GEOSCIENTIST

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The Fellowship Magazine of the Geological Society of London

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[FIELDWORK & NEW TECHNOLOGY ACCESS & ENGAGEMENT SPECIAL]

Predicting the subsurface

How computer models can integrate field and borehole data to create regional models of physical properties

ONLINE SPECIAL: WILLIAM SMITH
Two hundred years of geo-modelling celebrated at IAMG17, Freiberg

FIELDWORK & DISABILITY
Reduced mobility widens one geologist's horizons

SPANISH GEOLOGY DAYS
Fieldwork provides the spur to popular outreach

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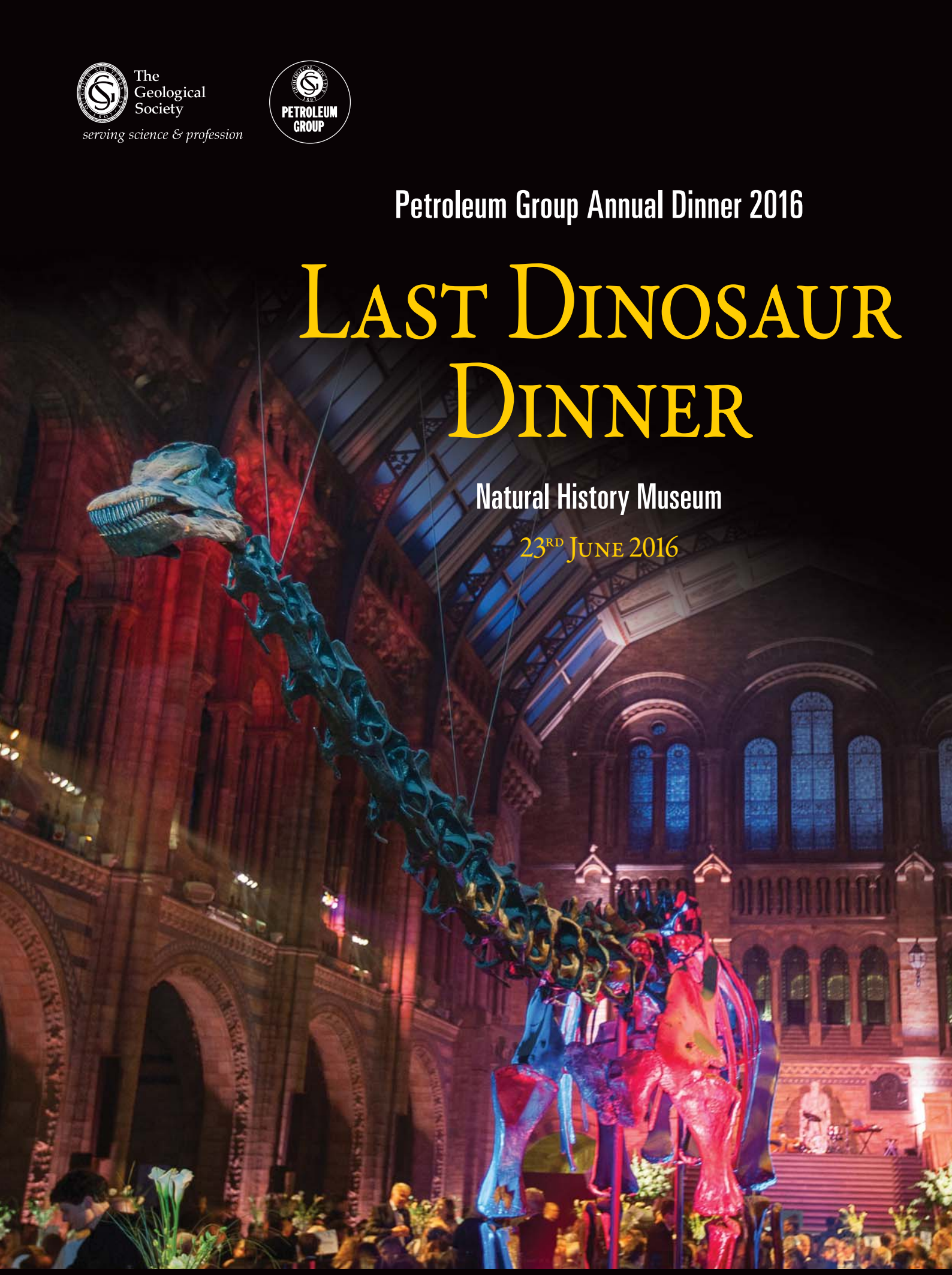
PETROLEUM GROUP

Petroleum Group Annual Dinner 2016

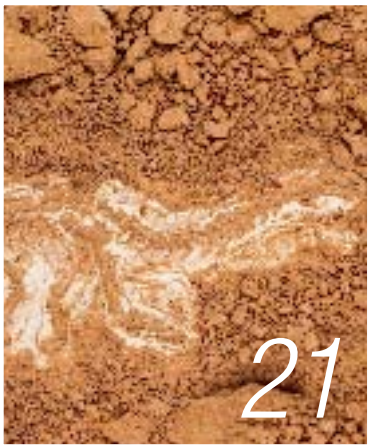
Last Dinosaur Dinner

Natural History Museum

23rd June 2016



For further information or to book a table for this event, please contact laura.griffiths@geolsoc.org.uk



IN THIS ISSUE...

ON THE COVER:

10 White Horse

The Westbury or Bratton White Horse, on the escarpment of Salisbury Plain, east of Westbury, England

ONLINE SPECIALS

William Smith, and 200 years of geo-modelling, **celebrated by the International Association for Mathematical Geology (IAMG)**

FEATURES

REGULARS

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LUNAR AND PLANETARY INSTITUTE

Martian Gullies and their Earth Analogues

20-21 June 2016

The Geological Society, Burlington House

This meeting follows on from the original workshop on martin gullies held in 2008 at LPI in Houston Texas. This happened 8 years after their first discovery and formed a focal point for researchers studying gullies through remote sensing, fieldwork studies of Earth analogues and laboratory simulation studies.

The aim of this second workshop would be not only to bring together the plethora of researchers involved in gully-research on Mars, but also to add a wider perspective by including contributions from those studying analogous environments on Earth. Such as, geomorphologists, sedimentologists glaciologists, hydrologists, climatologists, soil scientists and mineralogists/petrologists.

We would particularly encourage Earth Scientists working on sites or topics which could be considered as informative analogues for water on the Martian surface. These wider perspectives add both depth and context, allowing researchers not traditionally attached to gully-research to add their outside expertise to the ongoing debate.

Convenors:
Susan Conway (Open University)
Jonathan Carrivick (University of Leeds)
Paul Carling (University of Southampton)
Allan Treiman (LPI)

Further information:
For further information about the conference please contact:
Georgina Worrall, Conference Office, The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: 020 7434 9944
E: georgina.worrall@geolsoc.org.uk
Web: www.geolsoc.org.uk/martiangullies
Follow this event on Twitter: @geolsoc #martiangullies

2016 YEAR OF WATER

Event sponsors: BGA BSG EAGE EGU IAS

Images courtesy of: Background – Susan Conway. From left-right: NASA/JPL/UofA (x2), NASA/JPL/UofA/OpenUni, Dennis Reiss.

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Arthur Holmes Meeting 2016

The Wilson Cycle: Plate Tectonics and Structural Inheritance During Continental Deformation

23-25 May 2016

The Geological Society of London, Burlington House, London, UK

Confirmed Speakers include:
Kevin Burke (University of Houston, USA)
Celâl Şengör (Istanbul Technical University, Turkey)
Henry Halls (University of Toronto, Canada)
Philip England (University of Oxford, UK)
Shijie Zhong (University of Colorado, USA)
John Dewey (University of Oxford, UK)
Haakon Fossen (University of Bergen, Norway)
Andrea Tommasi (University of Montpellier, France)
Myra Keep (University of Western Australia)
Robert Hall (Royal Holloway University, UK)
Erik Lundin (Statoil, Norway)
Sergey Drachev (ExxonMobil, UK)
Damien Nance (Ohio University, USA)
Susanne Buiter (NGU, Norway)

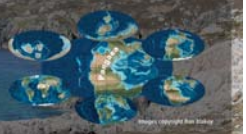
Further information:
For further information about the conference please contact:
Naomi Newbold, Conference Office, The Geological Society, Burlington House, Piccadilly, London W1J 0BG
T: 0207 434 9944
E: naomi.newbold@geolsoc.org.uk
W: www.geolsoc.org.uk/ahm16
Follow this event on Twitter: @geolsoc #ahmwilson16

This meeting will mark the fiftieth anniversary of Tuzo Wilson's landmark paper asking "Did the Atlantic close and then re-open?". This paper was one of a series of papers which led to the "Wilson Cycle" concept, in which the repeated opening and closing of ocean basins along old orogenic belts is a key process in the assembly and breakup of supercontinents. This implied that the processes of rifting and mountain building somehow pre-conditioned and weakened the lithosphere in these regions making them susceptible to strain localization during future deformation episodes.

