
Bujak*** reveal how
a unique plant
changed our
planet's climate

Above: Azolla from North America

The Cenozoic was characterised by enormous changes in the Earth's climate that affected the entire biosphere, including the evolution of our own species.

These changes resulted from a combination of factors that progressively sequestered the greenhouse gas carbon dioxide from the atmosphere, resulting in cooler global temperatures, particularly at the poles with their year-round cover of ice and snow.

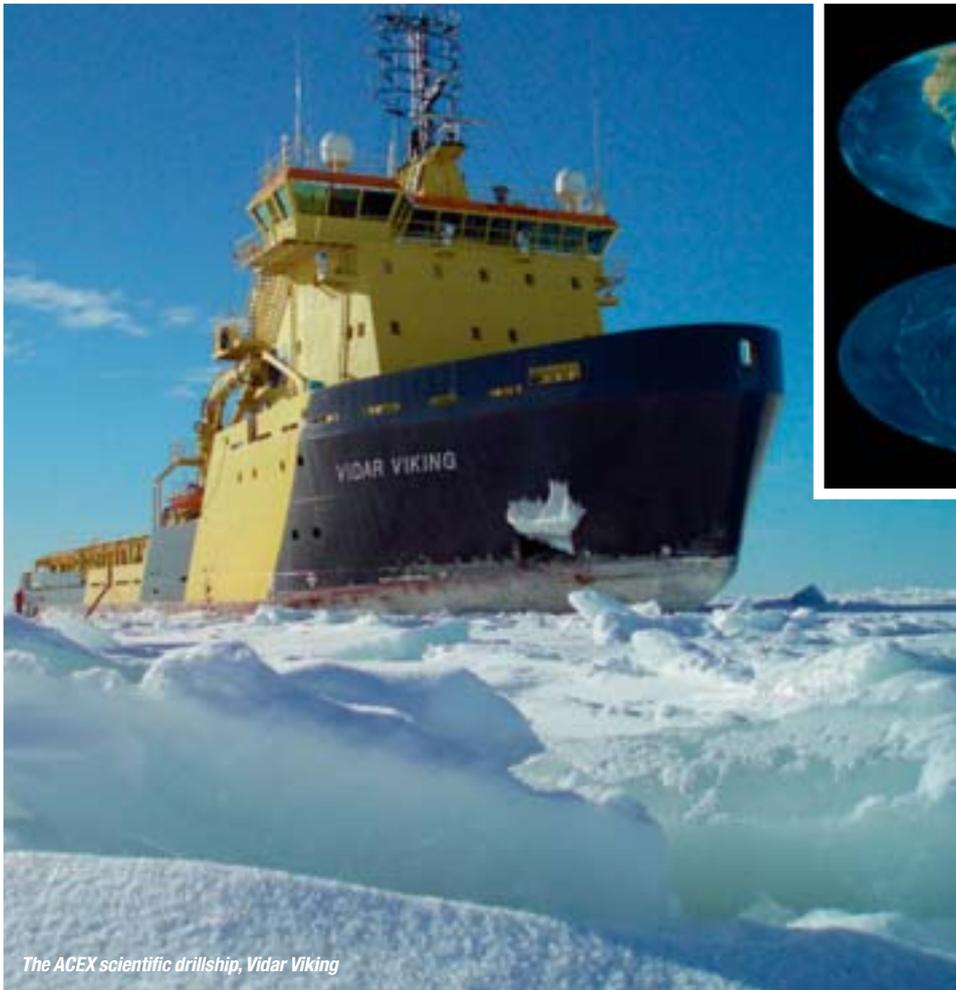
Our modern bipolar icehouse world contrasts strongly with the earlier greenhouse climate of the Mesozoic, which had lower latitudinal thermal gradients and poles that were much warmer than those of today. The Cenozoic greenhouse-to-icehouse shift is even more striking because the geological record indicates that our present climate, with its bipolar

glaciation and succession of glacial-interglacial cycles, is highly unusual and possibly unique in the Earth's history.

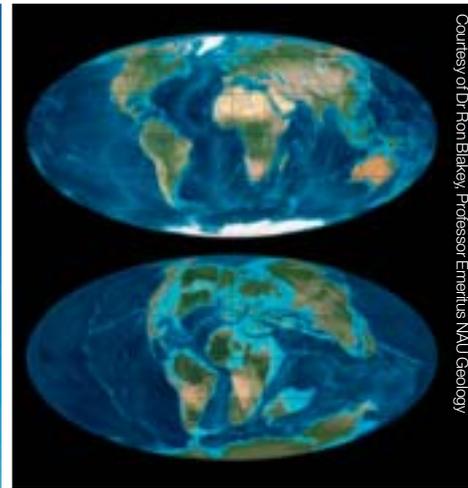
The asteroid impact at Chicxulub on the Yucatán coast, which marked the end of the Mesozoic 66 million years ago, combined with other factors may have had a devastating effect on marine and terrestrial biotas, but it did not affect long-term climate. The early part of the Cenozoic therefore inherited the Mesozoic greenhouse world, which continued through the Paleocene. Extensive volcanism associated with the Greenland mantle plume injected enormous quantities of gases, including carbon dioxide, into the atmosphere, raising temperatures and triggering the release of methane clathrates.

This potent combination resulted in high levels of greenhouse gases 55 million years ago during the Paleocene-

“ THE ARCTIC AZOLLA EVENT LASTED FOR ABOUT A MILLION YEARS, BEGINNING IN THE LATEST EARLY EOCENE (YPRESIAN) AND ENDING JUST AFTER THE ONSET OF THE MIDDLE EOCENE (LUTETIAN) ”



The ACEX scientific drillship, Vidar Viking



Courtesy of Dr Ron Blakey, Professor Emeritus, NNU Geology

The greenhouse world at the end of the Cretaceous 66 million years ago compared to the modern icehouse world with its bipolar glaciation



Part of the ACEX core dominated by thin brown beds of Azolla

Eocene Thermal Maximum (PETM, aka. the Early Eocene Thermal Maximum, EETM).

Trigger

Although temperatures fell after EETM, they remained high during the early Eocene and averaged 12°C to 15°C in the Arctic, where the remains of lush forests are preserved in sediments on Ellesmere Island. It is therefore surprising that initiation of the greenhouse to icehouse shift occurred at the end of the early Eocene which, apart from the EETM, experienced the highest temperatures of the Cenozoic. What could have triggered this remarkable climatic change which eventually led to our present bipolar icehouse world?

The answer came in 2004, when reduced ice conditions allowed the scientific drillship, *Vidar Viking*, supported by the Swedish and Russian

icebreakers *Oden* and *Sovetskiy Soyuz*, to undertake a unique voyage to the North Pole. This was Leg 302 of the Integrated Ocean Drilling Project (IODP), also known as the Arctic Coring Expedition (ACEX). Over the past five decades, IODP and its predecessor, the Deep Sea Drilling Project (DSDP), had systematically drilled sediments beneath the world's oceans, but extensive ice cover had prevented an expedition to the Arctic Ocean.

The expedition's objective was to core Upper Cretaceous and Cenozoic sediments of the Lomonosov Ridge, which extends for 1800km across the Arctic Ocean and rises three and a half kilometres above the surrounding seafloor. Would the expedition accomplish its mission to core more than 300 metres, while maintaining its drilling location in constantly moving sea ice?

Lomonosov

Vidar Viking reached its drilling location on August 13, but was forced to move to a nearby site due to deteriorating ice conditions. Drilling began on August 18 in 1209 metres of water, but soon encountered more problems, this time due to a shattered core liner, forcing *Vidar Viking* to move to a third location on August 27. This time it was successful and cored into the Lomonosov Ridge as the two ice-breakers protected it from the drifting sea ice.

Finally, on September 8, ACEX recovered cores from sediments deposited during the initial greenhouse to icehouse shift, revealing thousands of organic-rich layers filled with beautifully preserved remains of the floating freshwater fern *Azolla*. Later analyses confirmed that the 'Arctic *Azolla* Event' lasted for about a million years, beginning in the latest Early Eocene ▶

Eocene palaeogeography of the Arctic Ocean before (Turgay Strait open) and during (Turgay Strait closed) the Azolla event



Specimens of Azolla from Ecuador where Dr Mariano Montaña is developing its use as a rice biofertilizer



Fossil Azolla dated between 50.5 and 55.5 Ma (million years) from the Green River Formation of Garfield County, Colorado, which are similar in age to Azolla in the ACEX core. The floating leaves and tendrils are identical to those of modern Azolla



Henk Brinkhuis at the North Pole



► (Ypresian) and ending just after the onset of the Middle Eocene (Lutetian).

Azolla is a floating freshwater fern that can only tolerate slight amounts of salinity. What were millions upon millions of *Azolla* plants doing in the middle of the Arctic Ocean, and why were they there precisely when the Earth experienced one of the most dramatic climatic changes in its history? Was there a connection between the two events?

Following ACEX, a model answering these questions was proposed and repeatedly tested during the next decade when scientists from all over the world analyzed the ACEX cores, confirming its validity and refining its details. It was subsequently published in a series of papers, and featured in the *New York Times* on 30 November 2004 ('Under all that ice, maybe oil'), *National Geographic* in May 2005 ('Was the icy Arctic once a warm soup of life?') and *Nature* in June 2006 ('From greenhouse to icehouse in 55 million years').

Turgay

Following the EETM, the Arctic Ocean was largely land-locked and centered on the North Pole, as it is today, so that it experienced Arctic summers with 24 hours of daylight and winters with 24 hours of darkness, but with much warmer temperatures than those seen today. Its only significant marine connection was through a long narrow seaway called the Turgay Strait, which extended southwards across western Siberia to the equatorial Tethyan Ocean.

