Steps & cycles

Interaction of steady trend & natural cyclicity produces ‘stepped’ global warming
The 14th PESGB/HGS Conference on African E & P
“Always Something New Coming Out of Africa”
3-4 September 2015 • Business Design Centre, London

Registration open at pesgb.org.uk

For further information on registration, sponsorship and exhibitions please contact events@pesgb.org.uk

This annual conference, alternating between London and Houston has established itself as the primary technical E & P conference on Africa, with attendances in recent years reaching over 600, including operators, consultants, governments and academia. There will be a large poster programme in addition to the oral programme of about 35 high quality talks covering E & P in all regions of Africa.

Session 1: New Exploration Hot-spots, Discoveries and Prospects
Session Chairs: Harry Davis (Delonex), Raymond Komori (Sasol)

Session 2: New Kitchens: Geodynamics and Heat Flow Modelling
Session Chairs: Helen Doran (Ophir), Julian Moore (BP)

Session 3: New Insights on Trap Types and Reservoir Geometries
Session Chairs: Jerry Jarvis (Tullow), Vincent Mashaba (Sasol)

Session 4: New Reservoirs: African Carbonates in Time and Space
Session Chairs: Fabio Lottaroli, (ENI), Ian Poyntz (HGS)

Interactive Session: Seismic Workshop
Session Chair: Patrick Coole (PGS)
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The 8th Petroleum Geology of Northwest Europe Conference 2015

The Petroleum Geology of NW Europe: 50 years of learning – a platform for present value and future success
28 – 30 September 2015
The Queen Elizabeth II Conference Centre, London

Benefits of attendance:

- Highly topical technical programme
- Unique chance to view diverse cores from across NW Europe
- Training opportunity for young professionals
- Evening dinner and networking reception

"The poster sessions form an integral part of the Conference programme, and allow a great deal of innovative and exciting new work to be shown, presented and discussed by the authors and delegates".

Michael Keaveny, Business Development Manager, Petroleum Geo-Services

For further information please contact Vickie Naidu at: vnaidu@energyinst.org

www.PetroleumGeologyConference.com

REGISTER NOW!
**INTERACTION BETWEEN SECULAR CHANGE AND CYCLIC PROCESSES COULD EXPLAIN OBSERVED ‘STEPWISE’ CLIMATE CHANGE, SAYS ANDY CHADWICK**

Cover: Jan Martin Will/Shutterstock.com

FROM THE EDITOR’S DESK:

**Leading the blind**

Historically, academic publishing has always had one aspect of its operations back-to-front, and that is the matter of who, in the reviewing process, should be anonymous.

It seems double-blindly obvious to me that, as a matter of principle, if anyone has to be anonymous, it is those who are being judged who should be protected, and not those passing judgement. This is why orchestral auditions place a performer behind a screen so that what they look like doesn’t render their judges selectively deaf. Peer review, however, has traditionally been organised the other way about. Reviewers know exactly who they are judging, yet many journals still allow reviewers to criticise from behind a discreet veil.

Internet trolling serves as a graphic reminder of what happens when people write un-attributably. It is (or should be) a principle that, except where extenuating circumstances apply (such as whistle-blowing, where the weak need protection) nobody — certainly nobody in a position of influence — should ever be permitted to write anything that they are not prepared to defend before those about whom they write. The wages of such secrecy are corruption and self-interest.

It is possible that people are basically good; but given the chance to get away with it, they are unlikely to be basically honest. Several of the papers I eventually published, long ago, suffered vexatious delay and sometimes needless rejection because one specialist editor proved to have a vested interest in maintaining priority, or suppressing falsification. I quickly learned to subvert this by an emasculating ‘acknowledgement’, which shows that their Harry Potter cloak didn’t even work; but the fact that they thought they were invisible, made the process paltry, unedifying and disenchanting.

Writing and reviewing should never provide sanctuary for the cowardly and passive-aggressive, whether they are powerful or not. But reviewing should certainly not place stronger weapons in the hands of those who already hold them all. For this reason I have, since first writing about this in the 1980s, advocated ‘double-blind’ reviewing - anonymity for authors. Although poo-pooed at the time in New Scientist’s correspondence columns, double-blind reviewing has since achieved a 76% approval rating1,2 from surveyed scientists. The leading UK science journal Nature now offers double-blind reviewing.

‘Geologica Britannica’

Dan Welch (Chair, West Midlands Regional Group) describes the 3rd Annual Geological Photographic Competition.

Geoscientists understand the value of diagrams, conceptual models and photographs to describe complex environments to each other and to the public. Visual evidence remains a key part of fieldwork – from the most basic ground investigation to cutting edge research, particularly for in situ features that cannot be taken away for later study.

With this in mind, the competition was first launched in 2013 by the West Midlands Regional Group for West Midlands-based Fellows and Black Country Geological Society members only. Images by Peter Twigg, John Schroder and Jon Amos took awards.

In January 2014 the competition was thrown open to include any local geologists, amateur or professional, working or retired in not just the West Midlands and Black Country Region but in the Southern Wales Region too. Provided you lived in either, you could enter. The theme: ‘What Lies Beneath our Feet’.

Nearly one hundred entries were received, representing famous geological locations from Namibia to Iceland and Bude to Torquay. Judges (Jon Clatworthy (Lapworth Museum), Bill Gaskarth (Geological Society of London) and Adrian Durkin (Dudley Museum & Art Gallery)) gathered at the Lapworth Museum, University of Birmingham and deliberated over the images. Malcolm Nugent’s ‘Etna Beneath Our Feet’ was awarded First Prize, taking away £200.

Themed years are at the heart of the Society’s Science Strategy, and this year the Society celebrates both the ‘Year of Mud’ and the bicentenary of William Smith’s famous geological map. With these in mind, the West Midlands, Southern Wales and North West Regional Groups of the Society and Black Country Geological Society are joining, with sponsorship provided by Geotechnical Engineering Ltd., to bring you the 3rd annual photographic competition on the theme of… ‘Geologica Britannica - Exhibiting the Geology of the British Isles and Applied Geology in the British Isles’.

Groups of the Society and Black Country Geological Society are joining, with sponsorship provided by Geotechnical Engineering Ltd., to bring you the 3rd annual photographic competition on the theme of… ‘Geologica Britannica - Exhibiting the Geology of the British Isles and Applied Geology in the British Isles’.

INFORMATION FOR ENTRANTS

Full details of the rules can be found at www.geolsoc.org.uk/JointPhotoComp - images will be selected by a panel of independent Judges and there will be 10 winners

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<thead>
<tr>
<th>Name</th>
<th>Expertise</th>
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<tr>
<td>1st Prize</td>
<td>£200 Sponsored by Geotechnical Engineering Limited, plus £150 special publication gift voucher donated by Geological Society Publishing House, plus William Smith Map Reproduction and Memoir</td>
</tr>
<tr>
<td>2nd Prize</td>
<td>£150 Sponsored by Geotechnical Engineering Limited plus Geological Map of Great Britain, Bicentennial edition</td>
</tr>
<tr>
<td>3rd Prize</td>
<td>£100 Sponsored by Geotechnical Engineering Limited plus Geological Map of Great Britain, Bicentennial edition</td>
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<tr>
<td>4th and 5th Prizes</td>
<td>Geological Map of Great Britain, Bicentennial edition</td>
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<tr>
<td>6th to 10th Prize</td>
<td>Geological Hammer USB Drive, donated by Geological Society London</td>
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You have until midnight Tuesday 1 December. Submit your images to jointPhotoComp@geolsoc.org.uk. For detailed rules, terms and conditions please visit www.geolsoc.org.uk/JointPhotoComp. @wmids_geolsoc #GeologicaBritannica #JointPhotoComp.
25 years of CGeol

Edmund Nickless, Executive Secretary, on the first quarter century of Chartership.

In 1972, the Council of the Geological Society set in train a series of events that saw the formation of the Institution of Geologists and ultimately, the creation of the Chartered Geologist title. The development of the Society to encompass regulation of the geological profession was made possible almost two decades later when in 1990, the membership of the Institution of Geologists decided by a large majority to accept an invitation from the then President to join the Geological Society.