It is now generally accepted that most geological architectures are controlled by interactions between plate motions, the horizontal mechanics of the lithosphere and pre-existing structures in the crust. However, our detailed understanding of the processes of structural inheritance is still very limited.

This 3-day meeting will therefore bring together geophysicists, structural geologists, and modellers in order to re-assess the legacy of the Wilson Cycle concept and how our understanding inheritance in continental tectonics has evolved over the past 50 years.

Thematic sessions include:
- The Wilson & Supercontinent cycles – how well do they work on a global scale?
- Lithosphere scale & deep earth dynamics
- Reactivation and reworking during the rifting, break-up and orogenesis
- Long-term weakening processes during continental deformation
- Regional themes & case studies



Field Trip
There will also be a four-day, post-conference field excursion to the *Scottish NW Highlands* to observe and discuss basement inheritance and reactivation processes in the field. This will take place from *Thursday 26 to Sunday 29 May 2016.*
Participants who would like to attend are encouraged to contact the conference organizers to register their interest, as places are likely to be limited.

Convenors
Woody Wilson (BP Exploration, UK)
Ken McCaffrey (Durham University, UK)
Tony Doré (Statoil [UK] Ltd, UK)
Greg Houseman (University of Leeds, UK)
Leigh (Wiki) Royden (Massachusetts Institute of Technology, USA)

Registration rates:

Fellow: £150	Speaker: £150
Non-Fellow: £200	Student: £85
Associated Society member*: £150	Retired: £100
Corporate Affiliates: £150	*AAPG, AIPG, GSA, NGWA and SEPM

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> WORK MUST BE DONE BY PEOPLE, PEOPLE HAVE TO LIVE, AND IT IS NOT BY (OR FOR) BREAD ALONE THAT WE DO IT

FROM THE EDITOR'S DESK:

Field versus mouse

This magazine is no stranger to arguments about fieldwork. Little seems to push our readers' buttons more effectively than a perceived threat to the primacy of looking at rocks, in the field – 'the geologist's laboratory'. Anyone daring to suggest that (perhaps) fieldwork might have had its day, or is no longer attractive, soon feels the walking-boot being put in good and proper in correspondence and, once down, the final killing blow to the head from H H Read's famous dictum about the best geologist being the one who has seen the most rocks.

This may all be good knockabout stuff, but these arguments usually end up artificially pitting virtuous fieldwork against evil virtual reality, as though the world ever presented us with such an either/or. But in doing so we succumb to bad reasoning – the false polarisation of complex issues towards non-alternatives. This issue of *Geoscientist*, I believe, perfectly illustrates how impoverishing such posturing is.

Nobody is seriously suggesting that fieldwork is totally passé. Nobody really believes we can replace the real with the virtual. The truth is that new technology offers new ways to interpret real data (Feature). It expands, rather than restricts, the ways we as individuals, and as groups, can experience the natural world (Soapbox). We need both. Enthusiasm for one does not mean denying the other. Using virtual technology, the better to assimilate real data, is not equivalent to walking blindly through life with your nose in an iPhone. (At least, not unless you let it.)

Fieldwork, and a love of the outdoors, initially attracted many of us to geology. But even in this increasingly indoor age, the call of the wild persists for millions of people (Second Feature), helping to draw large numbers onto geological excursions, and so afford them the opportunity to learn about landscape while at the same time enjoying simply being out in it. And that is our chance to demonstrate how much more pleasure is to be had by looking with an understanding eye.

Finally, yes – sometimes we may in our enthusiasm over-state our claims for fieldwork, simply because we like doing it and will resist any attempt to diminish our quality of life by allowing Mr Gradgrind to think that maybe the bottom line could do just as well without it (Letters). But so what? In the end, work must be done by people, people have to live, and it is not by (or for) bread alone that we do it.

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

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.

2016 meetings: 11 May, at The Athenaeum Club.

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

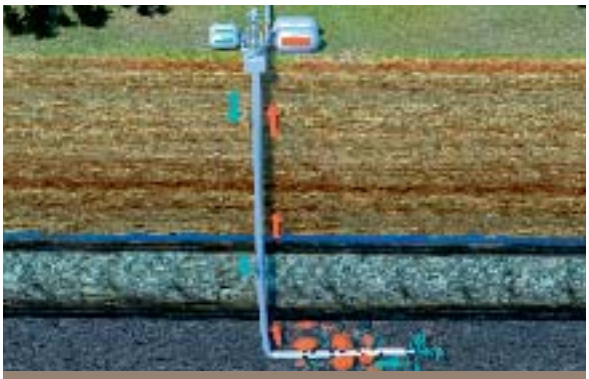
President's Awards, 2016

The President's Awards for 2016 are made to Huw Clarke, Cuadrilla Resources, for his contribution to the interpretation of seismicity associated with shale gas exploration; and Ann Rowan, University of Sheffield, for her contribution to geomorphology in glaciated terranes. Congratulations to both. They will be presented with their awards on President's Day (below).

Notification of Officers for 2016/2017

At the AGM Fellows will be asked to elect the following members of Council as Officers for 2016/17:

President: Mr Malcolm Brown. Vice-Presidents: Mr Chris Eccles, Mr Keith Seymour. Secretaries: Miss Liv Carroll, Dr Marie Edmonds, Dr Colin North. Secretary, Foreign & External Affairs: Mr Michael Young; Treasurer: Mr Graham Goffey.



LONDON LECTURE SERIES

What coal mining hydrogeology tells us about the real risks of fracking

Speaker: Prof. Paul Younger (University of Glasgow)
Date: 18th May

Programme

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

Further Information

Please visit **www.geolsoc.org.uk/gsllondonlectures16**. Entry to each lecture is by ticket only. To obtain a ticket please contact the Society around four weeks before the talk. Due to the popularity of this lecture series, tickets are allocated in a monthly ballot and cannot be guaranteed.

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

Election results

A total of 1718 valid votes were cast for the seven vacancies on Council. The election was conducted by Electoral Reform Services and where the voting was close the numbers were confirmed by a recount (*). The results are as follows:

Name	Valid Votes	Name	Valid Votes
Sarah Gordon	869 (50.5%)	Stuart Jones	570 (33.2%)
Jason Canning	720 (41.9%)	Chiara Petrone	514 (29.9%)
Alexander Whittaker	666 (38.8%)	Simon Neale	480 (27.9%)
Sheila Peacock	637 (37.0%)	Richard Collier	464 (27.0%)
Naomi Jordan	633 (36.8%)	Daniel Le Heron	462 (26.9%)
Robert Larter	607 (35.3%)	Toby Strauss	421 (24.5%)
Nicholas Reynolds	596 (34.7%)*	Jack Matthews	335 (19.5%)
Teresa Ceraldi	595 (34.6%)*	Toby Hopkins	326 (19.0%)
John Talbot	593 (34.5%)*		

The seven candidates receiving the most votes will go forward to the Annual General Meeting on 8 June 2016 for election as Council members.

Come and meet the award winners at the Society's gala day

President's Day

President's Day at Burlington House on 8 June will begin with the Annual General Meeting (11.00) followed by a buffet lunch with the award winners (members with ticket only – £27.50/head). As in previous years, the recipients of the major medals have been invited to give short talks; thus the Awards Ceremony will be followed by presentations from Lyell, Murchison, William Smith and Wollaston medallists (details below). The timetable for President's Day and the agenda for the AGM are also below.