Then, 49 million years ago, the shallow Turgay Strait became blocked, and the Arctic Ocean became isolated from the other oceans, similar to today's Black Sea, which only has a single very narrow connection to the Mediterranean

through the Bosphorus. Like the Black Sea, the Arctic Ocean became 'stratified', with little vertical mixing of its water, so that its bottom waters became anoxic and all bottom-dwelling benthic organisms died out. High greenhouse temperatures also caused more energetic weather than today and increased the amount of rainfall. Rivers discharged large volumes of freshwater, resulting in layers of surface freshwater extending out into the ocean. Satellite images show similar freshwater layers spreading out from today's Amazon River for hundreds of kilometres into the Atlantic Ocean.

This explained *Azolla's* presence far from the ancient Arctic Ocean shoreline. In the Arctic spring and summer, the free-floating freshwater plant spread and multiplied on surface freshwater layers that extended from rivers discharging into the ocean. Each bed of *Azolla* in the ACEX cores represents a single mat or succession of mats of floating *Azolla* that extended away from shore towards the centre of the Arctic Ocean. As the floating mats became waterlogged or as storms fragmented them, the plants died and sank to the sea floor and lay undisturbed, due to the absence of benthic organisms. The remains of *Azolla* were then gradually buried by fine sediments or the remains of plankton and other organisms living in the surface water, which formed the thin beds separating the *Azolla* layers.

This process was repeated again and again, gradually forming the thousands of *Azolla* beds seen in ACEX cores. Some of them may have been deposited annually, some every few years or longer, others in clusters that were related to climatic cycles that affected temperature and the amount of rainfall and runoff. These details would be gradually teased from the core samples, and many still wait to be refined as increasingly sophisticated techniques become available. However, the general model has stood the test of time.

The Arctic *Azolla* Event lasted for about a million years and scientists are still unsure why it ended. Perhaps the Turgay Strait re-opened and the Arctic Ocean resumed its earlier configuration, or maybe the nutrients needed for *Azolla's* growth were finally depleted – nutrients such as phosphates that

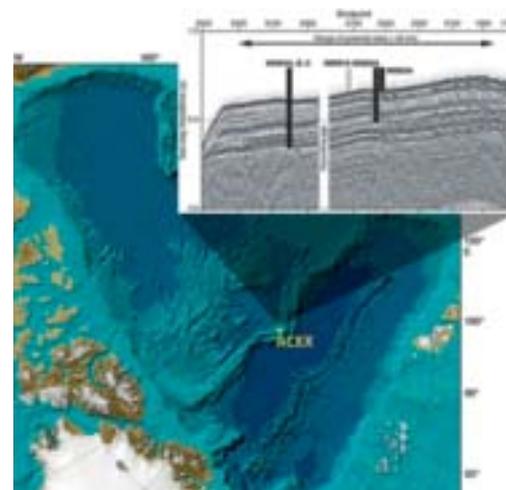
were supplied by rocks exposed on the land surrounding the Arctic, rocks that may have eventually been eroded away, ending the *Azolla* Event.

Impact

Calculations of *Azolla's* volume during the event show that it had a huge impact on the world's climate. The billions of tiny plants drew down the carbon dioxide needed for their growth directly from the atmosphere, reducing greenhouse gases, and ending the greenhouse climate that had prevailed for hundreds of millions of years. Levels of atmospheric carbon dioxide that had been as high as 2500 to 3500ppm before the *Azolla* Event were reduced by up to a half by the *Azolla* Event.

Atmospheric carbon dioxide continued to fall over the next 49 million years due to mountain uplift and changing oceanic currents that sequestered even more carbon dioxide. As atmospheric carbon dioxide fell below 1000ppm about 40 million years ago, permanent ice and snow increased in Antarctica. Then, as it fell even lower to 600ppm just 2.6 million years ago, widespread glaciation began in the Arctic, initiating the succession of glacial-interglacial cycles that characterise today's icehouse world. Present values are just above 400ppm, having risen from pre-industrial values in the mid 18th Century of about 280ppm.

The atmospheric carbon dioxide sequestered by *Azolla* was incorporated into the plant biomass, which is preserved in sediments beneath the Arctic, but a crucial question still needed answering. Nitrogen is essential for the growth of all plants and almost all of them obtain this nutrient from nitrogen-based compounds present in the soil or underwater substrate. How was *Azolla* able to grow so rapidly, free-floating in the middle of an ocean without this source of nitrogen? ▶



Above: ACEX coring locations close to the North Pole

Below: ACEX scientists at the North Pole

“WHAT WERE MILLIONS UPON MILLIONS OF AZOLLA PLANTS DOING IN THE MIDDLE OF THE ARCTIC OCEAN, AND WHY WERE THEY THERE PRECISELY WHEN THE EARTH EXPERIENCED ONE OF THE MOST DRAMATIC CLIMATIC CHANGES IN ITS HISTORY?”



► Nine months after ACEX, Henk Brinkhuis, the expedition's palynologist, arranged the first meeting of the 'Darwin *Azolla* Group' at Utrecht University in the Netherlands for geologists with expertise relevant to the *Azolla* Event. Also invited was biologist Francisco Carrapiço, Assistant Professor at the University of Lisbon's Department of Plant Biology, and the world's leading expert on modern *Azolla*. He was to provide information that would answer the question.

Superorganism

Azolla is a fern that floats freely on the surface of quiescent freshwater bodies, such as ponds, lakes and gently flowing rivers, and it is one of the fastest growing plants on the planet, doubling its biomass in as little as two days. We know that *Azolla* is a fern because of its internal structure and the way that it reproduces, but it looks nothing like a fern. Its leaves are composed of small spongy lobes, just a few millimetres long, which float on the water with hair-like tendrils dangling in the water below. Its larger dorsal leaves are buoyant and contain cavities enclosing a

symbiotic cyanobacterium called *Anabaena azollae*.

Although a few other plants have cyanobacterial symbionts, the relationship is lost when the plant dies and has to be renewed each generation. *Azolla* is unique because it is the only known plant in which a cyanobacterial symbiont is passed to successive generations during the plant's reproduction. The fossil record indicates that the relationship between *Azolla* and *A. azollae* was established in the mid Cretaceous, so that the two organisms have been co-evolving for about 100 million years. This has resulted in their developing highly efficient and complementary biochemistry, enabling *Azolla*'s phenomenal growth rate.

It is a perfect marriage: *Azolla* provides a home for *A. azollae*, which sequesters nitrogen fertilizer for *Azolla* directly from the atmosphere. Their relationship is now so intimate that many of *A. azollae*'s genes have been lost or transferred to the nucleus in *Azolla*'s cells, so that *A. azollae* can no longer survive independently outside *Azolla*. All of the genetic evidence indicates that *A. azollae* is evolving towards a nitrogen-

fixing organelle in *Azolla*, and in 2010 Francisco Carrapiço published his landmark paper: '*Azolla as a Superorganism*', proposing that *Azolla* and *A. azollae* are so closely interconnected that they represent a single superorganism. This was the missing part of the puzzle needed to explain the Arctic *Azolla* Event. It showed how *Azolla* was able to repeatedly spread across freshwater surface layers in the Arctic Ocean, sequestering large quantities of atmospheric carbon dioxide, to trigger the initial change from a greenhouse to icehouse climate.

Perfect storm

We humans are threatened by a perfect storm as our population passes seven billion thanks to shortages of land, food and energy. Increased emissions of greenhouse gases are also reversing climatic changes that occurred over millions of years. The greenhouse-to-icehouse shift was caused by a succession of processes that took 49 million years, but mankind's emission of greenhouse gases could reverse this process in just a few decades, changing the climate back to a greenhouse world



Azolla fertilizing a rice paddy in Ecuador Inset: *Azolla* usually floats freely on the surface of freshwater, but tendrils that dangle freely beneath the plant can also root in wet muddy substrate to provide additional nitrogen fertilizer for the plant



Bread made from *Azolla* by Erik Sjödin at Wysing Arts Centre, England. Erik also has recipes for pancakes, soup, burgers, and more...

with dizzying speed. Could *Azolla* help us combat man-made climate change and also provide local renewable food, livestock feed, biofertilizer and biofuel?

Azolla has been used for thousands of years in India and the Far East as a biofertilizer and livestock feed, and its potential as a biofuel is indicated by (unpublished) studies on modern *Azolla*. It has also been taken on space missions to confirm its use as a food, water purifier and oxygen provider for space travel because of its ability to rapidly grow in stacked trays of shallow water less than three centimetres deep. *Azolla* can therefore help us tackle the threat of man-made climate change and shortages of land, food and energy. Its potential can be increased because the water in which *Azolla* grows is enriched in nitrogen sequestered by *A. azollae* from the atmosphere.

For example, *Azolla*'s growth can be integrated with the production of algal oil ('algoil'), with the nitrogen-enriched water from *Azolla* fertilizing algal growth and increasing the sequestration of carbon dioxide to produce a range of biofuels precisely where they are needed. Or, to take another example, the

nitrogen-enriched water used to grow *Azolla* is an ideal biofertiliser for hydroponics to grow fruit and vegetables, providing local renewable food. And because *Azolla* can be grown indoors, anywhere in the world under carefully controlled conditions, it has the potential to provide these products globally, promoting urban agriculture in our growing cities and megacities, and helping to provide a permanent solution to regions with repeated famines such as East Africa.

Global potential

This flexibility is the key to *Azolla*'s global potential. The complex biotechnology has already been developed by *Azolla* and *A. azollae*'s co-evolution, so all we need to do is work *with* nature instead of destroying it. And because *Azolla*'s biosystem addresses the problems of energy and food as well as climate change, it is not necessary to prioritise them. This resolves the main problem that plagued the 2009 and 2013 Copenhagen and Doha Summits on Climate Change when many developing countries argued that their priority was to feed

their people, rather than dealing with problems of climate change. The billions of pledged 'climate change dollars' can therefore help developing countries using *Azolla*'s synergy, thus turning Perfect Storm into Perfect Opportunity.