The process of change started by the absorption of members of the former Institution of Geologists has seen a fundamental restructuring of the Society with continuing evolution during the succeeding decades to meet the changing needs of the geological sciences, the geological profession and society at large.

Looking back, it is always difficult to judge actions then by the standards of today and 25 years is not all that long. In seeking to advance professionalism within the geosciences there were concerns to widen access and to achieve a better level of gender equality. We have made some progress. In 2001 15.5% of the Fellowship was female; a decade later that was 19.5%. In 2011 women made up 12% of Chartered Geologists, up from 7% in 2002.

The Society has never (of late!) been consciously exclusive, but greater awareness of the needs of individuals means we are more proactive in broadening gender and ethnic participation. Continued change over the next 25 years is inevitable, furthering wider diversity within our Chartered Fellowship.

Confronting barriers to inclusion

George Jameson heralds a forthcoming conference on ‘opening the gate to accessible fieldwork’.

Field experience is a crucial component in the professional practice of geoscience. All learners, regardless of their stage of education, should see geoscience as an accessible academic endeavour which offers viable career opportunities.

For learners with disabilities, however, the physical and psychological challenges presented by fieldwork characteristic of most undergraduate programmes, can deter talented individuals from engaging with geoscience beyond compulsory education.

This one-day event explores the issues involved in making fieldwork accessible to learners with a diverse range of abilities. We welcome and encourage participation from geoscience educators, industry professionals, and organisations involved in the provision of fieldwork in both formal and informal capacities.

How can we the wider geoscience community embrace this undertaking to attract and foster the talents of people with diverse abilities?

Join us at Burlington House on Friday 26 June and take part. Registration is now open – visit http://bit.ly/1OoxUV

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. There is a cash bar for the purchase of aperitifs and wine. Burlington House dinners include wine.

2015: 9 September (Athenaeum); 7 October (Athenaeum)

Fellows wishing to dine or requesting further information about the Geological Society Club, please email Caroline Seymour on carolineseymour554@hotmail.com

Careers Day 2015

The Geological Society’s Careers Days are the most recognised geological careers-based forum in the UK. These events are a great opportunity to showcase your company to aspiring early career geoscientists – the future of your industry! For more information about the opportunities available, visit: www.geolsoc.org.uk/careersdaysponsorship

Awards 2016

Make your nominations for our 2016 Awards, writes Stephanie Jones. Fellows of the Society are invited to submit nominations for the Society’s Awards for 2016 to the Awards Committee. Full details of how to make nominations can be found at www.geolsoc.org.uk/gsl/awards. Nominations must be received at the Society no later than 1 October 2015.
SOCIETY NEWS

‘University Geoscience UK’

The body formerly known as the Committee of Heads of University Geoscience Departments (CHUGD) has a new name, write Tim Minshull* and David Manning§

The Geological Society and the Committee of Heads of University Geosciences Departments (CHUGD) have increasingly worked together to represent the university geoscience community to government and others regarding higher education and research matters, to share information and to promote the study of geoscience at universities. During 2014, a GSL-CHUGD working group developed proposals for a new model of closer cooperative working, building on recent progress.

New Name

From July 2015, CHUGD will work under the new name of ‘University Geoscience UK’. A new Joint Higher Education Committee has been established by our two organisations, to address the needs and promote the interests of geoscience students, researchers and teachers in UK universities. The Society will provide administrative support and will lead delivery of a shared programme of activities and communications. University Geoscience UK will continue as an independent body and a small executive committee (with secretariat provided by GSL) will oversee its activities and its input to the new joint committee.

A full meeting of University Geoscience UK will be held annually, starting this November. This will provide an opportunity for representatives from all UK geoscience departments to discuss in depth a small number of strategic matters. The 2015 discussion meeting is planned to focus on field teaching. The executive committee will remain in contact with University Geoscience UK members throughout the year – the engagement of this wider group is essential if we are to represent our community effectively to government and others, and provide valuable support to students and academicians.

The new closer working relationship between our two organisations and the changes to University Geoscience UK’s methods of working have been approved unanimously by Council and by University Geoscience UK’s membership. We are excited about the opportunities that this relationship will afford our two organisations – and, more importantly, the university geoscience community – building on recent successes.

We believe it will strengthen input to joint responses to government consultations and Parliamentary inquiries by University Geoscience UK, on behalf of the community it serves. It will also provide a simple mechanism for the Society to better access the expertise of University Geoscience UK, as well as to support its services and activities. In this way, we believe that our new model of working will allow us to maximise the impact of our two organisations’ respective expertise, capabilities and capacities.

Work Plan

The new joint committee is now developing an initial work plan. Early priorities are to gather reliable information on the full costs of field teaching to support communication with government and funding bodies; to improve provision of career and further study information to those at school, university and beyond; and, working with the American Geosciences Institute, to survey those completing geoscience degrees to find out more about the paths they have taken and their future plans.

We welcome comments and suggestions from University Geoscience UK members and Geological Society Fellows regarding future plans and activities. Please contact nic.bilham@geolsoc.org.uk.

*Chair, University Geoscience UK; §President, The Geological Society

Transforming for the future

Mike Bowman, Professor of Development & Production Geology, University of Manchester, will chair a session at the 8th Petroleum Geology of Northwest Europe Conference (PGC) this September.*

Geoscientist: How should the North Sea sector adapt its practices to ensure the most efficient exploration and extraction of remaining resources?

MB: I see a number of areas where industry could make a bigger impact and build on the momentum being set up by the creation of the Oil & Gas Authority and the appointment of the new regulator together with the recent government tax changes. We need greater collaboration across operators, service sectors, academia and other SMEs through sharing of knowledge and information and learning from each other more effectively.

Geoscientist: What is your view on onshore unconventional gas and oil exploration in Europe? Is the prize worth the pain?

MB: Given the pace of growth in the global demand for energy and the need for hydrocarbons, together with security of supply concerns and the pretty dismal track record of global exploration for conventional oil and gas in recent years, I feel we should do all that we can to safely and securely explore for both conventional and unconventional resources in our own region. The value of shale and also conventional gas as a clean fuel that will help bridge to a less hydrocarbon dependant future is clear and we should be doing all we can to support this and make it happen.

Geoscientist: What technologies will shape the industry in the next 10–15 years?

MB: I see four areas here – one will be transforming the unconventional shale based exploration and production through new and more advanced drilling, completion and stimulation technologies. Secondly, in the North Sea and related mature basin we must create novel solutions that will help transform those many small, currently uneconomic, resources and create value from them. This will require low cost, simple and increasingly automated engineering solutions that will improve operating efficiency, reduce operating costs and also the capital costs of a new development.

Geoscientist: Do you foresee North Sea infrastructure being significantly re-purposed for alternative energy use such as CCS or hubs for electricity transmission?

MB: I remain astonished that there is such little activity other more effectively.

The 2015 discussion meeting is planned to focus on field teaching. The executive committee will remain in contact with University Geoscience UK members throughout the year – the engagement of this wider group is essential if we are to represent our community effectively to government and others, and provide valuable support to students and academicians.

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The 2015 discussion meeting is planned to focus on field teaching. The executive conference Centre, London (see advert, p4) The full interview with Mike Bowman may be found in Geoscientist Online
**Diversity, Equality and Inclusion**

The Geological Society (Edmund Nickless writes) thanks all fellows and candidate fellows who have completed and returned the Diversity, Equality and Inclusion Survey.

We have received a modest number of returns which will help tremendously in our efforts to identify and address any actual or perceived barriers to inclusion and to measure our success at improving diversity over time.

The survey is not compulsory and will remain so - but in order for us to achieve our aims we would love as many people as possible to complete and return it. This will allow us to develop a more accurate picture of the Society’s demographic. We can then direct our resources to where they are required, allowing us to benchmark progress.

"THE SURVEY IS NOT COMPULSORY, BUT WE WOULD LOVE AS MANY PEOPLE AS POSSIBLE TO COMPLETE IT"

If you haven’t already completed the survey, please do so. Fellows and Candidate Fellows can complete the Survey form via their online accounts, by logging in to their ‘MyGSL’ dashboard on www.geolsoc.org.uk.