To obtain luncheon tickets please send cheques (made payable to The Geological Society) to Stephanie Jones at Burlington House, or email **stephanie.jones@geolsoc.org.uk**. Please also contact Stephanie if you wish to attend the afternoon events, for which there is no charge.

Timetable

Time	Event
11.00	Annual General Meeting (members only)
12.30	Lunch with the Award winners (members with tickets only)
1400	Awards Ceremony
1515	Talks by Lyell, Murchison and William Smith medallists
16.30	Tea
17.00	Talk by Wollaston Medallist
17.30	President's closing remarks
17.40 – 19.30	Drinks reception

AGM Agenda

- Apologies
- Minutes of the Annual General Meeting held on 3 June 2015
- Appointment of Scrutineers for the ballots for Council and Officers
- Ballot for Council
- Annual Report and Accounts for 2015
- President's Report
- Secretaries' Reports
- Treasurer's Report
- Comments from Fellows
- Formal acceptance of the Annual Report and Accounts for 2015 and approval of the Budget for 2016
- Annual Fellowship subscriptions for 2017
- Deaths
- Report of Scrutineers on the ballot for Council
- Ballot for Officers
- Appointment of Auditors
- Report of Scrutineers on the ballot for Officers
- Election of new Fellows
- Any other business
- Provisional date of next Annual General Meeting
- Meeting closes

TALKS BY SENIOR MEDALLISTS

Wollaston Medal:

Susan Brantley – Distinguished Professor of Geosciences, Pennsylvania State University: *Exploring the critical zone: Where rocks meet life*

Lyell Medal:

John Underhill – Chair of Exploration Geoscience, Institute of Petroleum Engineering, Heriot-Watt University: *The need for and increasing role of forensic geosciences and visualisation in accurately characterising the subsurface*

Murchison Medal:

Jon Blundy – Professorial Research Fellow in Petrology, University of Bristol): *The mute testimony of volcanic crystals and what we can learn about the build up to eruptions*

William Smith Medal:

Michael de Freitas – Distinguished Research Fellow, Faculty of Engineering, Department of Civil and Environmental Engineering, Imperial College: *Homage to William Smith: aspects of recent research*

SOCIETY*NEWS...*

Annual Fellowship subscriptions

Council agreed in April 2015 that Fellowship fee increases would be linked to the rate of Consumer Price Inflation (CPI) as measured in February of each year. The increase for 2016 was 0%, based upon a zero CPI rate rise as at February 2015. The CPI figure for February 2016 was 0.3%. The Finance & Planning committee recommended to Council **not** to increase Fellowship fees for 2017 on the basis that the total increase in the Society's fee income by applying this formula was minimal, that even a small rise would be unwelcome to those Fellows affected by the economic downturn in the extractive industries; and that in future years it may be necessary to increase fees above the rate provided by this formula. At its meeting on 6 April Council agreed to recommend to the Fellowship for approval at the Annual General Meeting the subscription rates for 2017 shown below.

Category	2016 (£)	2017 (£)
Junior Candidate Fellow	10.00	10.00
Candidate Fellow	15.00	15.00
Candidate Fellow full course fee	0.00	0.00
27 and under	70.00	70.00
28-33	130.00	130.00
34-59	198.00	198.00
34-59 (Overseas)	152.00	152.00
60-69	99.00	99.00
60-64	130.00	130.00
65-69	99.00	99.00
70+	68.00	68.00
Honorary Fellow	0.00	0.00
Life Fellow	0.00	0.00
Senior Fellow	0.00	0.00
Concessions	70.00	70.00
Concessions (ERET)	0.00	0.00
Special Free Rate	0.00	0.00
Joint Fellow Non-Payer	0.00	0.00
Full time postgraduate MSc	28.00	28.00
Full time postgraduate PhD	41.00	41.00
BP-funded postgraduate	41.00	41.00
Unemployed	0.00	0.00
Supplement (to payer) for Joint Fellowship	58.00	58.00
CGeol supplement payers	48.00	48.00

FUTURE MEETINGS

Dates for meetings of Council and Ordinary General Meetings until April 2017 shall be as follows:

Ordinary General Meetings:

- **2016:** 22 June; 20 September; 24 November;
- **2017:** 1 February; 4 April

Meetings of Council:

- **2016:** 22 June; 20 & 21 September (residential); 24 November;
- **2017:** 1 February; 4 & 5 April (residential)

FROM THE LIBRARY

Library newsletter

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A month-by-month list of new books and serial special issues which have been added to the catalogue can be viewed on our website at **www.geolsoc.org.uk/library_collections**

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Fellows of the Society can access over 90 journals online using Athens authentication. There is no charge to Fellows for this service. Visit **http://www.geolsoc.org.uk/ejournals to register.**

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➤ The library is open to visitors Monday-Friday 0930-1730. For a list of new acquisitions click the appropriate link from **http://www.geolsoc.org.uk/info**

Need? Or enjoyment?

Is fieldwork actually essential to making good geologists? Or do we pretend it is because we enjoy it? **Martin Carruthers*** reflects on access for all

Though fieldwork was the most enjoyable aspect of my training, I have learned far more from mapping exercises, borehole data, lab work, microscopy, study, and spending time with geological collections. To be a good micropalaeontologist, for example, you need good academic and analytical skills, not boots and a hammer. Geophysicists and Reservoir Engineers need primarily to be physicists and engineers with strong IT skills. The vast majority of geology and Earth science graduates go on to pursue non-geological careers – probably not requiring fieldwork. Those who do go on to field-based careers have a lifetime to hone their craft on-the-job.

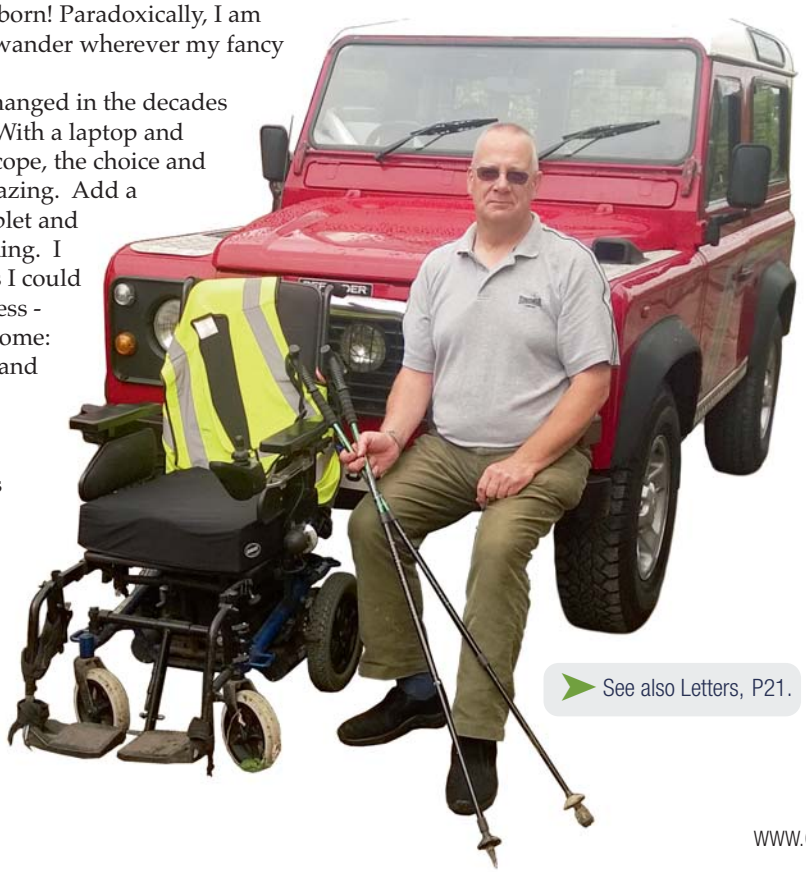
Inclusivity

This becomes particularly poignant when considering access and inclusivity for all abilities. Yes, I enjoyed fieldwork, but did I actually need it? I have become disabled and am no longer able to work full-time. Though this has created personal challenges, far from restricting my access to geology – it has caused it to be re-born! Paradoxically, I am now at liberty to wander wherever my fancy takes me.