Geologists are fortunate in having a unique perspective grounded in deep-time. We have traditionally used the present as a key to the past, but we can also use the past to understand the present and shape the future in a positive way. Perhaps the remarkable events that occurred 49 million years ago in the Arctic can help us do that. ♦

* **Dr Jonathan Bujak** is a palaeontologist who has spent the past 40 years studying Arctic palaeoclimate and the greenhouse to icehouse shift. His daughter, **Alexandra Bujak**, is an environmental scientist specializing in modern *Azolla*'s multiple uses. Their book '*The Azolla Story*' will be published in 2014. Author contact: **E: jonathan@theazollafoundation.org**

➤ **FURTHER INFORMATION**
 You can read more about this remarkable plant at:
<http://theAzollafoundation.org>



Above (upper): *Azolla* and inset *Azolla*'s cyanobacterial symbiont, *A. azollae*
 Above (lower): *Azolla*'s leaves and a magnified image of *A. azollae* living inside *Azolla*'s leaf cavities

DECENT

EXPOSURE



As the Society develops its 100 geosites project, **Rob Butler*** looks at some of these islands' great outcrops



Above top: Siccar Point still attracts the masses, with no prospect for an end

Above middle: Getting to grips with fault zone processes and reservoir properties at Clashach Cove, Moray

Above lower: Excursions in deep time - Aberdeen undergraduates seek to piece together the complex history of igneous intrusion, metamorphism and deformation in some of the oldest rocks of NW Europe - Scourie More, Sutherland

Left: Skrinkle Haven Pembrokeshire - a great location to examine the marine transgression during the late Devonian that inundated a swathe of the Old Red Sandstone continental environment

“THERE IS SOMETHING SPECIAL ABOUT BRITISH OUTCROP GEOLOGY. PERHAPS IT'S THE EXCEPTIONAL VARIETY”

I will remember my first residential field trip: day one - among the Permian breccias at Oddicombe, Devon, picking through the detritus of the Variscan Orogeny.

We had been directed by trip leader, Mike Coward, to 'find pieces of ophiolite'. It was a crazy challenge, picking over pebbles - how would you know if a chunk of basalt came from former sea-floor? Pretty much everything was slate and limestone anyway. But it filled me with an enthusiasm for British geology that remains to this day, some 36 years later.

Since then I've had the immense privilege to research in some truly brilliant field locations, and visited many others around the World. But there's something special about British outcrop geology. Perhaps it's the exceptional variety that has inspired me and many other geologists over the centuries. As the Society began its search for 100 top geosites - with the list set to appear during October's Earth Science Week, I got to thinking - what makes a truly great outcrop?

Playfair

Top of most people's list, perhaps even of world outcrops, comes Siccar Point - a rather anonymous corner of the Berwickshire coast were it not for the work of James Hutton and his publicist - John Playfair. There are many other stratigraphic sites of importance in Britain but Siccar Point stands out not only for historical precedence but also because of its architectural simplicity - part of the site has been replicated by casting in the American Museum of Natural History.

Gazing away from the headland itself, with gently inclined Devonian red beds and the steeply-dipping Silurian turbidites, helps us to "upscale" - the term used by some to express the concept of taking local observations and visualising their impact on a scale beyond the immediate. Zooming into the contact itself reveals fragments of the underlying turbidite sandstones trapped in hollows and crevices passing up into continental sandstones, which

talk to Earth processes and ancient landscape evolution.

For some, great outcrops must be large. A list of great global stratigraphic sites must include the Grand Canyon: nowhere in Britain is there such a remorseless demonstration of the law of superposition. We rely on unconformities, such as Siccar Point, to tell stories of deep time. Non-geologists might find it perplexing that such narratives speak of the missing, rather than the present - the lost stratigraphy and the deductions of tectonics and denudation rather than the dynamic landforms themselves. And there are many greater stratigraphic omissions in Britain - such as the two billion year gap caught between the base of the Applecross Formation of the Torridonian and the late Archaean gneisses of the Lewisian's Central Block in Assynt.

My personal favourite British unconformity for getting up close and personal with ancient landscape processes is up on the north Sutherland coast, at the tiny fishing village of Portskerra. The contact undulates, picking out low hills within the Caledonian mountain belt. Fragments of the metamorphic Moine rocks form scree on the hill slopes that grade out into fluvial sandstones. Small, compared with the Grand Canyon, but perfectly formed.

So, size isn't everything. For tectonic folk like me, perhaps the most dramatic global location is the Alpine Fault of New Zealand. Ocean is juxtaposed against 3000m peaks along an active thrust - mountain building in action. But the processes that shape these mountains - mutually focusing tectonics and meteorology, serve also to continuously bury and re-excavate the Alpine Fault Zone itself. While the surface processes are exciting - the outcrops themselves are often deeply disappointing. For great fault zones, Britain's long-dead structures such as the Outer Isles Fault on the Uists, or the Mesozoic structures that creep onshore around Durness, in Sutherland are better places to see the products of slip and shear. ▶



Footprints

Or try Clashach Cove on the Moray coast - perhaps best known for its rather spectacular dune sandstones and the early reptilian tracks, uncovered by quarrying on the cliff-top. These dune sandstones are excellent outcrop analogues, perhaps the best in Britain, for showing non-geologists what a conventional hydrocarbon reservoir can look like. But the normal fault and its associated deformation bands, perhaps only bettered by examples in Utah, hint at the complexities of exploiting oil and gas from structurally complex reservoirs.

Structural geologists now use the site to discuss with reservoir engineers about how these features and their impact on permeability structure in the subsurface might be predicted. Gazing across the Moray Firth to the platforms and wind turbines of the Beatrice field give such discussions special relevance. Likewise the relationships and fracture patterns in the Old Red Sandstone and its basement at Portskerra have inspired discussions of subsurface geology

pertinent to the Clair field, out in the Atlantic, west of Shetland.

Britain has dozens, perhaps hundreds, of important sites for the history of geology. The key places are listed in the great Geoconservation Review. But for me, few qualify as great outcrops. Away from Siccar Point's storm-swept crags, other examples of unconformities described by Hutton have fallen beneath vegetation, left to rot. Likewise it is hard to be inspired by a pile of grey, lichen-covered slate hidden under a thicket of brambles - even if it once yielded a particularly critical graptolite to the diligence of a 19th Century natural scientist.

Perhaps as a community we have tended to tell our outcrop stories through stratigraphy, rather than Earth processes. By all means keep the classic palaeo-biological and stratigraphic sites protected - especially from collectors. For me, great outcrops are those that have great architecture - show the relationships between rock units and give our imaginations some tantalising

glimpses at the processes that put them together. It's about form and structure - be it sedimentary, igneous or tectonic in origin.

Moine

So what makes UK and Ireland's outcrops so great? Certainly there are some stunning large outcrops and geological landscapes, from the inner architecture of the Tertiary volcanic centres and their lavas on Skye to the mountainsides of structures in the Moine Thrust Belt. And certainly upland landscapes and coasts tell stories of Quaternary climate change and glaciation. Yet these can all be upstaged by global examples. It's not their size - it is their human scale that makes British outcrops so special. They can be appreciated immediately and accessibly - as if laid out in a gallery. They serve to inspire and educate current and future geoscientists. And the really great exhibits tend to lie along our coast.

British coastal geology is second to none, from the huge sea cliffs and remote beaches of the Scottish islands to the popular tourist beaches of SW Wales and SW England. For me, these are the outcrops that define the quality of our geosites. It's perhaps no coincidence that the UK geology's two totemic World Heritage Sites, the Giant's Causeway and the Jurassic Coast, are both beside the sea.

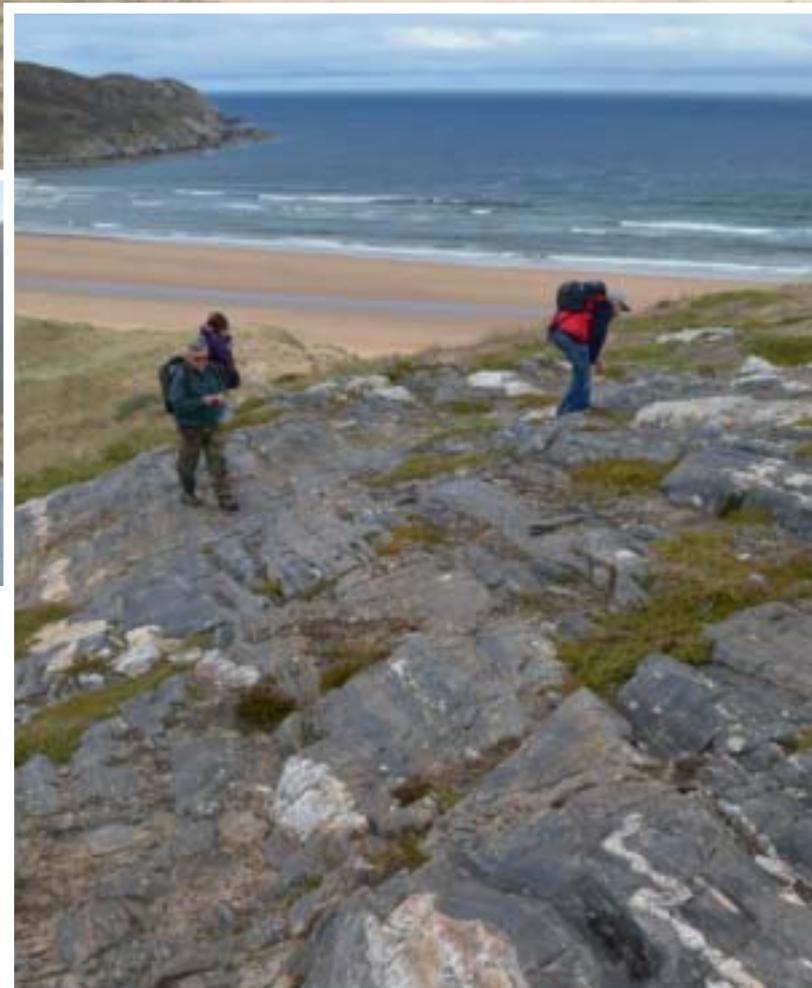
“BRITISH COASTAL GEOLOGY IS SECOND TO NONE, FROM THE HUGE SEA CLIFFS AND REMOTE BEACHES OF THE SCOTTISH ISLANDS TO THE POPULAR TOURIST BEACHES OF SW WALES”



Achmelvich - Late Archaean gneisses in the Lewisian at Achmelvich, a window into the formation (and deformation) of the continental crust



Neist - The exhumed igneous complexes in the Hebrides have been a proving ground for models of volcanic and subvolcanic processes



Adventures in the middle crust - syn-tectonic granitic pegmatites in sheared Moine metasediments at the remote beach of Torrisdale, north Sutherland

With Scotland's Land Reform Act and the opening of the Welsh Coast Path in 2012, many of these great locations can be accessed - tide, surf and the occasional steep scramble permitting. You would think that with the Marine and Coastal Areas Act (2009), England would be following suit, delivering access to the rest of the shoreline. But implementation has been painfully slow, hampered by some commercial lobby groups. Even with improved access rights, some of our outcrops are threatened by coastal defence schemes, exacerbated by last winter's storms.