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**FUTURE MEETINGS**

Dates for meetings of Council and Ordinary General Meetings until April 2016 shall be as follows:

Ordinary General Meetings:
- 2015: 22 September
- 2015: 25 November
- 2016: 3 February
- 2016: 6 April

Meetings of Council:
- 2015: 22 September
- 2015: 23 September
- 2015: 25 November
- 2016: 3 February
- 2016: 6 April

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**Re-fitting the flagships**

A Science Committee working group on Society Flagship Meetings has reported, writes Al Fraser.

Flagship Meetings have formed the mainstay of our science communication to Fellows and non-fellows for many years. ‘If it ain’t broke don’t fix it’ came to mind; but we very quickly found that there were a few strategic changes we could make to bring them up to date and enhance the Society’s overall scientific output.

The group met on 11 December 2014 and made a series of recommendations, subsequently reviewed by Science Committee and SERC in February and March and approved at Council on 8 April. I want to share these proposals at an early stage and particularly ask for your support in identifying subject matter and suitable conferences to populate our new Flagship Meetings calendar. I also wanted to bring two exciting new events to your attention that will be joining the line-up, details of which can be found on www.geolsoc.org.uk.

The William Smith Meeting was identified as a ‘blue ribbon’ event and the working group agreed there should be no change in its remit.

The Lyell Meeting will continue to report annually on and discuss key science in stratigraphy.

The Fermor Meeting has traditionally been held every two to three years but there is no reason why it can’t be annual. Let’s have some proposals please!

The remit for the Arthur Holmes Meeting will be re-written to emphasise the substantial field-based activity required. Novel formats will be welcomed (e.g. a field meeting with a short conventional conference attached) and it can be on any aspect of geoscience. The conference doesn’t have to be held at the Society and could take place near to the fieldwork. And we would like to encourage conference proposals with an element of student field teaching.

The group agreed that the focus for the Frontiers Meeting should be on early career geoscientists presenting research to their peers and potential industry employers, and should predominately be discussion-led. Frontiers Meetings were originally also intended to provide an opportunity for early career scientists to propose and organise meetings themselves, to gain convener experience. This aspect has not been successful. It was agreed that meetings of this type need to be facilitated by a convener who is not necessarily an early career researcher, but who can stimulate the involvement of this community. In an important change, the group agreed that the title ‘Frontiers’ (originally meant to refer to cutting-edge areas) was not helpful. In future this meeting will be called ‘The Janet Watson Meeting: an early career geoscience symposium’.

There is no obvious opportunity within the current range of flagship meetings to address the ‘societal challenges’ outlined in the ‘Geology for Society’ report, most at present being research-based. Although some are more applied (or mixed), the group noted that such meetings nonetheless tend to focus on an area of science (as per the ‘subject map’ in our science strategy) rather than on societal application.

The group therefore proposed a new flagship meeting series to focus on societal challenges and the geoscience relevant to addressing them. The group noted that the ‘Geology for Society’ report is a useful starting point for potential topics and proposed that the new series be called the ‘Bryan Lovell Meeting’, after former President Bryan Lovell (picture). Bryan has enthusiastically supported this proposal and plans to be present at these events when they kick off in late 2016 or early 2017.

Please forward meeting proposals for the 2016/2017 flagship meetings to Laura Griffiths, Conference Manager, laura.griffiths@geolsoc.org.uk.
Climate-change ‘sceptics’ have made great mileage out of the current hiatus in observed global warming. Atmospheric temperatures have not really increased since the turn of the 21st Century, a fact frequently cited as incompatible with, or even disproving, global warming.

These same commentators draw a discreet veil over the fact that temperatures also didn’t rise between 1940 and 1970 - an inconvenient truth for them, since that pause was followed by 30 years of rapid warming.

However, the truth is that a long-term rising temperature trend, steepening with time, has lifted average global temperatures by around 0.9°C since the early 20th Century. This long-term trend correlates closely with the rise in atmospheric CO₂ and with its expected greenhouse warming effects. But anthropogenic emissions are not the only game in town, and that is why the observed temperature variation is more complex.

The basic picture of long-term warming is in fact characterised by thirty-year ‘ramps’ (where temperatures rise relatively quickly), alternating with thirty-year ‘flats’, where temperatures either fall slightly, or remain roughly constant. The latest ‘flat’ commenced around the year 2000.

It is relatively easy to set out, simply and without complex modelling, the way in which global temperatures and atmospheric CO₂ concentrations have changed over the past century and more. By teasing apart the different natural, shorter-term variations that affect the atmosphere, we can show quite clearly why we should not expect temperature increases to be as smooth...
The basic pattern of long-term warming is characterised by 30-year ‘ramps’ alternating with 30-year ‘flats’.

Global temperatures from NASA (2014), showing measured annual values (crosses) and values smoothed with a 3-year moving average filter (solid line), plotted relative to the 1909 minimum value. Arrows denote prominent ‘flats’ (blue) and ‘ramps’ (red) in the overall temperature trend.

As the rise in CO₂ content, and how it is that the interference between the steady curve and the different cyclicities produces just the stepped graph that is observed. From there we can make predictions of how temperatures are likely to change over the next 50 years or so, assuming these patterns continue.

It was Swedish physical chemist Svante Arrhenius (1859-1927) who wrote in 1896 that “…if the quantity of carbonic acid [in the atmosphere] increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression”. Arrhenius rather welcomed the idea of global warming and optimistically predicted that Scandinavian climates might become more equable. Although our understanding of how climate is affected by different greenhouse gases has become much more sophisticated since then, Arrhenius’s basic thesis still stands today.

Datasets
A number of long-term global temperature datasets exist and are publicly available. Some are restricted to measurements taken on land and others covering the entire Earth’s surface. Here we use the NASA database, available in tabular form online. The dataset comprises temperature measurements from 1880 to the present day expressed as temperature difference relative to the 1951-1980 mean. Here, for clarity, we redisplay them as temperature difference relative to the lowest recorded annual value (in 1909).

The raw data are quite noisy, with significant year-to-year variation, so a simple three-year moving average filter has been applied to smooth these out and make it easier to see the overall variability.

The most obvious aspect of the dataset is a hundred-year warming trend, from the early part of the 20th Century to the present day. This can be illustrated by fitting a simple power-law curve to the data. As defined by the power-law fit, global temperatures today are some 0.8 – 0.9°C higher than they were during the latter part the 19th Century.

Measured annual temperatures do not follow the long-term trend exactly, but rather include a number of pronounced multi-decadal variations. These are characterised by ‘ramps’ (periods of roughly 30 years when temperatures rose rather rapidly) and ‘flats’ (periods of roughly 30 years when temperatures decreased slightly or remained roughly constant).

Thus, and running counter to the overall warming trend, temperatures fell significantly between 1880 and 1910.
decreased slightly in the 30-year period 1945 to 1975, and have remained roughly constant since the end of the 20th Century to now. Viewed in this context, the current ‘flattening off’ of global temperatures seems to be part of a rather regular pattern.

CO₂ data show a significant increase, from around 290ppm at the end of the 19th Century, to nearly 400ppm by the present day (CO₂ levels at Mauna Loa observatory (Hawaii) reached 400ppm for the first time on 9 May, 2013). Like the long-term temperature trend, the rate of CO₂ increase is not itself constant, but accelerates steadily with time. In general terms, it is clear that with time (particularly in the second half of the 20th Century), higher atmospheric CO₂ concentrations are associated with higher temperatures.

Correlations Cross-plotting CO₂ levels and temperature shows a direct correlation. The simplest fit to the data is a simple linear function, with a gradient of around 0.1°C for every additional 10ppm of CO₂. Other, more complex, fits can be made. For example, a logarithmic function gives an equally satisfactory correlation.

Applying the two correlation functions to the CO₂ observational record gives equivalent ‘CO₂-scaled’ temperature records. These two scaled curves essentially represent the component of the observed temperature record that correlates with CO₂, and excludes any shorter term variability.

These curves also include the effect of other greenhouse gases that have also accumulated in the atmosphere, over similar timescales to CO₂ – methane, for example. For simplicity we shall just use the term ‘CO₂-scaled’ temperatures.
CO₂-scaled curves produce a match to measured temperature data that is much superior to the empirically-fitted power-law curve. This is quite remarkable, given that the power-law curve is derived purely from the temperature data, whereas the scaled curves depend on the relationship between CO₂ and temperature.