So much has changed in the decades since university. With a laptop and (optional) microscope, the choice and access is truly amazing. Add a smartphone or tablet and you're really cooking. I can research areas I could never hope to access - without leaving home: far more efficient and affordable than trudging through terrain in all weathers. Mars is fascinating, but I don't need to go there to study it.

We are blessed with world-class geological collections up and down the country, which I have no problem accessing; with staff happy to help, if I want a closer look or more details. Online collections are open 24/7. One wonders how undergraduates are able to turn their back on this vast resource, just to produce original pieces of fieldwork! Should we not be embracing technology, and using the likes of Google maps and BGS online geological maps for training and distance learning? A good scientist's mind-set surely constantly challenges the premise of the questions asked and remains open to explore all means and options.

I have recently (just in time!) bought an automatic Land Rover Defender. My current project is to see how much access that affords. The biggest help in this regard would be using the influence of The Geological Society to obtain, organise, and facilitate permissions for vehicle access to areas where I am unable to walk, but can drive. To enable those who still want to do fieldwork rather than need, we must be provider- and user-focused in equal measure to ensure best delivery.



See also Letters, P21.

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).

> "I CAN RESEARCH AREAS I COULD NEVER HOPE TO ACCESS WITHOUT LEAVING HOME. MARS IS FASCINATING, BUT I DON'T NEED TO GO THERE TO STUDY IT"
>
> **Martin Carruthers**

PREDICTING THE SUBSURFACE

Images: Alan Jeffery/Shutterstock.com

Mark Woods* and colleagues from British Geological Survey ask: How can we confidently predict the nature of the ground beneath us?

***Above:** Westbury White Horse. On the Chalk, Salisbury Plain*

Britain is blessed with a magnificent variety of landscapes, much of it the result of the diverse range of rock types that form our small island, and the different ways in which they respond to weathering and erosion. Nowhere is this clearer than when enjoying a walk along many of the paths that snake around our coastline; dramatic colour changes in the cliffs, steep climbs and descents between headlands and bays all reflect changes in the underlying geology.

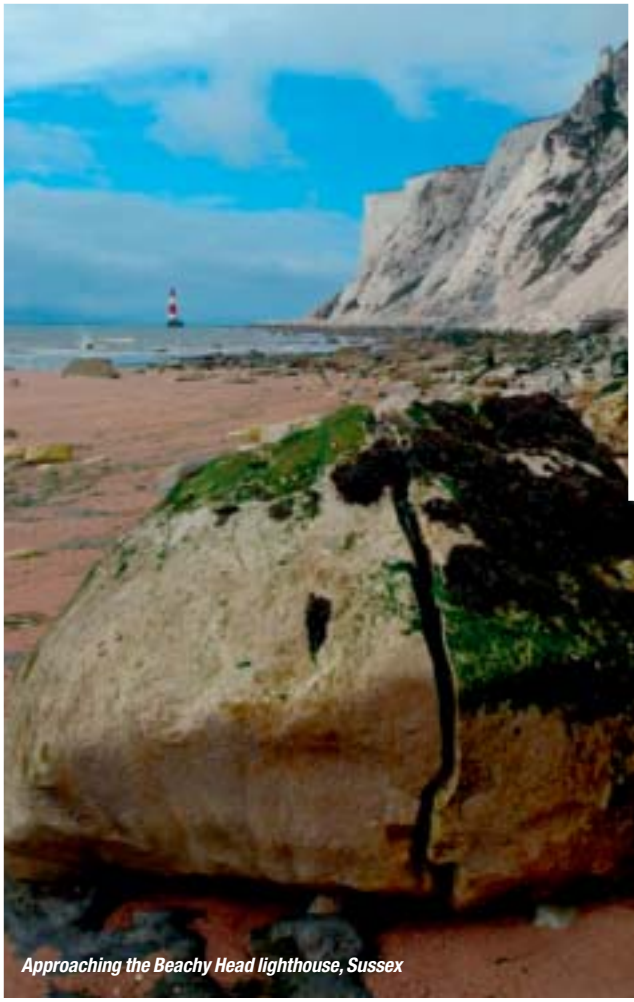
Sometimes the connection is obvious, such as the contrast between the low, sandy and muddy cliffs that tumble into the sea along the coast of Essex, and the rugged white cliffs on the south coast of England. These natural features, which we take for granted, have a significant impact on how we live and move about our island.

Our modern society requires a huge variety of infrastructure and resources, not just the things we see at the surface, but things we build in and extract from the underground. Much of the water we consume in our homes and factories comes from buried bedrock units – supplies that we must manage, predict and safeguard from contamination. Rapidly varying geology might be good for landscape diversity, but it can create real headaches for planning future growth and economic development.

Variability

Currently, we only have highly detailed understanding of how rocks' physical properties vary in relatively limited areas, where geological units are of particular commercial interest – for example, the hydrocarbons industry, which requires a holistic knowledge of how such properties relate to geological structure,

> BRITAIN IS BLESSED WITH A MAGNIFICENT VARIETY OF LANDSCAPES, MUCH OF IT THE RESULT OF THE DIVERSE ROCK TYPES THAT FORM OUR SMALL ISLAND



Approaching the Beachy Head lighthouse, Sussex

Traversing the hazardous shoreline beneath the 160 m high cliffs forming Beachy Head, Sussex

Dissolution cavities in Chalk developed along a fault plane

and burial history. More generally, what we need is a broad 3D model framework capable of containing disparate data types and showing how they inter-relate.

This approach would provide a comprehensive overview of observable data, display statistically-derived predictions for regions lacking data, and allow new models to be calculated as new observable data become available. This is the goal of current work at the British Geological Survey (BGS), focusing on the Chalk Group (hereafter 'Chalk') of southern England and East Anglia.

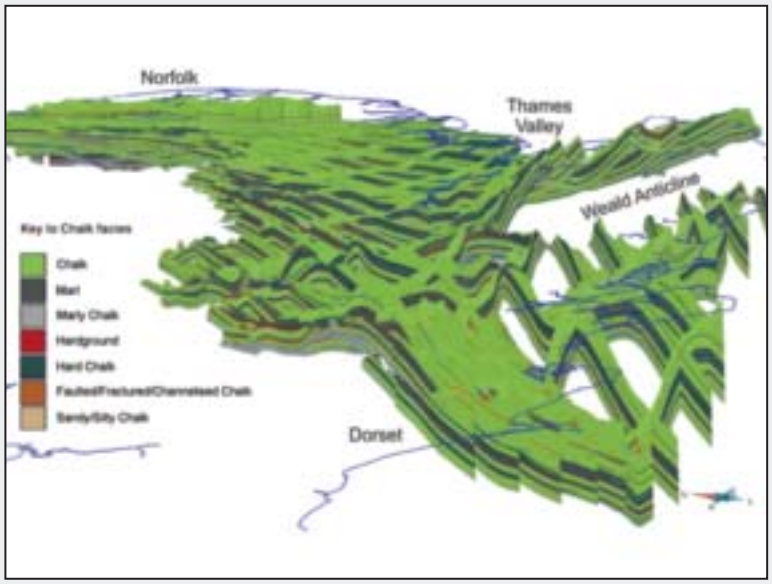
Conventionally, field geologists slowly accumulate knowledge about the extent of rock variation in the subsurface as they make geological maps and cross-sections; but the rock classifications used in these documents typically only provide an overview of physical properties for each unit. Related memoirs, sheet explanations and published papers may provide more detailed descriptions of variation within units, but it may be difficult to relate spatially all of this information to the geological map in order to arrive at a trend synopsis. Furthermore, the extent and resolution of the data are likely also to be highly variable.

Ideally, we want to be able to see beneath our urban and rural landscapes, and observe both the distribution and thickness of different geological units and the range of internal variation within each. We want to envisage how these properties vary across broad swathes of country, and understand the extent to which these features are affected, and/or controlled by, structural features, such as patterns of faulting.