So we cannot take our outcrop heritage for granted - and we certainly should celebrate its diversity and importance, not just for the history of our science but for its continued use as a training resource for future geoscientists, and a showcase for inspiring others to understand Earth processes. ♦

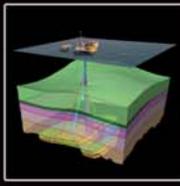
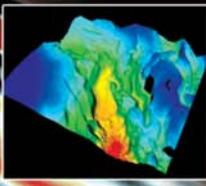
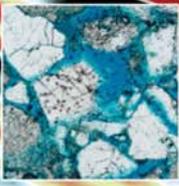
* **Rob Butler** is Professor of Tectonics at the University of Aberdeen and chair of the Society's Geoconservation Committee

EDITOR'S NOTE

To see the list as it builds and to contribute a geosite, visit www.geolsoc.org.uk and click on the link to the Society Blog, top right. All submitted geosites must be within the UK and Ireland.



Debating the relationships between deformation and intrusion in the Moine at Portvasgo, Sutherland



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Registration now open

Operations Geology Conference

"The Life-cycle of a well"

26-27 November, 2014

The Geological Society, Burlington House, Piccadilly, London



Following the highly successful Operations Geology Workshop held in Aberdeen in October 2012, the Petroleum Group of the Geological Society are pleased to announce the dates for the next event, which will be held over two days in 2014. Operations Geologists play key integrating roles at all stages of the life cycle of a well. This conference will look at the life cycle of a well and the contributions of Operations Geology at each stage:

- **Well Planning** - hazard identification (due to rocks, fabric, pressure, stress, geometry etc) and avoidance/mitigation, targeted data acquisition for all disciplines for life of field
- **Execution** - real-time techniques, managing the drilling window, the acquisition and use of Integrity test data, appropriate isolation of permeable zones in the overburden
- **After Action Review** - NPT analysis and the learning loop, continuous improvement
- **Emerging Technologies** - the next generation of needs and solutions – logging, formation and gas detection/analysis, real-time well bore stability analysis tools, PPFG tools
- **Professional Competence** - the need to strengthen the available processes

CONFIRMED KEYNOTE SPEAKERS:

Malcolm Brown, BG Group
Iain Stewart, University of Plymouth

Conference Dinner

Registration is now open for the Conference Dinner to be held on Wednesday 26th November at the Cavendish Hotel, Jernyn Street

For further information, please contact Laura Griffiths, Event Co-ordinator;
+44 (0)20 7432 0983 or E-mail : laura.griffiths@geolsoc.org.uk
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Selling geology - another way

Sir, Having read the discussion on 'selling' geology to prospective university students (*Geoscientist* 24.3 April 2014). Can I offer this as an outline sales pitch that other people might want to adapt?

No other subject touches more bang up-to-date political, economic and social concerns than geology. Want a long term view of climate change and how, and by how much, CO₂ varies in the atmosphere? How about energy supplies and natural resources? What about natural resources in the Arctic? Want to have a sensible discussion about shale gas? Concerned about relationships with Islamic countries? The answer to all these questions is - ask a geologist.

Geology is an observational rather than experimental science, which makes it appealing to people (like me) who can't do maths and prefer to think in images and like to construct a narrative from physical clues. But you can still be a geologist even if you can do maths! Geologists get to think at micron to global scale and at scales ranging from minutes to billions of years, very few professions need a such a perspective. You can do geology up a mountain, down a mine, in a quarry, down a microscope, in a laboratory, in a library or on a computer, practically anywhere in fact. You may be the best accountant in the world but then you will never have the chance to discover something new to science every day you go to work.

(And you get to do work outdoors in beautiful countryside - and even on tropical beaches, from time to time, and always at someone else's expense too.)

PETER GUTTERIDGE

Fieldwork forever

Sir, Having read the article 'Adapt or Die' by Jonathan Paul, one of my AS classes suggested that we rise up as one to defend the role of fieldwork.

As sixth formers, the roaring consensus is - fieldwork rocks! We have embraced the cliché and pulled on our waterproofs, jumped into the mud and puddles, and if it is raining sideways, even better. We do not shy away from this 'manual labour' and Clare from my A2 geology class would like to point out that the 10kg weightlifting exercise she undertook on Penarth beach last February was well worth it - not only did she give her quads a workout, but the giant ripple marks now enjoy pride of place in her bedroom.

My AS students, washed out from their Penarth experience this year, are ridiculously enthusiastic about climbing the hills around Martley, Worcestershire, attempting to find trilobites and other exciting marine dwellers.

Every year I take my second year class to the Isle of Arran. Yes, there were looks of outright hatred when I first mentioned the idea. But, give my second year students any time to talk about the week-long field school and words such as 'awesome', 'engaging', 'fantastic', and 'life-changing' are bandied around with ease.

Not all our sixth formers are couch potatoes, or think that geology is now the domain of computer analysts. Let us not suggest however that academics and industrialists do not need similar skills. In colleges across the country A level geology includes students with a wide range of skills and abilities. Not all of them love fieldwork, but most thrive on it. I have a PhD, work in industry (in my spare time) and teach. The consensus in this college is simple - Jonathan can keep his books and comfy sofa. We will all be half way up a mountain, measuring strike and dip!

DAN BOATRIGHT & WORCESTER 6TH FORM COLLEGE GEOLOGISTS

Reality wins

Sir, Whether or not fieldwork works as bait, it remains a necessity. Experience of the real Earth, by reading rocks and by being subjected to its processes now and in person, are essential for any thinking geoscientist and paramount.

If a graduate wants somewhere 'warm and dry' then the local supermarket is but a few steps away. Geoscientists need to be fit, capable and able to climb mountains, carry loads and be good sailors if they are to truly understand the planet. They must experience planet Earth in all its glory.

Of course scientists must keep up to date with technology and industry, but getting to grips with reality early on in your career should still be seen as our prime attractor for the most able, lively and creative thinkers leaving school.

Would Jonathan Paul conduct intimate relations by remote sensing? Are his summer holidays spent on virtual beaches? Does he play tennis with a Wii? If he answers 'no' then real experience wins.

ROY GILL

As sixth formers, the roaring consensus is - fieldwork rocks! We have embraced the cliché and pulled on our waterproofs, jumped into the mud and puddles, and if it is raining sideways, even better. We do not shy away from this 'manual labour'

WORCESTER 6TH FORM COLLEGE GEOLOGISTS

► **Erratum:** In May's issue (p21) we erroneously suggested that the author of the letter 'Off the rails' was Hugh Torrens. We are happy to acknowledge that its true author was Ian Harrison, and apologise to all concerned. *Editor*

Island on Fire



In 1783 a section of south west Iceland split open. Huge volumes of lava and ash spewed out along a wall of fire - the Laki Fissure Eruption. It lasted into 1783, causing famine and death in Iceland and beyond. Crops

failed all over northern Europe and its climatic repercussions may even have helped precipitate the French Revolution. Similar eruptions are bound to occur again. How would we cope? This is the question this book's two science-writer authors set out to examine. The answer is not cheerful.

Ask a member of the public to name any historic eruption, and you will get 'Krakatoa' and for another year or two, one with the already forgotten name that stopped flights in 2010 - Eyjafjallajökull, news peg for this book. However it is one of the authors' more surprising assertions that Laki is 'forgotten'. Actually, commented on by great contemporaries, documented in detail by local eyewitness Jón Steingrímsson, perpetuated in Earth science curricula, rarely omitted from popular volcanology books, Laki is a lot less forgotten than most.

The book reads like a set of excellent lecture notes, detail omitted for the sake of brevity (and to give students something to look up in the library). Difficult science is rather glossed over. Areas of controversy (most interesting to the general public) are sadly ignored while history comes perilously close to the 'cardboard' that Steven Jay Gould so abominated. Scholarly accounts are name-checked throughout and well referenced, which will please students and academics.

What of human interest? The story of Laki hardly lacks harrowing tales - death by starvation, asphyxia, fluorosis - described by Pastor Steingrímsson (the miracle worker whose 'fire mass' apparently halted the lava, and to science, Laki's great chronicler). His career is perhaps even more compelling raw material for a writer than Iceland's volcanoes; but it is recounted here in surprisingly neutral tones, crammed into a short chapter. The 'completist' urge to mention everything has won out over creative storytelling. Once again, students may be grateful for this.

Island on Fire is an excellent undergraduate reader, and its notes and

further reading lists will recommend it to an academic audience, who also will welcome the way it broadens to look at global volcanic eruptions generally. However while lay readers will end it better informed, they may, as I was, be a little surprised that they were not better entertained.