Short-term temperature variation can be isolated by subtracting long-term trends from the observed data, to obtain ‘de-trended’ or ‘residual’ temperatures. These residual temperature variations have no correlation with CO₂ and so can be thought of as a response to natural or other shorter-term processes. By simply looking at the curves, one can discern a number of cyclical components. The strongest of these by far has a periodicity of around 60 years and corresponds to the obvious ‘multi-decadal cyclicity’, which has a variability approaching ± 0.15°C, with peaks around 1880, 1940 and 2000 and troughs around 1910 and 1970. Smaller, shorter-term components seem to display periodicities in the range of five to 20 years or so, contributing decadal variations in the order of ± 0.01°C.

Spectral analysis provides a more rigorous way of determining cyclical variations within time series like these. Application of a Fast Fourier Transform (FFT) to the residual temperature curve (obtained after subtracting the logarithmic fit between CO₂ and temperature) gives the power spectrum shown in Figure 7.

The peaks in the spectrum indicate the presence of discrete cyclical components. In fact, the peaks are all distributed across several frequencies - so we compute the ‘true’ frequency as the weighted average of those frequencies comprising the spectral peak. The reason for doing this is that a spectrum computed by FFT is evaluated at frequencies fixed by the sampling frequency and the number of samples in the data sequence. So, for our input sample size of 131 years (with sampling every year) the periods of the first three frequency components are: infinity (by definition, the constant term), 131 years, 65.5 years and 32.75 years (i.e., the period halves with each successive spectral estimate).

The weighted averaging helps compensate for the effect of undersampling, which is most important at the low-frequency end of the spectrum, where gaps between adjacent periods are largest. By taking weighted averages of the frequencies that make up peaks A, B and C, we determine periods of 59.9, 20.3 and 14.6 years respectively.

The phases of the three cyclical components were similarly estimated by averaging the individual phases of spectral components making up the peaks in the power spectrum, weighted by their respective powers. Smaller peaks in the spectrum (associated with cycles of less than 10 years) were not considered.

A synthetic curve, incorporating the three principal cyclic components, is shown in Figure 8, using the identified frequencies and phases of the principal spectral components. This captures well the multi-decadal variations in amplitude of the observed temperature residuals. (We have not included higher frequency components from the spectral analysis, partly for simplicity, but also to avoid giving a false impression of precision when extrapolating the data into the future).

**Close match**

It is clear that the long-term warming trend extracted from temperature data closely matches the observed rise in atmospheric CO₂ concentrations. In particular it matches well the temperature trend scaled from the logarithm of CO₂ concentration - the relationship first proposed by Arrhenius.

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**Below: Figure 7:** Power spectrum of the residual temperature variation showing distinct peaks at several frequencies. The largest components (peaks A, B and C) are associated with periods greater than 10 years and have estimated cyclicities of 59.9, 20.3 and 14.6 years respectively. We also indicate where the 11-year solar cycle would plot on the spectrum.

**Below lower:** Figure 8: Synthetic time series of temperature residuals (thick black) reconstructed from three sinusoidal frequency components corresponding to the spectral peaks in Figure 7 associated with periods of 59.9, 20.3 and 14.6 years (denoted by the thin black, green and blue lines resp.). The observed temperature residual is shown in red. A linear decay of amplitude with time has been applied to the lowest frequency component.
The shorter term variations correlate with a number of natural oceanic circulation phenomena, all of which are associated with enormous heat exchanges between the oceans and the atmosphere. The dominant ~60 year temperature periodicity is comparable with a 60-year cyclicity in global sea level and is correlated with the Atlantic Multidecadal Oscillation. Other shorter-term cyclic phenomena further complicating the record include the Pacific Decadal Oscillation and the more notorious ‘El Nino’.

Additional, non-cyclic events all add ‘noise’ to the longer-term temperature record. Of these, the most important natural process is volcanicity, which produces dust and atmospheric aerosols that act as transient cooling agents. Human activity is also variable in the short term, notably in the production of aerosols and carbon particulates. It seems the 11-year sunspot cycle has no discernible imprint on the temperature record.

For simplicity, we shall refer to all these non-CO₂ related multidecadal/decadal temperature effects as ‘natural’ variation.

Ramps and flats

The prominent ‘ramps’ and ‘flats’ in the temperature curve can readily be explained as the interaction between the long-term warming trend (steepening with time) and the dominant ~60-year cyclic variability.

Thus from ~1880 to ~1910, the still relatively gentle long-term rising trend (0.03°C per decade) was outweighed by a fall (0.13°C per decade) in the ‘natural’ cycle to produce an overall cooling over 30 years of about 0.3°C.

From ~1910 to ~1940, the long-term rising trend (by then increased to 0.04°C per decade) was enhanced by a 30-year (0.12°C/decade) rise in the ‘natural’ cycle, to produce a ramp in temperatures of about 0.5°C in 30 years.

From ~1940 to ~1975, the long-term rising trend (now up to 0.07°C per decade) was just outweighed by a 35-year (0.09°C per decade) fall in the ‘natural’ cycle - to produce a slight cooling over 35 years of 0.07°C.

From ~1975 to ~2000 the long-term rising trend (which by that time had reached 0.12°C per decade) was enhanced by a 25-year (0.08°C per decade) rise in the ‘natural’ cycle, resulting in an increase of over 0.5°C in 25 years - the fastest rise yet recorded.

And so, from 2000 to the present, the latest downswing in the natural cycle is just about balancing the rapid underlying upward trend.

Looking ahead

What are the implications of this for future global temperatures, assuming continued increase in atmospheric CO₂?

The first step is to extrapolate the synthetic residual function forward by 50 years or so. This has been accomplished by extrapolating the three sinusoidal frequency components (with periods of 59.9, 20.3 and 14.6 years) to around 2070, and summing them.

The second step was to project forward the long-term rising temperature trend, scaled from the logarithm of CO₂ concentrations. To do this, we assumed that atmospheric CO₂ would rise at a constant increment of 1.69 ppm per annum - the average value from 1990 to 2012. (Recent yearly increases suggest that this might be rather conservative.)

Summing the projected synthetic residuals and the projected long-term trend gives a synthetic temperature curve that provides an estimate of future global temperature. It is clear that in coming decades temperatures will continue to rise, albeit not at a uniform rate.

The latest downswing of the ~60 year cycle, which started around the turn of the century, will probably restrict average global temperature-rise to around 0.1°C per decade until around 2035; but this will increase to around 0.2°C per decade as we enter the next ‘ramp’.

Clearly this is just an estimate and subject to uncertainties. Take, for instance, short-term variation. As discussed above we have not included cyclicities with periods of less than about 15 years, mainly to avoid a false impression of precision in the forward projection. Our temperature curve cannot therefore capture this type of variability. Thus, while our curve indicates the general warming slowdown that we have witnessed since 2000, it...
does not accurately replicate the actual flattening, which would require the addition of shorter-term variables.

Our analysis shows that the ~60 year periodicity is the key factor, which we interpret to be mainly responsible for the prominent ramps and flats observed in the recent temperature record. The evidence runs to just over 130 years of data, however, barely more than two complete periods; so the longer-term stability of this cycle is open to question. Rohde et al. produced a temperature record back to around 1750. The ~60 year periodicity is discernible on this, at least as far back as the early 1800s; but before this the record becomes increasingly uncertain.

Conclusions

Our analysis shows a number of interesting patterns and interactions in the global temperature record. A long-term rising trend, steepening with time, has lifted global temperatures by around 0.9°C from the early part of the 20th Century. Superimposed on this, a decadal to multidecadal cyclic variability imposes shorter-term temperature variations in the order of ±0.15°C.

The long-term rising trend correlates closely with the rise in atmospheric CO2 and with its expected greenhouse warming effects. The shorter-term cyclic variability is a ‘non-greenhouse’ effect, influenced by some aspects of human activity, but principally the result of natural processes—in particular, large-scale multi-decadal to decadal oscillation of the oceanic circulation system.