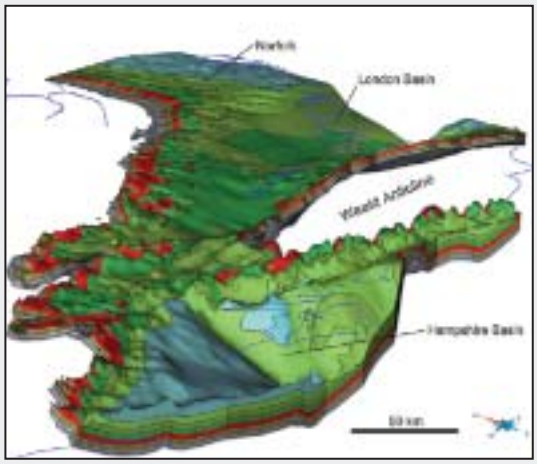
With this knowledge we could predict geographical trends, in things such as patterns of hardness and compositional changes – variation that is not so great as to cause a geological unit to be differently classified, but that is enough to affect its behaviour for particular applications (such as its engineering and hydrogeological use). Recently, BGS has begun to explore how we can characterise variation in physical properties. The Late Cretaceous Chalk, with its wealth of recent research, relatively simple subdivision, structure and range of physical properties, provides the ideal test-bed to develop this innovative approach to geological parameterisation.

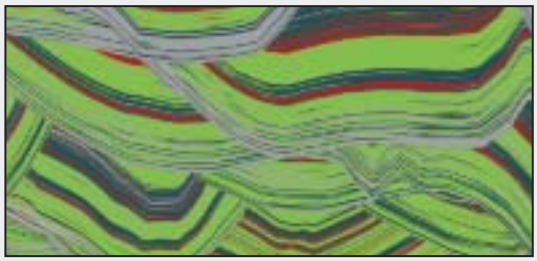
Chalk

The Chalk is one of the most widely occurring units across southern England, frequently worked during civil engineering projects, and one of the UK's most important units for water supply. A walk beneath the towering 160m-high, dazzling white, flint-banded Chalk cliffs of Beachy Head (Sussex) is not for the faint-hearted – with dangerous tides and ▶



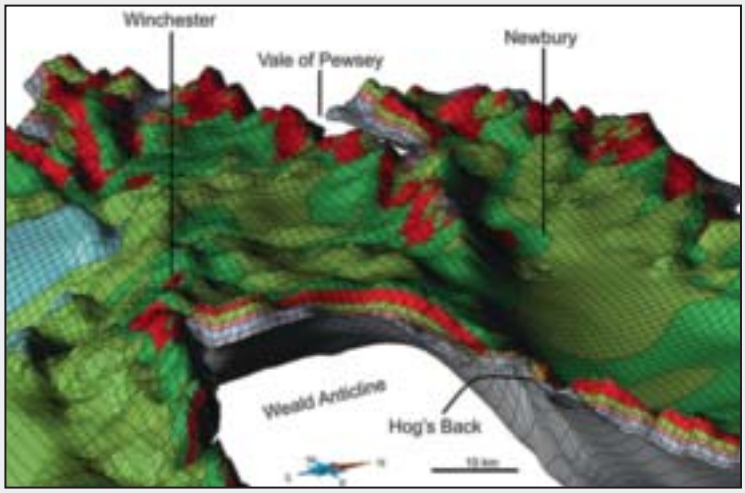
Left: Cross-sections through the Chalk facies model. Setting the vertical scale at 40 times the horizontal scale exaggerates the east-west trending buckles within the Chalk created by Alpine orogenesis. Folding diminishes toward the north onto the London Platform under Norfolk and the Thames valley



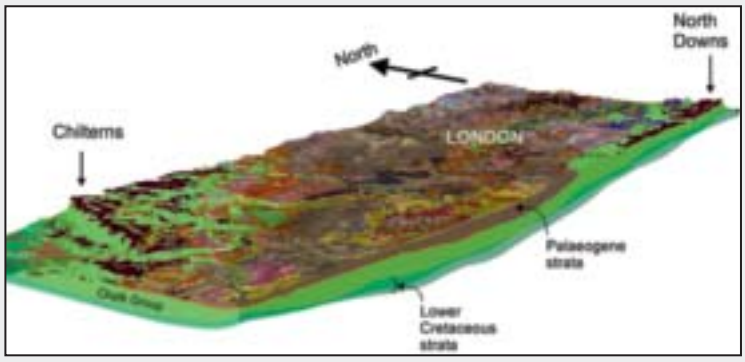


Above right: Three-dimensional Chalk model of southeast England with the coloured layers representing different Chalk formations

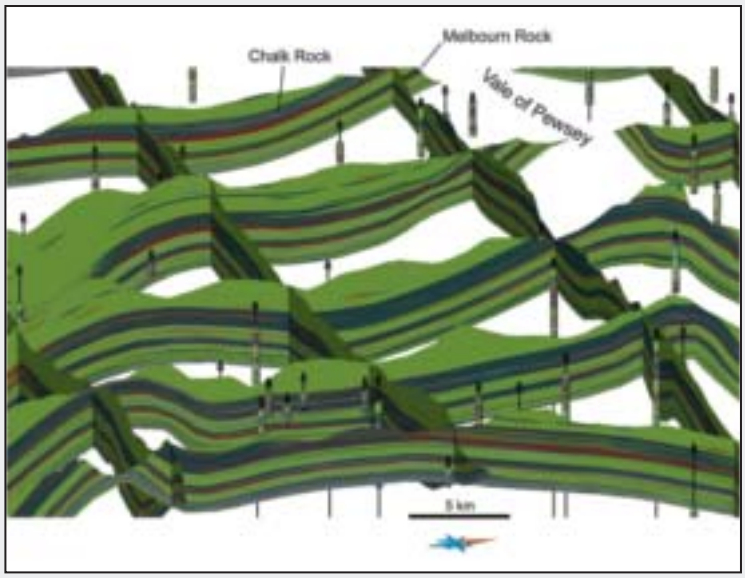
Lower right: A modeller's eye view of the Chalk and its physical properties. Here multiple cross sections extend into the distance



Cellular geological model showing Chalk formations to the west of the Weald Anticline. The area in the immediate foreground shows the Chalk arching around the edge of the broad dome formed by The Weald in south-east England



3D geological model of the London Basin showing geometry of main bedrock geological units (Burke et al., 2014)



Cross-sections through the interpolated facies model clearly showing the undulating traces of the Chalk Rock and Melbourn Rock (dark green and red colours) across the northern Wessex Basin. Vertical cylinders represent the location of boreholes which have been coded for chalk facies

frequent rock falls; but recent work along this coast shows that even a seemingly uniform rock like the Chalk is riven with variations in physical characteristics.

Some units are very soft and lack flints, while others are intensely hard and fractured. Some are even rich enough in clay to form a barrier to water migration through the rock. Variations in these properties have very significant implications for construction, water management and pollution control, as well as for evaluating the risk from ground-water flooding. Established stratigraphy [1, 2] which sub-divides the Chalk into formations, describes the general pattern of this variation but not the detail or regional differences that are potentially significant at the project-scale.

For example, the pattern of cementation in the Lewes Nodular Chalk Formation varies hugely across southern England, both in its degree and stratigraphical distribution. The typically marl and flint-rich Newhaven Chalk Formation is virtually devoid of these features in parts of East Anglia and Kent. If an apparently uniform rock like the Chalk can display such wide variation in physical characteristics, then it is clearly imperative to understand physical property variation across a broader spectrum of geological units that might be interpreted as 'strategically important' for national development and well-being.

Unique model

In recent years, the use of 3D geological models has become commonplace, like that recently developed for the London Basin[3]. In many of these, geological formations are the basic building blocks; but the range of physical property variation capable of being displayed is limited by the extent to which different sub-units have been

defined. In the case both of formations and their sub-divisions (i.e. members), the only physical property data that can be inferred are the generalised details that define them. So if these formations are basin-wide, it is not possible to perceive regional trends and variations easily.

Ideally, physical property models would show the total amount of variation within a geological unit. In the case of commercial enterprises for which this knowledge is essential, huge investment can achieve this high degree of understanding across limited areas. However, attempting to duplicate such data-richness is impractical for large, basin-scale models. We need to balance what is useful to model against the availability of data that allows it to be modelled. Arriving at this balance will define the list of features that can, realistically, be modelled.