Reviewed by **Ted Nield**

ISLAND ON FIRE – THE EXTRAORDINARY STORY OF LAKI, THE VOLCANO THAT TURNED EIGHTEENTH-CENTURY EUROPE DARK

ALEXANDRA WITZE & JEFF KANIPE, 2013. Published by Profile Books. ISBN 978-1781250044 Hbk. List price: £12.99

Tambora



Tambora's stupendous 1815 eruption can hardly be oversold. The author, a professor of English at the University of Illinois, broadens our understanding of this event beyond the

well-rehearsed 'year without a summer' clichés, and all those oft-parroted stories of Mary Shelley and Lord Byron gloomily penning *Frankenstein* and *Darkness* in the eruption's aftermath while staying at history's most famous holiday let, the Villa Diodati near Lake Geneva.

Tambora's eruption completely devastated the island of Sumbawa in Indonesia, and led to a miserable decade of adverse weather that spread starvation and disease across North America, Europe, India and China — notably Yunnan Province, where successive crop failures turned a rice bowl into an opium-growing state.

The author's command of the scientific

literature is impressive and more than matched by his knowledge of world history during this horrific episode of catastrophic global climate change. Through the mass of information he has assimilated, he skilfully weaves a tale full of human and cultural interest, drawing in a "forgotten" 1818–16 Irish potato famine and Monticello, the Virginia estate where Thomas Jefferson's dream of the New World as an Arcadian agricultural idyll fell apart during the "Tambora period".

Also making an appearance is John Barrow. This scheming second secretary to the British Admiralty successfully petitioned his employers to resume the quest for a North West Passage. This he did, with support from naturalist Joseph Banks at the Royal Society, on the basis of whaler William Scoresby's reports of finding ice-free waters off northern Canada in 1817. With Napoleon defeated, Navy men needed to be kept busy, and this provided another compelling reason for renewed exploration. Many Navy men, Rear Admiral John Franklin being the best known, were sent to their deaths in the following decades. Tambora's far-flung climatic effects having waned, the ice had returned with a vengeance to destroy them all.

This book is much more than just a piece of brilliant popular science. Drawing together a world of data relating to this epoch-changing eruption, Wood has made a major contribution to volcanology, climatology and cultural history, in a writer's quest that was clearly driven by a deep personal passion and conviction.

Reviewed by **Ted Nield**

TAMBORA – THE ERUPTION THAT CHANGED THE WORLD

GILLEN D'ARCY WOOD, Princeton University Press, 2014. ISBN: 9781400851409. 312pp. List price: £19.95.

Forum finale

Book in brief reviewed by **Alan Lord**

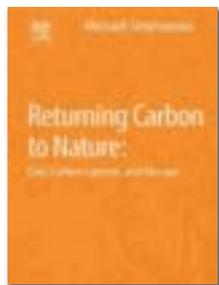
The Llanbedr (Mochras Farm) Borehole (1967-69) penetrated and cored the longest Lower Jurassic sequence onshore in Britain with an essentially complete and expanded section. Over the years most but not all biostratigraphically important fossil groups have been published, and now the final major group, the foraminifera, has

appeared. Drs Philip Copestake, FGS and Ben Johnson have authored the monumental 'Lower Jurassic Foraminifera from the Llanbedr (Mochras Farm) Borehole, North Wales, UK' Monograph of the Palaeontographical Society, 167: 1-403 + 21 plates. For the non-specialist the opening introduction on the NW European onshore and offshore geological context is a helpful read.

➤ COPESTAKE, P & JOHNSON, B 2014: Lower Jurassic Foraminifera from the Llanbedr (Mochras Farm) Borehole, North Wales, UK. Monograph of the Palaeontographical Society, London: 1-403, pls 1-21. (Publ. 641, v167, 2013).



Returning Carbon to Nature



In this slim, dense, yet highly readable volume, BGS Director of Science and Technology Mike Stephenson sets out the whole landscape of coal use, climate change and CCS with great clarity. The account benefits greatly from the 'long view' which geology affords.

The first chapter, 'Of Hockey Sticks and Coal', sets out the central dilemma: reconciling the increasingly pressing need to address climate change with the ongoing centrality of coal to economic development in the world's most populous countries. It is no good wringing our hands and wishing it were otherwise: "A CO₂ emissions strategy for these countries therefore relies on an abatement method that is consistent with long-term coal use, or coal use as a bridge to renewables. Such an abatement method could be carbon capture and storage".

The second chapter takes a brief pause from present-day controversies to offer an absorbing update on the scientific understanding of coal formation and its consequences for palaeoclimate. Stephenson highlights how the swift-growing nature of the main Carboniferous swamp plants, coupled with rapid subsidence and burial of the peats, led to a "negative greenhouse" effect attested by $\delta^{13}\text{C}$ signatures in sedimentary organic matter.

The account then returns to the present day, with overviews of carbon capture technology and its scope for deployment in distinct industrial clusters in the UK and elsewhere (Chapter 3), and the practicalities of creating deep underground carbon stores (Chapter 4). In addressing the key question "Is there enough storage space, then?" Stephenson examines CCS prospects in the crux countries of India and China.

Clearly those prospects need much more research, but by this account there are certainly grounds for cautious optimism. The fifth chapter ("Will it leak?") addresses the *bête noir* of the new generation of geologically-challenged opponents of all subsurface engineering, while the final chapter ("Accounting for carbon") considers the economics and politics of making CCS happen.

Again, the discussion is honest, lucid and engaging.

The book is beautifully illustrated in colour throughout, though Elsevier could have made put a little more effort into proof-reading, and putting the title on the spine might have been useful. But these quibbles are minor: the book is a *tour de force* and I recommend it without hesitation.

Reviewed by **Paul L. Younger**

RETURNING CARBON TO NATURE: COAL, CARBON CAPTURE AND STORAGE

MICHAEL STEPHENSON, Elsevier, 2013, 143pp, ISBN 978-0-12-407671-6. List price: £30.99
www.elsevier.com

The Frackers



The book tells the story of the shale gas revolution, tracing the renaissance of an old-established Appalachian cottage industry into the boom in shale gas and oil brought about by the combination of hydraulic fracturing and horizontal drilling. Gregory Zuckerman, who writes for the *Wall Street Journal*, describes the birth of artificial fracturing using gunpowder (a technique developed by John Wilkes Booth - who later more famously applied it to Abraham Lincoln). The tale continues with the advent of gel-fracks and then how, almost by accident, by diluting the gel, slick-water fracks finally enabled gas to be produced at economic flow-rates. Parallel with this tale the book describes the evolution of horizontal drilling by Sun Oil and its spinoff Oryx.

The science and technology is presented higgledy piggledy, with geo-boobs to make geologists wince. But what really makes it come alive are the characters - like the late George Mitchell. He drilled 200 wells in the 'tombstone' rock of the Barnett shale before his company perfected the drilling/fracturing combo that made the tombstone yield up its gas. Many others, winners and losers, litter pages along the way in colourful descriptions of physical characteristics, sporting and business prowess, and sexual proclivities.

Zuckerman credits George Mitchell's

geologist James Henry with identifying the productive potential of the Barnett shale but does not include the paper in the bibliography (below). The book shows every sign of being written in haste and is poorly edited. It contains extensive dialogue, much of which, if not made up, must be hearsay at best. The book concludes with a brief 'Afterword' that dismisses the environmental opposition to fracking.

These criticisms should not detract from the reader wanting an exciting account of the shale gas revolution. This is not a book to read for a careful study of the renaissance of the US shale gas (and oil) industry. It is perfect however, in tone and length, for a flight between London and Dallas-Fort Worth.

Reviewed by **Dick Selley**

Reference: Henry, J.D., 1982, *Stratigraphy of the Barnett Shale (Mississippian) and associated reefs in the northern Fort Worth Basin*, in Martin, C.A., ed., *Petroleum geology of the Fort Worth Basin and Bend Arch area*: Dallas Geological Society, Dallas, Texas, p157-177.

THE FRACKERS

GREGORY ZUCKERMAN, Portfolio Penguin. London (2013) 404pp. ISBN 978-0-670-92367-0
List price: £14.99 www.penguin.com

BOOKS Available 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! Seismic Reflections of Rock Properties** by Dvorkin, J., Gutierrez, M.A & Grana D. Cambridge UP, 324pp, hbk
- ◆ **NEW! Geology of Gem Deposits (2nd edn.)** by Groat, Lee A (Ed.). Mineralogical Ass. Canada, Short Course Series Vol 44. 405pp, sbk.
- ◆ **NEW! Antarctica and Supercontinent Evolution** by Harley S L *et al* (Eds). Published by The Geological Society SP 383 2013 237pp (hbk)
- ◆ **NEW! Isotopic Studies in Cretaceous Research** by Bojar A-v *et al*. (Eds) Published by The Geological Society 2013 SP 382 221pp (hbk)
- ◆ **NEW! Remote Sensing of Volcanoes and Volcanic Processes: Integration Observation & Modelling** by Pyle D M *et al*, (Eds). Published by The Geological Society SP 380 2013 360pp (hbk)
- ◆ **Orogenic Andesites and Crustal Growth** by Gomez-Tuena A *et al*, (Eds) Published by The Geological Society SP 385 2014 414pp (hbk)
- ◆ **Thick Skin Dominated Orogens - from initial inversion to full accretion** by Mencok, Mora & Cosgrove (eds), 2013 Geological Society Special Publication 377 482pp (hbk)

PEOPLE NEWS

CAROUSEL

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

◆ Phil Gibbard



Phil Gibbard has been awarded the André Dumont Medal by Geologica Belgica, the Belgian national geological society. The medal was presented in Ghent on 1 April 2014, in recognition of Professor Gibbard's contribution to Quaternary Geology.

◆ Ian Harper



Ian Harper has been appointed by ENVIRON to join its Birmingham office, as Principal Consultant. Ian's role will be to direct and deliver contaminated land and due diligence projects, in the UK and abroad. He will also further develop ENVIRON's expertise in probabilistic liability modelling, linking up with key practitioners across the international business.

Professor Graham Evans

Mrs Flora Patten has written in with an unusual request. She is compiling a collection of messages and memories about her father, Professor Graham Evans, to give to him as a present to celebrate his forthcoming 80th birthday. She is keen to hear from anyone who feels they may have something to contribute.