Taken together, natural cyclic variation and the underlying rising trend produce the observed global temperature curve. When natural cyclicity acts against the greenhouse trend we get a temperature ‘flat’, while when the two act in unison we get a temperature ‘ramp’. The ramps are getting steeper with time, and the flats (which were initially characterised by cooling) are no longer.

Projections suggest that CO2-driven warming will continue, initially ameliorated by the current down-swing in natural cyclicity. However, as this unwinds, temperature increase will accelerate from around 2035. Shorter-term variability might disguise these trends for periods of a few years or so.

There is a significant chance therefore that the current warming ‘hiatus’ might continue for a number of years. But it is critically important that this is not allowed to derail climate-change policy. The current hiatus is not ‘buying us time’ in any sense. As the natural cycle unwinds, excess energy stored in the oceans will be released back into the atmosphere, and temperatures will rise again—in all probability, more quickly than before. The climate change consensus is not threatened by the current apparent lack of global warming.

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REFERENCES

HUNTING PTEROSAURS
Elizabeth Martin-Silverstone* describes her investigations into pterosaur flight, and the evolution of flying vertebrates

Thanks to the Society’s Daniel Pigeon Fund, I recently spent a few weeks travelling around Germany in search of pterosaur fossils in various collections. Flight is a truly remarkable adaptation that has evolved only three times in vertebrates: in birds, bats, and in the extinct flying reptiles that are the subject of my studies - the pterosaurs. Of all these different lineages, pterosaurs produced the widest range of body sizes (with wing-spans ranging from 0.2 to 11m), the largest overall size (the largest extant bird has a wingspan of 4 m, largest extinct was 7m) yet were also the first to achieve powered flight, first in the Late Triassic. Despite being known from the fossil record for over 200 years, basic questions on pterosaur biology and biomechanics - such as reliable body mass estimates and flight abilities - remain unknown.

Body mass
Estimating body mass is one of the most basic and essential features in understanding locomotory capabilities of an animal, and is even more important with respect to flying animals, because an animal’s mass is directly proportional to its ability to take off and achieve lift. As the largest animals ever to take to the air, pterosaurs pushed the limits of aerodynamics, and as there remains much debate around whether or not these large pterosaurs could actually fly, making accurate mass estimates vital to our overall comprehension of them. Previous mass estimates have varied drastically depending on the methods used. For example, one of the largest pterosaurs (Quetzalcoatlus northropi) has been estimated at an improbably light 70kg\(^1\), at a more reasonable 250kg\(^2\) and very heavy 544kg\(^3\).

Fortunately, modern imaging technology allows us to make accurate estimates of bone mass in relatively uncrushed specimens using computed tomography (CT) scans\(^4\). These take x-rays from several different angles, allowing the fossil to be visualised in 3D, and the volume of actual bony material within each element to be calculated. When multiplied by bone density, this gives you a mass estimate.

Finally, after the bones have been digitally visualised, muscle mass can be estimated by reconstructing the muscle attachments and muscle volumes. This should produce a more accurate estimate of total body mass. This is what I am working towards now. CT scans also give us an idea of the degree of ‘pneumaticity’, which allows for comparison between different elements and species through the bone’s Air Space Proportion (ASP). This can also be performed using cross-sections, but these are less accurate\(^5\).

Pneumaticity, which is the presence of air sacs and diverticulae that invade the soft tissue and bones as part of the animal’s respiratory system, is also found in birds, some theropod dinosaurs, and sauropod dinosaur necks. ASP gives a quantifiable measurement of the pneumaticity, which has implications for the biomechanics of an animal as it directly affects the stiffness of a bone.

Zittel wing
So far, I have visited the collections of four German museums: Staatliches Museum für Naturkunde Karlsruhe (SMNK), Staatliches Museum für Naturkunde Stuttgart (SMNS), Institut für Geologie und Paläontologie, Universität Tübingen (GPIT), and the Bayerische Staatssammlung für Paläontologie und Geologie, Munich (BSPG). I have been able to take a large number of pictures to start understand the variation in ASP throughout the skeleton and in different species.

I greatly enjoyed the museum visits - especially Karlsruhe, where I was greeted at the front of the museum by a giant azhdarchid model and got to stay there (which felt a bit like Night at the Museum). There’s also a giant fuzzy azhdarchid model in flight hanging from the ceiling of the museum! Munich was fascinating for the number of historically significant specimens in its collection, including the first pterosaur known to science (unfortunately that one is highly protected and I wasn’t able to work on it).
I was completely surprised when I opened a drawer to discover the ‘Zittel wing’, the famous fossil that first gave us an idea of pterosaur wing structures, way back in 1880.

**Trends**

While the work is still very much in its infancy, some trends are becoming visible. First of all, ASP is consistently lower (meaning that there is proportionally more bone than air), in smaller pterosaurs (e.g. *Rhamphorhynchus, Pterodactylus, Germanodactylus*) than larger ones (e.g. *Ornithocheirus, Anhanguera, azhdarchid pterosaurs*). Previous studies have suggested that pterosaurs are among the most, if not the most, pneumatic animals to have lived5. However, this now appears to be true of only the larger pterosaurs, and is not the case for smaller ones.

As ASP refers to the physical amount of air present within a bone, (the degree of hollowness if you will) this can tell us something about biomechanics. Pterosaur bones probably underwent deformation in flight (as all bones do in movement), and would have been particularly susceptible to bending. The bending resistance of a hollow tube, related to the second moment of area, is dependent on the amount of material in the tube and how far from the centre it is (how large of a diameter the bone has). Pterosaur bones commonly have cortical thicknesses of 0.5-2mm. For two bones with a cortical thickness of one millimetre, the bending stiffness is much higher (i.e., it is more resistant to bending) in a bone with a diameter of 30mm than one with a diameter of 10mm.

Most pterosaur wing bones studied so far have ASP values ranging from 0.4-0.8, with very few exceeding 0.8. However, one pterosaur is showing much lower values, of just 0.1. This value was obtained from the dsungaripterid pterosaur *Lonchognathosaurus* from China. Dsungaripterids have been noted by pterosaur palaeontologists as having unusually thick-walled bones, which also affects their ASP. Modern birds that spend a significant time in water (such as cormorants, or penguins) have similarly thick-walled features, and dsungaripterid palaeoecology is not fully understood. The implications of this thick-walled, low ASP feature are currently under investigation.

The main purpose of this study was to CT scan as many pterosaur fossils as possible to understand pterosaur bone and body mass. This is going ahead thanks to the large number of specimens on loan from the SMNK, including one nearly complete *Tapejara*, two partial ornithocheirid wings, one partial *Coloborhynchus* skeleton, and more. So far, only portions of the *Tapejara* have been scanned, but these have been very successful.

**Future work**

The main thing I have focused on during the last six months has been finishing the CT-scanning of all the SMNK specimens, and begin analysis - as the fossils need to be returned to Germany this month. I will also continue looking at the ASP, and how that affects the biomechanics of the pterosaur wing.

Depending on how much it will cost to return the specimens, I may visit additional museums in Germany as well, to collect yet more data.

**ACKNOWLEDGEMENT**

In addition to the Society’s Daniel Pigeon Fund, additional funding for my PhD is provided by the Graduate School of the National Oceanography Centre, Southampton, and the Natural Sciences and Engineering Research Council of Canada (NSERC). I would like to thank all those who helped me at each museum and allowed me into their collections - Dino Frey (SMNK), Philippe Hauk (GPIT), Oliver Rauhut (BSPG) and Rainer Schoch (SMNS), and my supervisors for pushing me and helping me get to Germany – Gareth Dyke, Colin Palmer, Mike Habib, and Emily Rayfield.

If you would like to find out more about Society fieldwork research grants, visit www.geolsoc.org.uk/grants. Applications for 2016 will be invited in September.
REFERENCES


*Elizabeth Martin-Silverstone* is currently studying for her doctorate in vertebrate palaeobiology at the University of Southampton.
Fieldwork and mining

A rigorous dose of mine or exploration work allows students to decide if the life is for them, and employers to assess future employees, says Mike Harris*

That fieldwork is essential to training geologists would seem a truism so universally accepted among geologists as to be unremarkable. However, although it is accepted in conversation, it is not always so at the point of financing it.