To do this requires knowledge of the range of geological features that can potentially occur, and a broad understanding of how they are defined by the data (for example, the combination of geophysical responses that permit us to identify a given physical characteristic). We need to consider also the likelihood that criteria for indirect inference of such features might be ambiguous, and that this may affect our model's degree of certainty. The aim should be for our models to form a framework capable of holding and visualising more detailed data, as and when they eventually become available.

Chalk physics

The Chalk is a relatively simple geological unit in terms of its main physical components. Publications that review its geology, such as the Geological Conservation Review Series[4], show the range of potential physical properties that might be useful to record in a physical property model. These would include primary features, related to depositional history; for example: abundance/presence of flint, marl (clay-rich chalk), hard chalk, nodular chalk, hardgrounds (hard chalk formed at times of reduced rates of sedimentation). They also include secondary (post-depositional) features, such as fracturing.

Not all of these can be shown in our model – some require visual observation to confirm their presence, and including them in our model would bias their distribution to regions with outcrop, field survey, cored borehole or borehole image data. Other types of physical property might be capable of interpretation, but not in the wide range of forms observed when describing outcrops. For this group of terms a degree of rationalisation is needed, by combining several categories of feature into a single generalised characteristic (for example, combining references to 'hard chalk' and 'nodular chalk'). The end result is a table of physical property types that form the core of the physical property model.

Data sources

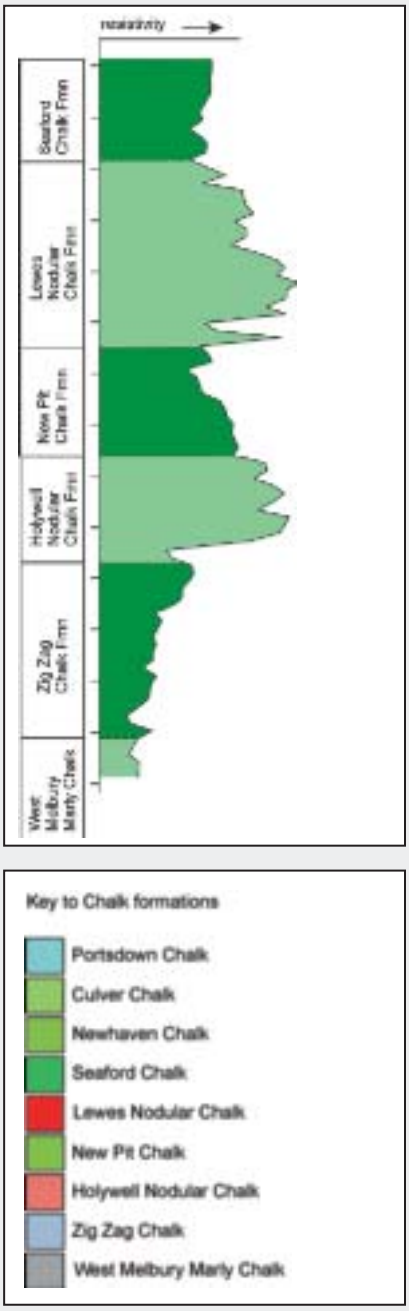
Building any type of geological model requires a lot of data, and ideally that data should be widespread and evenly distributed across the region of interest. The importance of the Chalk as an aquifer means that water supply boreholes are numerous across outcrop, many with geophysical logs. Confident interpretation of these, as well as deeper boreholes drilled for hydrocarbons and coal-investigation, is permitted by cored and optically scanned boreholes, in which features such as mud content and hardness can confidently be matched to associated inflections on geophysical logs[5].

There is also a lot of exposed Chalk, in coastal cliffs, large inland quarries, or in the numerous smaller inland 'pits' that lie scattered across Chalk downland, from which lime for agriculture and construction was historically extracted. Both boreholes and outcrop sections can function as data points for our model, each being defined by unique combinations of geographical co-ordinates and topographical elevations.

Where Chalk is particularly well exposed, for example in coastal sections and large quarries, we can deploy laser-scanning technology, allowing detailed features of exposed surfaces to be converted into 3D images (point clouds) that can be 'draped' with high-res digital photographs for direct interpretation of rock-properties, fracture patterns and structures.

Chalk and many other geological units display 'marker-beds' – units that are physically distinctive and widespread, having formed in a comparatively short time. These units are often useful in correlation, but they can also be used to define packages of strata, allowing us to make high-resolution analyses of physical property distributions between selected pairs of marker-beds. In this way, relationships between thickness trends and physical properties can be assessed, and may prove useful in predicting likely patterns of physical properties in areas where few data exist.

The modern geological classification of the Chalk [1,2,4] that has been mapped at outcrop[6] and recognised in borehole geophysical logs [1,5,7] provides a vast ▶



Above top: ***Example of a borehole geophysical log – used to interpret Chalk stratigraphy and variations in physical properties***
Above lower: ***Key to Chalk formations (opposite. For facies key, see online.)***

> BUILDING ANY GEOLOGICAL MODEL REQUIRES A LOT OF DATA, AND IDEALLY THOSE DATA SHOULD BE WIDESPREAD AND EVENLY DISTRIBUTED ACROSS THE REGION

improvement on the traditional three-fold classification. Modern digital map data for the Chalk compiled by recent BGS surveys provides detailed control for matching subsurface geology with surface topography. Areas across which obsolete Chalk subdivisions persist, or where there is particular structural complexity, are the focus of a programme of continuing field survey, to allow full integration of outcrop and modelled subsurface data.

Data-crunching

The first step in creating a physical property model is to build a framework that will hold all the data, show how it is related, and be capable of performing calculations and analyses of that data. Our model has been built in GOCAD-SKUATM software, and can be thought of as a large three-dimensional cellular meshwork that is coextensive with the Chalk outcrop and subcrop across southern England.

The mesh relates to geographical and topographical data within which outcrops and boreholes can be accurately located. It is also designed to obey a set of stratigraphical rules that closely reflects how bed geometries naturally respond to geological features (such as unconformities). The mesh is cut through by geological surfaces, representing different kinds of geological boundary - including formations, members and marker-beds. Cells between these surfaces are coded to represent the different physical properties.

This last aspect – assigning physical property information – is the most difficult, because 'real' data only exist for the boreholes and outcrop sections that form part of the model: in this case, 380 boreholes and 150 logged sections covering the Chalk as far north as The Wash (in northern East Anglia). Physical property logs were created in WELLCADTM software and exported as simple depth-attributed digital files, with different properties translated to numerical codes. Stratigraphical and physical property interpretations of adjacent data points can be compared by selecting alignments ('correlation lines') of boreholes within the model, allowing the relative positions of geological and physical property boundaries to be compared, and if necessary, adjusted.

An important function of our model is to predict physical properties in areas where raw data are lacking. Statistical techniques (kriging, variograms) are used to achieve this, based on assumptions about the likely lateral extents of the different physical property components.

For example, large spatial extents can be assigned to marls, because we know (from outcrop and borehole evidence) that these persist across tens and sometimes hundreds of kilometres. However, smaller extents have to be assumed for features such as hardgrounds, which tend to be localised in certain regions or at discrete geological structures.

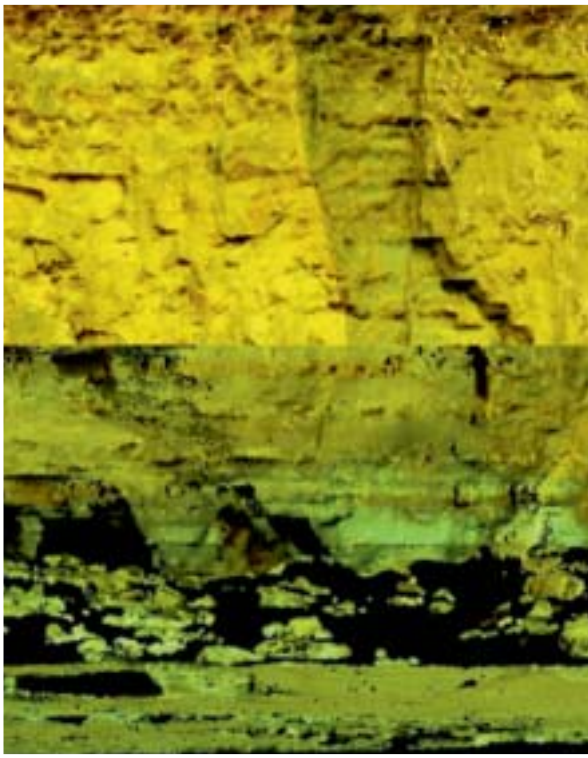
Kriging looks at the extent to which data points close to one another are also similar in character, while variograms describe the extent of this similarity. In essence, the variogram provides a template for determining how far real data can be projected into the model mesh, with the caveat that the extent of certain features might be limited by what is known about the general behaviour of these geological features.