E: florapatten@hotmail.co.uk *Ted Nield*

Rose to the occasion

In the year during which the world is marking the centenary of the start of the First World War, the Library is restaging the lecture given by Lt Col Tannatt Edgeworth David on 26 February 1919, before his return to Australia to be officially demobilised.

Until recently the contents of the lecture, 'Geology at the Western Front', were unknown. Only the title appears in the 'Proceedings', and it was thought that the War Office had denied permission for it to be published. However a few months ago, the handwritten notes to David's lecture were rediscovered tucked into a box in the Library.

South pole

The troopship on which the extraordinary Tannatt William

Edgeworth David (1858-1934), was to set sail in had been delayed and seizing the opportunity, he was persuaded by the Society's officers to give an impromptu account of his experiences of the 'application of geological knowledge to the War on the Western Front'.

His full career had already seen David study under John Ruskin and Joseph Prestwich in the 1870s, setting up the new School of Mines at the University of Sydney in the 1890s and accompanying Ernest Shackleton to the magnetic South pole in 1907-09. Four years previously, David had convinced the Australian government to establish a corps of geologists and miners for military use in the First World War, and at the mature age of 57, he enlisted as

a commissioned major to the new mining battalion in October 1915. Travelling to France and the Western Front in February 1916 he provided invaluable advice to troops on groundwater and the positioning and design of trenches and tunnels.

Not well

Despite seriously injuring himself falling 24 metres down a well in October 1916, David continued his war service as geologist to the British Expeditionary Force, collaborating with his British counterpart William Bernard Robinson King (later President of

the Society 1953-1955).

The re-staged lecture will be delivered by Colonel Edward P F Rose, this year's Sue Tyler Friedman medallist, in the Upper Library on Thursday 10 July 2014 at 1830. As was the custom for Ordinary Meetings during the First World War, tea and non-anachronistic biscuits will be served at 1800.

▶ If you would like to attend, spaces are limited to 40 people. Tickets cost £5. Please contact library@geolsoc.org.uk

IN MEMORIAM WWW.GEOLSOC.ORG.UK/OBITUARIES

THE SOCIETY NOTES WITH SADNESS THE PASSING OF:

Baker, John Macrae Christian Wellstood*

Hull, John

Crook, John P

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 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.



William Tannat Edgeworth David, the 'Knight in the Old Brown Hat'



Images: <http://www.dawn.gov.au>

DISTANT THUNDER

Guess who's coming to dinner?

Emma Darwin - making small talk with great men whom even her husband found hard going



By George Richmond (1809-1866) via Wikimedia Commons

Geologist and science writer **Nina Morgan*** sympathises with the geological wives

The important intellectual role played by women in geology during the 19th Century is now increasingly celebrated. But often these achievements went unrecognised at the time.

The credit given by the geologist and palaeontologist John Phillips (1800-1873) to his sister Anne in his 1848 Geological Survey Memoir on the Malverns, highlighting her discovery of a crucial piece of evidence about the origin of the Hills is a rare example of credit being given where it was due.

More usually, the behind-the-scenes social and diplomatic skills of loyal wives, sisters and daughters in bringing together scientists and providing the favourable environment for

discoveries to take place is hinted at only in posthumously published 'Lives and Letters', but not in scientific publications of the time.

Socially inept

In letters written on 29 March and 2 April 1839 to her sister Elizabeth Wedgwood, Emma Darwin, then just two months into her marriage to the geologist and biologist Charles Darwin (1809-1882) reveals the difficulties of dealing with socially inept scientists, including geologists, Adam Sedgwick (1785-18730), Charles Lyell (1797-1875) and WH Fitton (1780-1858).

On 29 March 1839, she writes: ...*On Thursday Mr Sedgwick called and was very pleasant; there is something remarkably fresh and odd about him. The Henslows [The Rev. John Stevens Henslow (1796-1861), botanist and geologist*



Adam Sedgwick

By Thomas Phillips (1770 - 1845) via Wikimedia Commons



William Henry Fitton

Images from Wikimedia Commons

and Darwin's mentor at Cambridge, who encouraged Darwin to join the Beagle expedition] come on Monday, and Charles is much more alarmed at the thought of them than I am. On Monday the Lyells dine with us...

Learned party

And on Tuesday 2 April 1839, she provides a full report of how it all went: ... *I must tell you how our learned party went off yesterday. Mr and Mrs Henslow came at four o'clock and she, like a discreet woman, went up to her room till dinner. The rest of the company consisted of Mr and Mrs Lyell and Leonora Horner [Mrs Lyell's sister], Dr Fitton and [botanist] Mr Robert Brown (1773-1858). We had some time to wait before dinner for Dr Fitton, which is always awful, and, in my opinion, Mr Lyell is enough to flatten a party, as he never speaks above his breath, so that everybody keeps lowering their tone to his... Mr Brown, whom Humboldt calls "the glory of Great Britain," looks so shy, as if he longed to shrink into himself and disappear entirely; however notwithstanding those two dead weights, viz., the greatest botanist and the greatest geologist in Europe, we did very well and had no pauses. Mrs Henslow has a good, loud, sharp voice which was a great*

comfort, and Mrs Lyell has a very constant supply of talk ... Charles [Darwin] was dreadfully exhausted when it was over, and is only as well as can be expected today ... He is rather ashamed of himself for finding his dear friends such a burden."

But for her part, Emma seems to have taken the evening in her stride. The food, at least, she reveals was very good!

➤ Acknowledgement

Sources for this vignette include: *Emma Darwin A Century of Family Letters 1792-1896*, edited by her daughter Henrietta Litchfield, John Murray, 1915; Anne Phillips and the Mystery of the Malverns by Nina Morgan, *Geoscientist*, Vol.16, No 7, July 2006, pp. 6 – 7 and 12-15; entries for John Henslow and Charles Lyell in Wikipedia and the Dictionary of National Biography.

➤ If the past is the key to your present interests, why not join the History of Geology Group (HOGG). For more information and to read the latest HOGG Newsletter, visit the HOGG website at: www.historyofgeologygroup.co.uk, where you'll also find abstracts for the talks and posters presented at the Conference on Geological Collectors and Collecting, April 2011 available free to download as a pdf file.

*Nina Morgan geologist and writer based in Oxford

OBITUARY EDWARD IRVING 1927-2014

Ted Irving was the doyen of land-based palaeomagnetism throughout the second half of the 20th Century. By the early 1960s he convinced sceptics that continental drift had occurred. His postgraduate work in Cambridge (1951-54) on the 'Torridonian' of NW Scotland was the first study of Precambrian rocks to establish consistent palaeomagnetic directions strongly divergent from the present geomagnetic field, including a coherent stratigraphy of polarity reversals.

“TED SEEMED QUITE SURPRISED AT THE HIGH REGARD AND AFFECTION IN WHICH HE WAS SO WIDELY HELD”

Discontinuity

He also discovered a previously unrecognised discontinuity in the lower part of the sequence – later recognised geologically as a major unconformity between the Torridon Group and the Stoer Group beneath. He wrote: “In 1951 it was not known if Earth had a magnetic field as far back as the Precambrian or even whether rocks could retain a memory of the geomagnetic field for that long. Demagnetisation techniques had not yet been developed; we had only field and consistency tests.”

Doyen of palaeomagnetism who discovered early geophysical evidence for continental drift

Nor was the reality of geomagnetic polarity reversals proven, or even widely accepted. The results were published in a landmark issue of *Philosophical Transactions of the Royal Society A* in 1957.

Astonishingly, Irving's PhD thesis was failed. It is thought his supervisor, Keith Runcorn, and the internal examiner and head of department (Ben Browne) were in conflict. The unorthodox evidence may have been unacceptable to his external, John Hemingway, who felt his geological fiefdom intruded upon. Later, Irving would simply say that his thesis had been 'skimpy'. But by then he had

been awarded an ScD (Cambridge 1965), elected Fellow of the Royal Society (1979) and of the American Geophysical Union (1976).

Bullard

From Cambridge, Irving was recruited by J C Jaeger to the fledgling Australian National University's Department of Geophysics where he swiftly determined an apparent polar wander path from Australian Phanerozoic rocks. This diverged wildly from both the British path and one from North America derived by Runcorn. For many, including Sir Edward Bullard, this evidence was the decisive proof of continental drift. It would be

a full decade before evidence of sea-floor spreading and transform fault motions clinched the argument. In the meantime he brought the comparison of geological and palaeomagnetic data to the forefront of the debate in a series of papers beginning with 'Palaeomagnetic and palaeoclimatological aspects of polar wandering' (1956) which also reported the first data from the Deccan Traps pointing to the enormous Cenozoic northward drift of India.

Ted Irving was born in Colne, Lancashire, on 27 May 1927, educated at Colne Grammar School and, after military service, graduated in geology from Cambridge (1951). He married Sheila (*née* Irwin) in 1957. They had two daughters and identical twin boys who arrived as Ted was completing his monumental 'Paleomagnetism and its Application to Geological and Geophysical Problems' (Wiley, 1964), which still makes salutary reading today.

In 2005, Irving was awarded the Wollaston Medal of the Geological Society. At dinner in the Council Room following that award, Ted seemed quite surprised at the high regard and affection in which he was so widely held.

Ted Irving died of cancer in Saanichton, British Columbia, Canada, on 25 February 2014.

► By **Jim Briden**. A longer version of this obituary is available online.