Mike Streule and Lorraine Craig (Soapbox, Geoscientist 25.1 February 2015) mention the sense of “being a ‘real’ geologist” that comes from seeing in the field what you have learned in a classroom. They write: “Yes, it is expensive, and yes, it takes dedicated staff to make it happen, but it makes [successful] geoscience graduates more truly valuable in the workplace than many others”.

Mining colleagues

Not being involved, I cannot properly comment on university funding or how universities structure their programmes, but I can imagine the difficulties. My intention here is to address my mining industry colleagues, as we depend upon universities producing graduates with the basic skills we need; from there, we train them up. Our highest priorities are the ability to observe and record field data, and then to interpret it usefully.

Graduate geologists must be able to recognise minerals, rocks, structure and geomorphology accurately and record them in ways useful to us. Beyond that, they should be competent with the usual software packages, use imagery effectively, have a pragmatic understanding of the principles of geology, geophysics and geochemistry and know the basics about ore deposits.

But most valuable is a passion for being in the field, working on or looking for ore. They must be tough in the field, and enjoy it – and not be worried about less than balmy conditions - just appreciating the opportunity of being there. They must be able to get along with a range of people, often very different from themselves, and to cope with relatively high levels of responsibility early on.

Conditions v drawbacks

Some recent articles have expressed concerns over how the extractive industries can attract graduates if employment involves being in the field much of the time and/or posted abroad to difficult locations – my reply is that those who see these conditions as drawbacks are not the type of people we are after.

Although good university field training instils basic field skills, attracting the best to mining or exploration involves giving students an opportunity to see what our business is about – a very good way being to spend a summer working at a mine or exploration project. This is considerably more difficult and costly to organise than university field-trips, as it may involve work visas, often tedious to obtain, is expensive, and can be disruptive to small teams.

However, the payback can be high. Many mining/exploration geologists, myself included, were hooked on the industry through summer jobs. A rigorous dose of mine/exploration work will allow students to decide if such a life is for them and employers to assess if they think the students will make good future employees. The trick, especially in the current restricted financial environment, is to be highly selective about who is chosen.
Morrison shelters for Nepal?

Sir, The recent earthquake in Nepal has shown that many of the victims were killed and injured inside buildings by falling or collapsing masonry. During WW2, occupants were protected from building collapse during air raids by so-called ‘Morrison Shelters’, named for the then Minister for Home Security. These were prefabricated steel cage-like enclosures (picture). They were simple to make and erect (it was said that they could be put up by a pair of boy scouts!).

GRAHAM WEST

Executive Secretary - chartered, or ‘charterable’?

Sir, Dick Selley’s call (Geoscientist 25.4, p21) for applicants for the post of the Society’s new Executive Secretary to be a Chartered Geologist (CGeol), while most laudable is, I believe, neither the most pragmatic nor necessarily the most ideal criterion.

To restrict applications to just this small pool would exclude many capable and deserving candidates. Selley says the Chief Executives of sister societies on Science Council – chemistry, physics and biology – were Chartered members of their discipline. Some of these, when applying, were not Chartered (or even non-Chartered) members of the body they went on to serve. Indeed, one of disciplines cited has found its past three Chief Executives among non-members - only becoming members, and indeed Fellows of their society, after accepting the post. Some have benefited from having a Chief Exec from outwith their discipline. Indeed, one has had a scientist from a wholly different discipline (albeit scientific) whose 28-year tenure saw membership increase by over 14,000.

Selley notes that some science bodies’ Chief Execs are ‘even PhDs’, as if this were both relevant for an administrative post and a necessary badge of belonging. The Society is no longer even dominated politically, let alone numerically, by researchers. Science graduates carve out successful careers in many walks of life. The post requires a mix of skills and getting it right is not easy. Indeed some (if not all) of our allied professional bodies have seen some Chief Execs leave office in less than ideal circumstances (folk who were relevant professionals with PhDs!). Let us not hamper our Council at this time with restrictive conditions.

JONATHAN COWIE

UK stone

Sir, Articles in June’s Geoscientist and Geoscientist Online lead me to reflect on the sad state of the UK’s stone industry (as opposed to aggregate).

I am having a new house built, and there is a requirement that ‘the roof shall be of natural slate’. Clearly quite a few houses have roofs of fake (fibre-reinforced cement) ‘slate’. The rest is Spanish or even Chinese, all much cheaper than Welsh slate. Scottish slate was always scarce as a result of geology, and is no longer extracted at all so is only available second-hand. Why should slate from Spain – an EU state – be so cheap despite greater transport distances? I also sought some walling stone, but none of the quarries still working flagstone in Caithness now produces it. The new house is near Dingwall, where no-one now quarries the distinctive, red, lower Devonian sandstone. I have managed to find some usable Moine psammite, which a local quarry saves from the crusher. It comes in handy brick-sized pieces as a result of close jointing and they have realised that there is a small market.

Why has UK-produced building and ornamental stone become so unavailable and unaffordable?

JOHN HEATHCOTE

Professional geologist needed

Sir, That the Executive Secretary should be a professional geologist is indisputable. However, the majority of professional geologists do not have chartered status: out of a membership of 11,606 a mere 21% (2495) are chartered. Therefore, I do not believe it should be essential for the Executive Secretary to have chartered status.

JOHN MURRAY

Morrison Shelter

Word count: 1768
The Desert - Lands of Lost Borders

This handsome book is informative, well-illustrated, broad-ranging, and clever. The author, a geologist and professional writer who in 2009 wrote the well-received ‘Sand: A Journey through Science and the Imagination’, has managed to weave together a whole array of different strands that serve to make deserts what they are.

Using some of his own field experiences, coupled with a wide reading of the literature, he has succeeded in covering the science of deserts (including climate, geomorphology, and wildlife), while at the same time discussing the human inhabitants, art and literature, and some of the arresting characters who risked their lives in discovering and traversing the world’s drylands.

It aims, as the author explains, to ‘provide an evocation, a celebration, a consideration of our response to the desert, the idea of the desert’, for ‘deserts are landscapes of the mind as much as physical realities, places of metaphor and myth.’ Using examples from central Australia, the Namib, the Gobi, the Sahara, the Mojave and the Atacama, he examines such landscapes in the context of their place in history, as birthplaces of civilisations, evolutionary adaptations, art, ideology and philosophy. To be sure, it does not cover everything relating to this vast topic, but it provides a superb introduction to what makes deserts so fascinating and alluring.

To give an example of how different material is cleverly combined, consider his treatment of flash floods. The climatic and geomorphological conditions that produce them are described, and there are some graphic descriptions from the literature; but there is also a description of an explorer who was killed by a flash flood in the Algerian Sahara, Isabelle Eberhardt. We learn that she probably had syphilis, was illegitimate, was a habitual user of drugs, was highly promiscuous, and cut her hair like a man.

Equally, some pervasive surface features - stone pavements - are explained scientifically, but are also placed in the context of the disturbance of desert surfaces in the Libyan Deserts by the narrow tyres of Model T Fords used by great desert explorers like Ralph Alger Bagnold. Similarly, dust storms are introduced by a consideration of the life and writings of Mildred Cable and her colleagues in the Gobi, but this is followed seamlessly by a discussion of how the global importance of dust storms has been revealed by the latest satellite-borne sensors.

Lovers of deserts will love this book and will also learn much from it.

Reviewed by Andrew Goudie

Stratigraphic landscape analysis, thermochronology and the episodic development of elevated, passive continental margins

Extensive low-relief plateau surfaces at high elevation, termed ‘peneplains’ in this bulletin, have been a challenge to geologists seeking to explain the long-term evolution of rift-margin landscapes. Attempts to understand these plateaux have long been focused on topography, leading to controversy and the episodic development of passive margins during continental fragmentation.

This extremely well illustrated book provides a ‘state-of-the-art’ review of these landscapes with specific focus on new research, particularly with respect to the on-shore/off-shore sedimentary records which has led to a re-evaluation of such landscapes within a new scientific approach termed ‘stratigraphic landscape analysis (SLA)’ (Chapter three).