Structures

Folding and faulting affect many UK Mesozoic formations extensively, but are generally less pronounced in the Chalk. Despite this, much published research suggests that structural features influence the character of local and regional Chalk successions [8, 9, 10]. Knowledge of these features has improved greatly with detailed formational mapping, partly because traditional stratigraphical subdivisions were simply too coarse to reveal them.

Faults are potentially an important

Unit of hard chalk (hardground) with burrow-systems picked out by dark-coloured mineralisation (glauconite)



Example of a laser-scan of coastal cliff section. Combining these scans with high-resolution digital photography provides a potentially rich source of data for physical property modelling.

source of physical property variation, in terms of both displacement and fracturing, as well as by influencing physical property patterns where movement took place during sedimentation, but perhaps without manifesting as discernible displacement. Consequently, structural analysis of the Chalk for physical property modelling has focused both on faults that are known to cut the Chalk as well as older Mesozoic structures that may have been rejuvenated by contemporaneous tectonism.

Folds and faults have been incorporated into the model from modern digital geological and tectonic map data, borehole stratigraphy records and published data. Cross-section analysis allows the likely geometry of these faults to be understood, and workflows within the model software allow fault planes to be converted into triangulated surfaces against which geological units can be cut and offset.

Synthesis

When completed, our physical property model should allow us to understand patterns of variation in a number of physical characteristics of the Chalk on a broad regional scale across southern England, and allow comparison of spatial trends in these properties against stratigraphy and structure. In future, it should be possible to define broad regional 'domains', distinguished by particular combinations of physical property and geology, that can guide engineers and hydrogeologists in their understanding of subsurface characteristics.

The model also has the capacity to act as a 'hypothesis generating engine', revealing linkages between diverse types of data or flagging up unusual patterns that can be used to guide field and laboratory research. Already, simple formational thickness plots, based on high-resolution stratigraphy data used to construct the model, are providing important information about patterns of Chalk deposition in relation to basin architecture.

As new data are acquired from outcrops and boreholes, refinement of the model will increase, revealing wider potential impacts on our understanding of the processes of Chalk deposition, and allow more detailed and reliable prediction of physical properties across more tightly defined geographical regions. ◆

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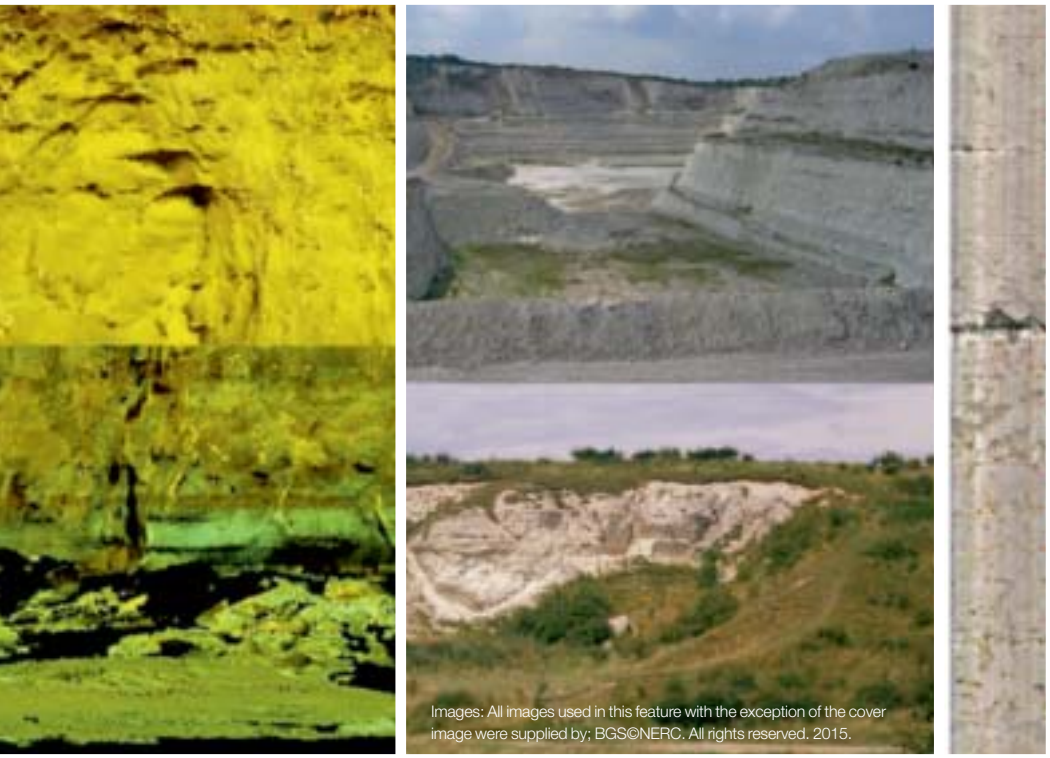

Modern and historical chalk quarries and cored boreholes provide detailed physical property data for inland exposures

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ACKNOWLEDGEMENT
Images of geological models have been generated in **GOCAD-SKUA™** software. This article is published with the permission of the Executive Director, British Geological Survey (NERC).

GEOLODÍA!

Ana Maria Alonso-Zarza[1] and friends[2-5]

describe Spain's hugely successful field-based outreach programme 'Geology day'

Science – perhaps especially geological science - is not as close to society as it should be, and so in recent times many different scientific organisations, universities and research institutes have been making a great effort to get lay-people interested through a variety of resources and activities.

In Spain one such initiative, *Geolodía* ('Geo-day'), is trying to bring geology closer to the general public through our most powerful tool - the observation of landscapes and rocks in the field. To this end we organise one free geological field trip in each of Spain's 52 provinces, as well as some extra ones within the various islands.

Voluntary

The latest, *Geolodía* 15, took place on 9 and 10 May 2015, with nearly 9000 people attending its 54 field excursions, guided by c. 500 volunteers. The incredible success we have seen in recent years has been the result of the continued involvement and voluntary work of many professionals, many from the very outset of this outstanding project.

Both the term '*Geolodía*' and subsequent activities originated in 2005 in Teruel province, when J L Simón and L Alcalá organised, for non-geologists, a Sunday field trip to the Geological Park of Aliaga (now part of El Maestrazgo Geopark, included in the Global Geopark Network of UNESCO).

Its aim was to make people familiar with the geology of the area and show its value. From 2005 to 2009, various provinces (Guadalajara, Alicante, Valencia, Huesca, Segovia and Zaragoza) joined the initiative, but all on different dates. In 2010 the Geological Society of Spain (SGE) took over coordination of *Geolodía*, and since then it has been celebrated on the same weekend (the second in May) all around the country.

These dates, considered the most convenient, are an attempt to hit on 'Goldilocks' weather conditions – which should be not too cold in mountain areas, and not too warm in the south - regardless of the basically unpredictable nature of the weather everywhere!

Conducting all the excursions during the same weekend lends greater media visibility to the activity, allowing geology to become a news focus. It also provides continuity from one year to the next, so that keen participants can be confident to book that weekend in their diaries every year.

Provinces

*Geolodía*10 (2010) was the first to be organised at national level, when 36 provinces of Spain joined the initiative and about 5400 people attended. *Geolodía*11 was celebrated in all Spanish provinces, and since then the number of participants and organisers has continuously increased. The map shows the number of participants in its latest manifestation (*Geolodía*15) in the various provinces and archipelagos.