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DIARY OF MEETINGS JUNE 2013

MEETING	DATE	VENUE AND DETAILS
President's Day, AGM, Awards Ceremony GSL	4 June	Burlington House. AGM begins at 11.00am. There is a charge for buffet lunch with Award Winners – see website and <i>Geoscientists passim</i> .
Hydrogeology & WASH: What can hydrogeologists contribute to safe water supply and poverty reduction? HWB UK, IAH, Hydrogeology Group	5 June	Burlington House 0930-1830, incl. Drinks reception. Charges apply, with discounts. See website. Contact: Kirsty Upton E: kirto@bgs.ac.uk
Bromate Pollution in Hertfordshire HC North Regional	5 June	Affinity Water, Tamblin Way, Hatfield Business Park, Hatfield, AL10 9EZ, 1800 for 1830. Speaker: - Rob Sage (Affinity Water). Contact E: homecountiesnorth@geolsoc.org.uk
Big, bad and bizarre, the devil frog from the Late Cretaceous of Madagascar. GA	6 June	Burlington House. Time: 1730 for 1800. Speaker: Susan Evans. Contact E: geol.assoc@btinternet.com
Groundwater Management in Construction EGGS. Hydrogeology Group	11 June	Burlington House. 0930-1830, incl. Drinks reception. Charges and discounts – see website for details and registration form. Contact (EGGS) Darren Page E: dpage@otbeng.com
Codes and Standards for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves	11 June	Burlington House, 0900. Course. Charges apply. Organised by: Amey. Instructor: Edmund Sides, Ph.D., P.Geo., EurGeol. See website. Contact: julian.aldridge@amec.com
Be a geo-detective at Boxgrove Priory. Rockwatch (members only)	14 June	Venue: Boxgrove Priory, W Sussex. Time: 1100-1800. E: Geraldine Marshall rockwatchatga@btinternet.com
Field Meeting: Geological Gems of The South Downs GA	14-15 June	Field Meeting. Venue not available at time of writing. See Website. Leader: Rory Mortimore. Contact: Sarah Stafford E: geol.assoc@btinternet.com
Geology in Space: Meteorites and Cosmic Dust GSL	18 June	A Society London Lecture. Speaker: Matt Genge (Imperial College). Entry free, by ballot only. Please see advertisement on p.6
Dealing with radioactive waste. The Geological Disposal option Yorkshire Regional	18 June	Brewery Tap, Leeds. Speaker: James Lawrence (NDA). Evening meeting. Time not available at time of writing. Further information E: James.barr@atkinsglobal.com
Fracking & Shale Gas Production Solent Regional	18 June	NOC So'ton. Speaker: Dr Juerg Matter. Time not available at time of writing. Contact: Wendy Fergusson E: wendy.fergusson@ramboll.co.uk
The Role of Geologists in World War I (prov.) West Midlands Regional	19 June	BGS, Keyworth. Time: 1830 for 1900. Speaker: Andrew Morrison (BGS). Contact: Helen Burke E: hbu@bgs.ac.uk
Communicating Contested Geoscience: new strategies for public engagement. GSL	20 June	Burlington House. A one-day conference. Charges and discounts apply. Please see website for details and registration. Convener: Prof. Iain Stewart. E: georgina.worral@geolsoc.org.uk
Geometry and Growth of Normal Faults GSL	23-25 June	Burlington House. Conference with field trip. Charges and discounts. Please see website for details and registration. Contact Laura Griffiths E: laura.griffiths@geolsoc.org.uk
ppv@10: Celebrating the 10th Anniversary of Post-perovskite University of Bristol	25-27 June	University of Bristol School of Earth Sciences. Please see website for details and registration. Contact organising committee E: ppv-meeting@bristol.ac.uk
Annual Dinner Petroleum Group	26 June	Natural History Museum. Contact Laura Griffiths E: laura.griffiths@geolsoc.org.uk Leader: Richard Scrivener. See website for details. Contact Sarah Stafford E: geol.assoc@btinternet.com



OBITUARY **RICHARD ALDRIDGE 1945 - 2014**

Richard John ('Dick') Aldridge died 4 February 2014, aged 68. He undertook his BSc at the University of Southampton where he completed a PhD on the early Silurian conodonts of the UK under the supervision of Ronald Austin. He moved to lecturing positions at UCL and then Nottingham University, finally moving in 1989 to the University of Leicester where he remained until retirement (2011). Dick's research was initially focused on exploiting conodonts to unravel the Silurian stratigraphy of the UK and beyond, before a lucky break served to define his career.

Conodonts

Conodonts are known almost wholly from their tooth-like 'elements' of an otherwise enigmatic organism, guessing whose biological affinity was the ultimate palaeontological parlour-game. As the UK's foremost conodontologist, Dick was called upon to pronounce on the discovery of conodont soft tissue remains by Euan Clarkson and Derek Briggs in the Lower Carboniferous limestones of Edinburgh's Granton foreshore. So began a renaissance in conodont palaeobiology that soon, led by Dick, recruited generations of researchers. Together they transformed understanding of the anatomy of conodonts and their significance in early

World authority on conodont palaeobiology, Silurian stratigraphy and fossil lagerstätten

vertebrate evolution. In parallel with this work, Dick continued his taxonomic studies; employed conodonts to unravel the geothermal history of the Caledonides; elucidated (with David Siveter) the micropalaeontology of Silurian stratotypes and, with Lennart Jeppsson, established a provocative model of alternating ocean-climate state in the Silurian world. However, conodont palaeobiology led him to the Ordovician Soom Shale which, with colleagues, shifted the focus of the last decade of his career onto elucidating the faunas and fossilization mechanisms of Konservat-Lagerstätten.

NERC

Dick took his role in supporting the careers of others seriously, serving two terms as Head of Department, as a Senator, and Chair of Physical Sciences, all at Leicester University. He also served on the Review Panel of the Natural Environment Research Council, as a Specialist Adviser for RAE2001 and RAE2008. He served on Royal Society research grant committees, co-chaired the Third International Palaeontological Congress (London, 2010), and co-wrote the bid to make the Chengjiang Lagerstätte a UNESCO World Heritage Site. Early in his career, Dick's

professional duties included being Chair of the Conodont Group of the British Micropalaeontological Society (as was), President of the Geology Section of the British Association, serving on the Councils of The Geological Society and The Palaeontographical Society and, for the Palaeontological Association, as Marketing Manager.

“DICK TOOK HIS ROLE IN SUPPORTING THE CAREERS OF OTHERS SERIOUSLY”

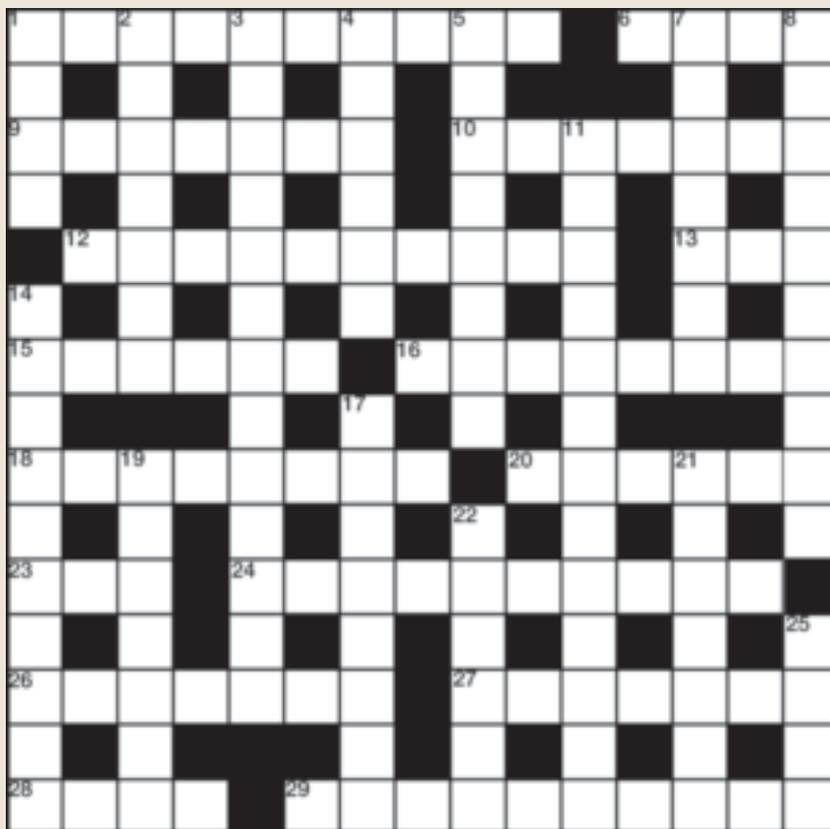
Dick also served as the Chairman/President of most of the major professional societies in palaeontology, but seemed happiest in a tutorial, lecture hall, lab or fieldtrip, sharing his knowledge but challenging his students to think for themselves. Dick became a father figure to those of us lucky enough to become his responsibility. None will forget long journeys shared with Dick, that passed invariably with games of 'conodont genera A-Z' and music trivia, interspersed with gentle teasing.

He leaves behind a large academic family in addition to his wife Alison, their children James, David and Rebecca, their partners and his seven grandchildren, to all of whom he was devoted. His loss is felt keenly by all.

► By **Philip Donoghue**. A longer version of this obituary is available online.

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.180 SET BY PLATYPUS



ACROSS

- 1** Unconformable strata, or cross-cutting intrusion (10)
- 6** Largest modern megacontinent (4)
- 9** Most powerful recorded earthquake, 1960 (7)
- 10** Greenockite is this metal's only significant ore, usually associated with sphalerite (7)
- 12** Wake region behind a moving object (10)
- 13** Last month, abbreviated Latinly (3)
- 15** Drug dealer (6)
- 16** Most rapid downhill mas wasting (8)
- 18** Organelle, primary site of protein synthesis (8)
- 20** 'Third eye' endocrine gland in vertebrate brain (6)
- 23** US spooks (1,1,1)
- 24** ...as opposed to nationally (10)
- 26** Compiler's spiny cousin and fellow monotreme (7)
- 27** Fancy, and rather old-fashioned, fly-boy/girl (7)
- 28** An hairy man, my brother (4)
- 29** Descriptive of a function performed by a contrivance rather than the human hand (10)

DOWN

- 1** Conduit (4)
- 2** Ancient continental cores (7)
- 3** Where pore pressure exceeds hydrostatic pressure in the hole (13)
- 4** Give, charitably (6)
- 5** Pearly lustre (8)
- 7** Detectable changes in the environment of a sensitive organism (7)
- 8** The point referred to being conceded (10)
- 11** Chapter one of the Origin describes variation under this (13)
- 14** Helically coiled diderm bacteria (US spelling) (10)
- 17** Mineral-infilled gas bubble (8)
- 19** Arms, not only of the Man (7)
- 21** Chipped flint nodules once supposed to be rudimentary artefacts (7)
- 22** Salt containing K (6)
- 25** Landscape with severe lack of available water (4)

WIN A SPECIAL PUBLICATION!