It provides a concise, thoughtful review of the topic, beginning with the detailed research on Scandinavian and Greenland landscapes (previously carried out by the authors) before expanding discussion to include other continental passive margins in the southern hemisphere. The early part of the book presents a comprehensive introduction of key points regarding passive margins with useful definition and discussion of terminology, long a source of geological debate, and the formation of different types of surface allowing reconstructions of a relative chronology of landscape evolution. Chapter four introduces low-temperature thermochronology, particularly apatite fission-track methods, to provide a thermal history, thereby allowing better appreciation of the timing of uplift events and the calculation of the amount of bedrock erosion by denudation.

This is exemplified in Chapter five by a detailed investigation of West Greenland, demonstrating the utility of combining stratigraphic landscape analysis with thermochronology to establish multiple uplift and subsidence events following rifting of the continental margin. This is expanded in the subsequent chapter by assessment of the geological evidence from other passive margins, again emphasising that present-day topography may reflect a series of a sequence of episodic post-rifting tectonic and denudational events.

This allows the final chapters (seven and eight) of the book to evaluate critically a number of presently accepted hypotheses for the formation of such passive margin landscapes leading to revised interpretations that reflect the complicated sequence of post-break-up uplift and subsidence events revealed by detailed stratigraphic landscape analysis.

Reviewed by Wishart Mitchell

Geophysics for the Mineral Exploration Geoscientist

Realistic estimates of the size and productivity of any oil or gas asset are essential for reservoir management decisions and minimising economic risk. An important estimation process in such
geologic, geochemical, and petrophysical controls of fluid flow. The needed data acquisition begins with field discovery through to the last phases of production and abandonment, but always direct knowledge of a reservoir is limited to a few drill-holes. In general, the large-scale features are most critical for the prediction of reservoir flow performance, and small-scale geological details summarised in effective properties at a larger scale. However all numerical models would be found in error if the inter-well volume were excavated and exhaustive measurements taken; there is always uncertainty.

The estimates of data distributions, if honed by statistical insights, can be more convincing. Geostatistics uses the geological origins of the data and how they vary in space and/or time. Using these statistically generated interpretations, alternative numerical models, (realisations), can be generated. The response of these realisations to, for example, time to water breakthrough, can be combined in a histogram as a model of uncertainty - geostatistical modelling.

This book describes how geostatistical reservoir modelling can contribute to making informed decisions by building and using numerical geological models of petroleum reservoirs which include geostatistical considerations. Beautifully prepared and illustrated, it details the practice, tools and techniques, and focuses on concepts and some important algorithms and examples from real reservoirs to illustrate those techniques. It uses work flow-charts to summarise operations.

Actual programmes are not given, but there is a list of sources where they can be found. Emerging developments are identified and briefly described. A glossary of relevant geostatistical terms and notation is provided as is an excellent bibliography, which provides a valuable resource for deeper detail, theory or software. The bibliography shows that the authors are pioneers in the subject and have contributed significantly. Finally there is an index.

This book would be a beneficial read for the practitioner wanting to understand the geostatistical tools and their usage in modern commercial programmes. It would be a good advanced undergraduate or graduate class text on modern reservoir characterisation and statistical modelling.

Reviewed by John Milsom

Geostatistical Reservoir Modelling

Realistic estimates of the size and productivity of any oil or gas asset are essential for reservoir management decisions and minimising economic risk. An important estimation process in such forecasting or comparison of different hydrocarbon recovery schemes and their economics is reservoir numerical modelling.

Reservoir models use the physically significant features that characterise the geologic, geochemical, and petrophysical controls of fluid flow. The needed data acquisition begins with field discovery through to the last phases of production and abandonment, but always direct knowledge of a reservoir is limited to a few drill-holes. In general, the large-scale features are most critical for the prediction of reservoir flow performance, and small-scale geological details summarised in effective properties at a larger scale. However all numerical models would be found in error if the inter-well volume were excavated and exhaustive measurements taken; there is always uncertainty.

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Reviewed by Richard Dawe

Geophysics for the Mineral Exploration Geoscientist

Reviewed by Michael Dentith & Stephen T Mudge

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GEOSTATISTICAL RESERVOIR MODELING - 2ND EDITION

Reviewed by Richard Dawe

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◆ Philip Donoghue
Professor of Palaeobiology in the University of Bristol’s School of Earth Sciences, has been elected Fellow of the Royal Society. Described as ‘major force in the emerging field of molecular palaeontology’, his work ‘bridges palaeobiology, developmental biology and molecular evolution. He first demonstrated the utility of synchrotron imaging in palaeontology and has been a world leader in driving forward our understanding of the remarkable fossil embryos from the late pre-Cambrian and Cambrian, and their biological significance.’

◆ Mark O’Neill
(PhD Geotechnical Engineering) has joined Earth Science Partnership to complement the partnership’s skills and to drive business expansion, bringing additional civil engineering, geotechnical and major projects experience to their team. Mark’s main experience was gained with global multi-disciplinary consultants, where he set up new geotechnical teams and led South West offices for Scott Wilson (now URS/AECOM), Buro Happold and subsequently as leader on geotechnical matters with Parsons Brinckerhoff.

◆ Patricia Pantos
has joined the Society’s Publishing House as Production Editor on Journal of the Geological Society and a range of book titles. Patricia has a PhD in inorganic chemistry and has considerable experience in STM publishing having worked at both ecancermedicalscience and the Royal Society of Chemistry.

◆ Hannah Sime
left the Geological Society at the end of March, and we wish her all the best for the future. After more than four years as Production Editor on JGS and a number of Society book titles, Hannah is leaving to dedicate her time to the family business, Really Decent Books.

◆ Tony Watts
Professor of Marine Geology and Geophysics at the University of Oxford, will deliver the 2015 Harold Jeffreys Lecture, given ‘on the interior structure, formation and composition of the Earth and/or planets’. Previous Jeffreys lecturers have included this year’s Wollaston Medallist James Jackson, and Wollaston Medallist Kurt Lambeck.
Smith plaques – spot the errors!

Geologist and Science writer Nina Morgan* rights a few wrongs

On 22 March 2015 – the 246th anniversary of Smith’s birth – a plaque was unveiled at the site of his birthplace in the village of Churchill, near Chipping Norton in Oxfordshire. The following day, another plaque was dedicated to 15 Buckingham Street, London, the site of the house that served as his base between 1804-1819. These new additions bring the total number of Smith monuments and plaques in the UK up to eight – and it turns out, serve to set the record straight. Each of the earlier six monuments contains errors.

A signpost memorial erected in at Rugborne Farm High Littleton Somerset, where Smith lodged ‘for half a guinea a week, plus half a crown for his horse’ while surveying the local coal mines states that Smith lived there from 1792-1795. He actually took up residence in October, 1791.

The plaque at Tucking Mill, near Midford outside of Bath (picture), which was designed to mark the house Smith purchased in 1798, is placed on the nearby and charmingly-styled Tucking Mill Cottage, rather than on the ashlar-faced and more austere Tucking Mill House, one side of which Smith actually owned. (Debates continue as to which side that was!)

A Bronze plaque at 29 Pulteney Street, Bath, the former residence of the Reverend Joseph Townsend [1739-1816], states that William Smith first dictated his list of the strata around Bath to Townsend and the Reverend Benjamin Richardson on 11 December 1799. But the event actually took place six months earlier, on June 11, 1799. A plaque unveiled in 2009 on The Manor House, The Square, Stow on the Wold, Gloucestershire, marks the house where William Smith lived with his employer, the surveyor, Edward Webb, from 1787-1791. But it wrongly refers to Smith’s pioneering map as a map of Britain, rather a map of England and Wales.

The monolith of local stone erected in Churchill in 1831 by the 3rd Earl of Ducie (picture) wrongly refers to Smith as the Father of British (rather than English) Geology.

A blue plaque hung on a building at 1 Newborough, Bar Street Elevation in Scarborough, where Smith lived from 1835 until his death in 1839, is placed on the wrong building.

The details on the plaques may suffer from some inaccuracies – as indeed, may my own account of the errors. But one thing is certain. Right up to the end of his life Smith continued to believe that his work and discoveries were not fully appreciated. As late as June 1838, just 14 months before he died – Smith was drafting an Appeal for Support entitled “The case of the Founder of Geology.” So when it comes to the plaques and monuments, accurate or not, Smith would certainly have been delighted with the recognition!

Acknowledgement


MARTIN DAVID BRASIER 1947-2014

Martin Brasier, one of the UK’s leading palaeobiologists, who tragically died in a car accident on 16 December 2014, was highly regarded for his research into key junctures in Earth’s early life, from Archaean origins to the emergence of multi-celled animals during the Cambrian explosion. Martin was Emeritus Professor of Palaeobiology, Department of Earth Sciences, University of Oxford, from where he had retired at the end of the previous academic year.

Born 12 April 1947, he took a degree at Chelsea College London, and was awarded his PhD from University College London in 1973, studying the ecology and microhabitats of modern Caribbean benthic foraminifera. Following brief employment with BGS and a lectureship at Reading University, he moved to Hull, developing an interest in the taphonomy and diversity of lower Cambrian small shelly fossils.

In the early 1980s, with colleague John Neale, he established a Masters Course in micropalaeontology. This coincided with the publication of *Microfossils*, which appeared in a second edition (with Howard Armstrong) in 2004. His study of foraminiferal architecture and evolution was published in a special publication (1982) honouring the work of Tom Barnard, Martin’s PhD supervisor.

Martin moved to Oxford in 1988, was elected Fellow of St Edmund Hall, and helped establish a dedicated palaeobiology research laboratory. He pursued high-resolution contextual analysis of Ediacaran and Cambrian evolutionary radiations, and took a leading role in the International Geological Correlation Programme (IGCP), visiting Cambrian and Ediacaran stratotype sections.

During the next 15 years Martin helped revolutionise the study of the earliest biosphere, pioneering a new, critical approach to interpreting the micro-fabrics – an approach that yielded a high scientific return in publications, and which he frequently referred to as his most satisfying research project.

**Lyell Medal**

Martin’s ability for storytelling was put to great effect in his popular science books *Darwin’s Lost World* (2009) and *Secret Chambers* (2013). In early 2014 Martin’s contributions were formally recognised by the award of the Society’s Lyell Medal (picture, left). Later that year, on his retirement, a day of talks in the department was followed by a dinner at St Edmund Hall. The diversity of attendees indicated the wide influence he enjoyed, and the warmth with which he was regarded.

Martin has left us with a substantial legacy of over 200 published papers and books. He was also a skilled jazz pianist, and built some of his own keyboard instruments.

He is survived by Cecilia, his wife of more than 40 years, sons Matthew and Alexander, daughter Zoe and two grandchildren.

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**By Owen Green**

These obituaries have been edited from longer versions, available online.
## ENDORSED TRAINING/CPD

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<tr>
<th>COURSE</th>
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<tr>
<td>The Geoscience Education Academy</td>
<td>23-26 July</td>
<td>Free Training for UK teachers. Venue: Burlington House. Free including travel &amp; accommodation. For registration and details see <a href="http://www.geolsoc.org.uk/gea">www.geolsoc.org.uk/gea</a></td>
</tr>
<tr>
<td>Lapworth’s Logs</td>
<td>n/a</td>
<td>‘Lapworth’s Logs’ is a series of e-courses involving practical exercises of increasing complexity. Contact: <a href="mailto:info@lapworthslogs.com">info@lapworthslogs.com</a>. Lapworth’s Logs is produced by Michael de Freitas and Andrew Thompson.</td>
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## EVENTS

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<tr>
<td>Abberley &amp; Malvern Hills Geopark - GEOFEST</td>
<td>July, August</td>
<td>Wide range of activities in the Geopark continues through July and August. For programme W: <a href="http://bit.ly/1HL9F2L">http://bit.ly/1HL9F2L</a></td>
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<tr>
<td>Early Career Hydrogeologists’ Conference 2015, Hydrogeology Group</td>
<td>8-9 July</td>
<td>CPD Approved conference and field visit. Venue: Newcastle University. See website for registration &amp; details. Fees apply. Contact Chris Jackson E: <a href="mailto:crja@bgs.ac.uk">crja@bgs.ac.uk</a>.</td>
</tr>
<tr>
<td>Groundwater: Our Hidden Asset - Recent developments in hydrogeology Hydrogeology Group</td>
<td>8 July</td>
<td>Dick Downing memorial meeting. Venue: Burlington House. Fees apply – see website for details &amp; registration. Contact Paul Howlett E: <a href="mailto:paul.howlett@rhdhv.com">paul.howlett@rhdhv.com</a></td>
</tr>
<tr>
<td>Geophysics for Critical Infrastructure Engineering Group; Near Surface Geophysics Group</td>
<td>16 July</td>
<td>Venue: BGS, Keyworth. Conference for industry professionals. See website for details. Contact: EGGS E: <a href="mailto:engineering.group@geolsoc.org.uk">engineering.group@geolsoc.org.uk</a></td>
</tr>
<tr>
<td>Shetland Fieldtrip, Metamorphic Studies</td>
<td>17-23 July</td>
<td>Venue: Shetland Islands. Registration officially closed in April. Contact: Clare Warren E: <a href="mailto:clare.warren@open.ac.uk">clare.warren@open.ac.uk</a></td>
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Roy Favell King (b. 14 August 1925) became a geophysicist in the early 1950s. King took a first in Physics at Cambridge followed by a PhD on friction, with David Tabor. But he was ready for a change from laboratory physics and was glad to accept an invitation from Donald Griffiths, a geologist, to join him on an expedition to collect varved clays in northern Sweden.

After the expedition, King was awarded an ICI Fellowship at Birmingham to do experimental and fieldwork on varves with Griffiths. In 1955 he was appointed Lecturer in a new sub-department of geophysics to start one of the first two 12-month taught MSc courses in the UK to meet the growing demands of the oil, mining, and engineering industries.

The work on varves was continued with a succession of students and led to ways of correcting for the deviations of the magnetisation directions from the field directions. The partnership also developed new teaching and research interests in Wales which concentrated for several years on following up a regional gravity survey by D W Powell, one of Griffiths’ early students.

Mochras

Fieldwork – while camping or living in makeshift accommodation – was very much to King’s taste. For several years it concentrated on a large fault discovered by Powell bordering the Cambrian rocks along the coastline near Harlech. This seemed to indicate a hitherto unsuspected sequence of younger rocks beneath Cardigan Bay. King took charge of refraction seismic work to study the stratigraphy of this basin and was able to verify its existence and to estimate its thickness and likely origin.

This work, together with his course teaching in seismology, led to the second main thread of his research career. His later investigations included two landmark long-range profiles: the Kenya Rift

Pioneer of applied geomagnetism, whose research in Wales pointed to Mochras discoveries

geological problems.

King and Griffiths became lifelong partners in teaching and research. The two editions of their textbook *Applied Geophysics for Geologists and Engineers* were popular with practitioners and students. They became great friends and, when King married Sheila Griffiths (d. 1977), became brothers in law.

King claimed to dislike administration though he was adept at organising his own work and that of his collaborators. He retired in 1990 as Reader in Geophysics, a fitting recognition of his academic status and the way he chose to work.

Fluent

In addition to hill walking, often in the company of his extended family, he enjoyed music, literature, travelling, and political discussion. He became fluent in German. In his last years he also learned Italian so as to best enjoy his visits to his daughter and her family in Verona.

Despite an increasingly frail appearance he remained active until he was struck by a sudden acute, and eventually fatal infection shortly after his 89th birthday (d. 20 August 2014). His two children, John and Kirsten, and four grandchildren survive him.
The winner of the May Crossword puzzle prize draw was Gordon Scott of Kuala Lumpur, Malaysia.

All correct solutions will be placed in the draw, and the winner’s name printed in the Issue 2014 issue. The Editor's decision is final and no correspondence will be entered into. Closing date - 20 July.

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

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1 Anthracite 4 Able 9 Brontosaurus 10 MORB
12 Vindictively 15 Slingshot 17 Steel
18 Elgon 19 Badgering 20 Tangentially 24 Sass
25 Abominable 26 So So 28 Perthshire

DOWN:
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