The winner of the April Crossword puzzle prize draw was **Bill Walbank of Cranleigh**.

All correct solutions will be placed in the draw, and the winner's name printed in the August 2014 issue. The Editor's decision is final and no correspondence will be entered into. **Closing date - 18 June.**

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 APRIL

ACROSS:

- 1** Seismicity **6** Draw **9** Emerges **10** Klippen
- 12** Parasitism **13** Ash **15** Caddis **16** Meanders
- 18** Neonatal **20** Plunge **23** MRI **24** Ideologies
- 26** Channel **27** Absolve **28** Late **29** Solipsists

DOWN:

- 1** Step **2** Iceland **3** Migmatization **4** Casein
- 5** Tektites **7** Replace **8** Winchester
- 11** Immunologists **14** Economical **17** Waterloo
- 19** Oxidant **21** Needles **22** Alkali **25** Zeus

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Communicating Contested Geoscience

new strategies for public engagement

A 1-day conference on how to communicate key geoscience challenges to the public
 20 June 2014
 The Geological Society, Burlington House, Piccadilly, London W1J 0BG

Geological issues are increasingly intruding on the everyday lives of people across the UK. Whether it be onshore exploration and extraction of oil and gas, subsurface injection of waters for geothermal power or deep storage of carbon and radioactive waste, many communities across the country are being confronted with controversial geo-engineering interventions under their backyard. Alongside the complex scientific and technical challenges this brings is the problem that, to most people, the geological subsurface is an unknown realm. That combination presents particular difficulties for professional geoscientists communicating what they do and what they know to the lay public. Developing public participation strategies that effectively engage with citizens, communities, and stakeholder groups, require geoscientists to better appreciate what the public knows and what they have concerns about.

This conference will be a forum to bring geoscientists from universities, industry and government together with specialists in communication and public engagement to explore the challenges of communicating contested geological issues to the wider public.

The one-day meeting will focus on three current and pressing societal concerns in the UK: (1) radioactive waste disposal; (2) shale gas and fracking; and (3) carbon capture and storage.

These themes will be explored through a mix of keynote talks and expert panel discussions, alongside active Q & A from an audience of geoscience and communication practitioners.

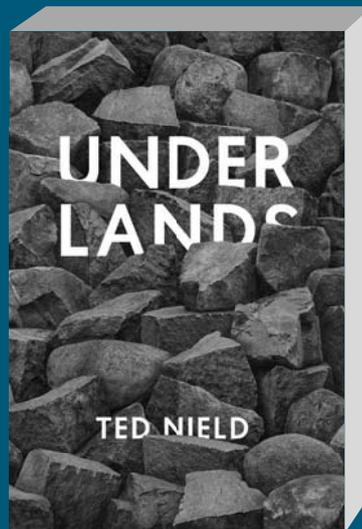
Registration Fees Non-Fellow £60 Retired £25 Student £10
 Fellow £40

Convenors:

Iain Stewart (Plymouth) - istewart@plymouth.ac.uk; Zoe Shipton (Strathclyde) - zoe.shipton@strath.ac.uk; Clare Bond (Aberdeen) - clare.bond@abdn.ac.uk; Nick Smith (Manchester) - nick.t.smith@nml.co.uk

For more information, please contact:
 Georgina Worrall, The Geological Society, Burlington House, Piccadilly, London W1J 0BG
 T: 0207 434 9944 E: georgina.worrall@geolsoc.org.uk
 W: www.geolsoc.org.uk/Communicating-Contested-Geoscience

The new book from Ted Nield



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 GRANTA



HISTORY OF GEOLOGY GROUP
 "Geology and Medicine: Exploring the Historical Links and the Development of Public Health and Forensic Medicine"
 Celebrating the Tercentenary of Sir John Hill
 November 3-4 2014
 Geological Society, Burlington House, Piccadilly, London

Organisers
 Professor Richard T. J. Moody, Dr Chris Duffin and Dr Christopher Gardner Thorpe

Call for Papers:
 The History of Geology Group calls for oral and poster contributions from historians, medical professionals and geoscientists on the following topic(s).

- **Founding Fathers of Geomedicine**, recording the historical links established by individual scientists such as Darwin, Astley Cooper, Charles Daubeny and Gideon Mantell etc.
- **Geological Therapies**, dealing with the evolution of treatments from primitive lithotherapies to the therapeutic use of geological materials in medicines and the advent of hydrotherapy.
- **The Origins of Public Health**, including Soil Chemistry, Water Quality, Health and Safety and the provision of the necessary infrastructure during the Victorian Era.
- **The Evolution of Forensic Medicine**.

Those wishing to contribute should contact r.t.moody@virgin.net.
 Visit: www.historyofgeologygroup.co.uk <<http://www.historyofgeologygroup.co.uk>>

Extended abstracts of 500 words and a maximum of 3 figures should be submitted by the 31st August 2014.

Co-evolution of Life and the Planet

Future perspectives in Earth System Science

5th and 6th November 2014

The Geological Society, London

Long-term co-evolution of life and the planet (NERC research programme)

Evening Ice-breaker: 4th November at UCL

Convenors:

Dr Alistair Crame, *British Antarctic Survey*

Dr Gavin Foster, *University of Southampton*

Professor Tim Lenton, *University of Exeter*

Professor Richard Twitchett, *University of Plymouth*

Professor Graham Shields, *University College London*

Programme Manager:

Ying Zhou, *University College London* (y.shields-zhou@ucl.ac.uk)

The Earth that sustains us today has arisen out of planetary scale co-evolution of the physical and biological worlds. The complexity of these interactions necessitates a multidisciplinary 'Earth System Science' approach. Two years on from 'Life and the Planet 2011', this two-day meeting will explore advances in our understanding of the coupled evolution of life and the planet.

The four main themes of this meeting are: 1) Precambrian origins of the modern Earth System; 2) Key events in the evolution of marine ecosystems; 3) Geological constraints on biological evolution in the polar regions; 4) Descent into the Icehouse during the Cenozoic Era.

www.lifeandplanet.net/2014-life-and-planet.html

Call for abstracts

Conference posters and a limited number of oral contributions are welcome. Abstracts should be no more than 500 words and should be submitted as a Word document by Monday 30th June 2014.

For further information about the conference, or to submit a poster abstract, please contact: Georgina Worrall, The Geological Society, Burlington House, Piccadilly, London W1J 0BG

T: 0207 434 9944 E: georgina.worrall@geolsoc.org.uk

W: www.geolsoc.org.uk/lifeandtheplanet14 Twitter hashtag: #LATP14



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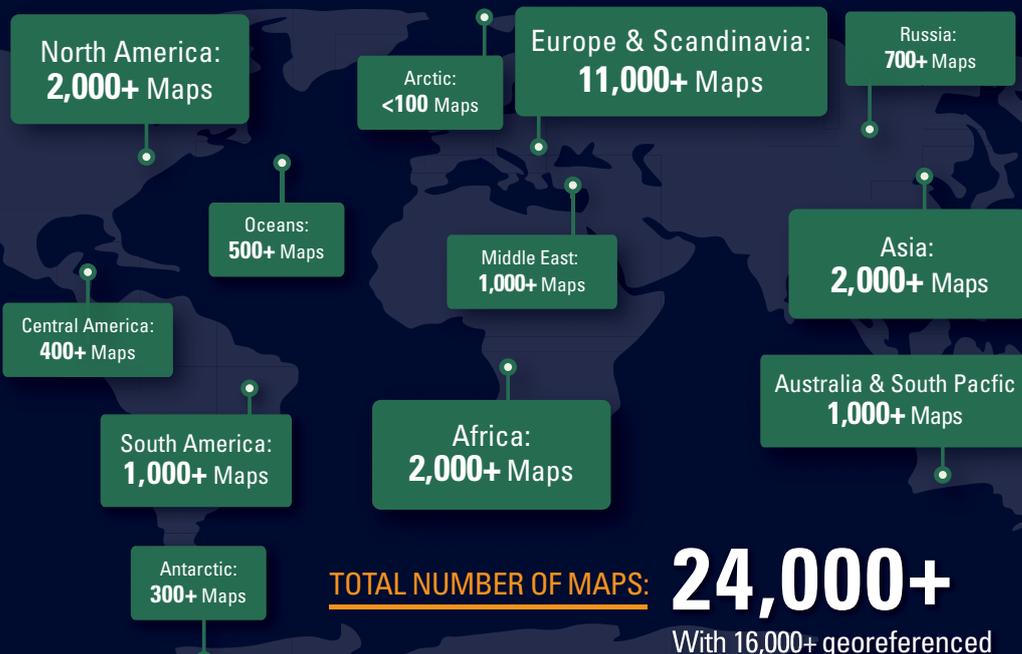


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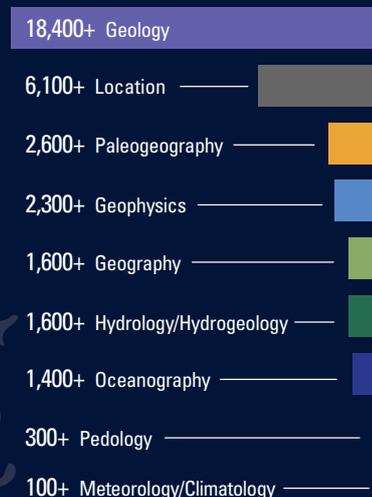
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