Throughout, *Geolodía* has tried:

- to teach how to regard, the environment in which we live with 'geological eyes'; how to read the language of rocks and landscape as the pages of the book telling the long history of our planet;
- to explain the effects that some geological processes (earthquakes, volcanoes, floods,…) have on the surface of our planet and thus on our lives, and how to minimise associated risks;
- to show how various natural geological resources are obtained, their uses and their sustainable management;
- to exhibit our rich and varied geological heritage in order to spread knowledge of it and protect it;
- to illustrate the work of geologists while revealing how they contribute to the well-being of society, and to encourage young people to become geologists.

Geolodía is coordinated by the Geological Society of Spain (SGE) with the collaboration of the Spanish Association of Earth Science Education (AEPECT), and is mostly funded by the Spanish Foundation for Science and Technology (FECYT), the Spanish Geological Survey (IGME) together with a pool of universities, research institutes, local administrations and industries. ▶

Above top: *Geolodía15. Ávila. Gredos National Park*
Above lower: *Geolodía15. Bizcaia*

Left: *Geolodía15. Asturias. In the Dinosaur Coast*

> GEOLODÍA IS TRYING TO BRING GEOLOGY CLOSER TO THE GENERAL PUBLIC THROUGH OUR MOST POWERFUL TOOL – THE OBSERVATION OF LANDSCAPES AND ROCKS IN THE FIELD

Above: *Geolodía15. A Coruña more cloudy weather in the Galicia*
Right: *Geolodía15. Castellón*

Budget

The overall budget and cost of *Geolodía*15 was €48,400. The Geological Society of Spain applied to FECYT under the project title *Geolodía*15: *Geology for the general public*, and was given €24,000. IGME contributed €5,000. The rest came from a variety of organisations. About half of the budget (€25,400) was spent in travelling costs, such as buses, or to cover the preparation costs and travelling of field-trip leaders. The other half (€23,000) was used in producting guides, posters and security vests.

This sum did not really cover the total cost, since salaries were not included at all, and many small costs were covered directly by local organisations and are not therefore included in the general budget. The support from FECYT and IGME are critical in organising *Geolodía*, as it forms the basic funding resource available to the SGE (Geological Society of Spain). In future the aim is to obtain some financial support from private companies, but so far we have had no success.

The overall coordination and program of *Geolodía* is carried out by a relatively small group of people led by the President of the Geological Society of Spain and a representative of the Spanish Geological Survey. This group receives proposals from local organisers in each province, and searches for potential organisers in provinces lacking proposals. Usually by January the entire programme is arranged. Once the leaders in each province are appointed, the task is to organise every field trip and to prepare material.

The selection of the area to be explored by the different field trips is left up to the local organisations, based mainly on both quality of outcrop and beauty of landscape, but also on accessibility and security. Once the leaders and localities are chosen, local organisers prepare a poster to announce the activity through the web, media and social networks.

Numbers

Field trips are carried out in different ways according to numbers. Easiest for organisers is a trip by bus, with just a few leaders explaining all the various stops. This does not however work well where a large attendance is expected. For bigger events (>100 participants), the most suitable method is to find an easy walking path along which a number of leaders can station themselves at the different stops, and explain them as the public passes by during the day. This requires a large number of leaders and the participation of many students to help with logistics and explanations.

Alicante and Segovia provinces have pioneered this type of large-scale trip, supporting in some cases more than 2000 participants each. In addition to the organisation itself, the local committee elaborates a simple but well-illustrated field guide written in an easy non-technical style. All of these guides are made available on the SGE website at www.sociedadgeologica.es/divulgacion_geolodia.html, so we are gradually accumulating a huge amount of material that can be used for teaching, tourism or to promote rural development. Once the yearly activity is over it is recorded in a photographic summary containing one image from each field trip. You can see a selection of these in this article.

Geolodía is becoming very popular in Spain, especially with people fond of nature. In future we aim to focus on two things. The first is to improve and make more uniform the style of the field trips, and to explain the main, basic geological concepts in a simple way, using high quality sketches. Our experience confirms people´s enjoyment of beautiful landscapes; but the look on their faces, when they understand and feel, for example, what a geological fault really is, is incredible.

We hope also to widen this initiative into neighboring countries. At present, Andorra has joined the initiative and we hope more countries will follow. ◆

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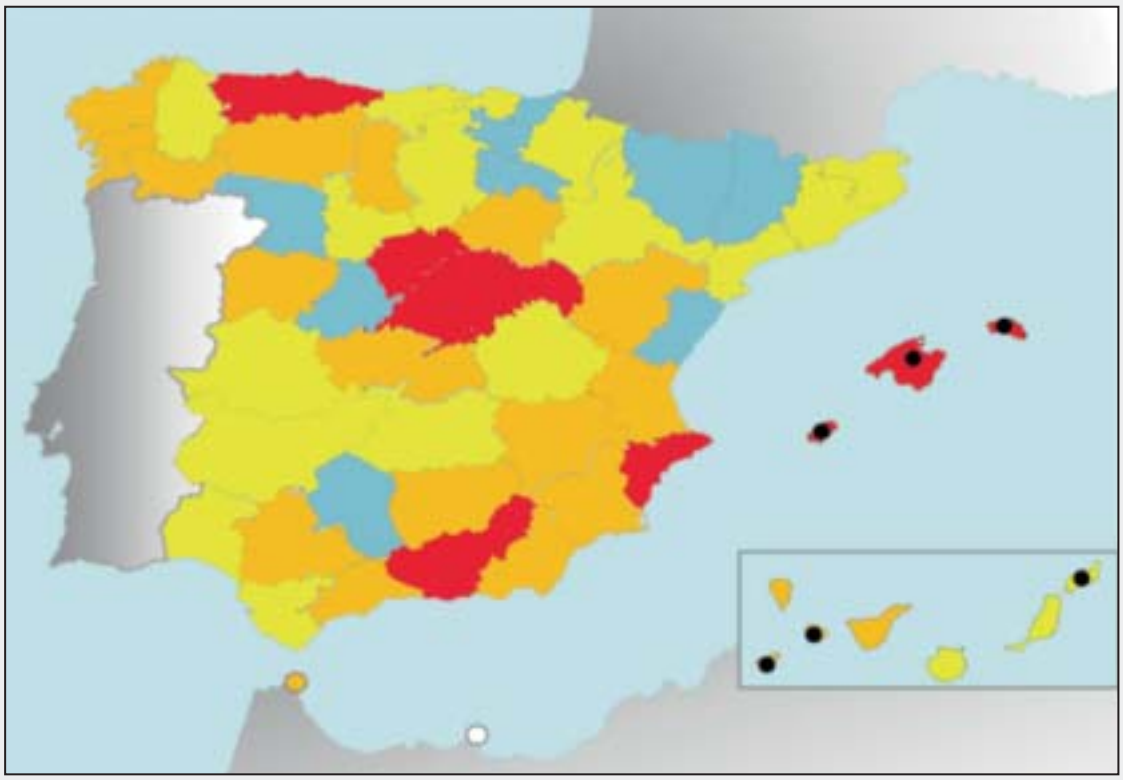
Top left: Geolodía15. Gomera looking at the volcanoes

Top right: Geolodía15. Granada on the fault plane

Lower left: Geolodía15. Madrid explained by the next geologist generation

Lower right: Geolodía15. Salamanca in the Spain-Portugal Frontier



Map showing the number of Geolodía 15 participants in the different Spanish provinces and archipelagos

READERS' LETTERS

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Fieldwork's importance - overstated?

Fossil attitude – are we guilty of overstating the importance of fieldwork just because we like it?

Sir, I feel having Gary Nichols, Managing Director of Nautilus, 'largest single provider of field based training' making the case for field based training *(Ground truth, Geoscientist 26.01 February)* is like having Jerry Garcia make the case for ice cream. I don't find he makes a good one.

We cannot walk along subterranean hydrocarbon reservoirs, but year-on-year enhanced recovery demonstrates we are doing something right. That would be the study of rock mechanics, fluid mechanics, porosity, permeability, reservoir pressures, injection pressures, flow rates, draw-down fluid contacts & so on - laboratory sciences. It is not true that we can only study the vertical in well bores. Most hydrocarbon-based well-paths now navigate horizontally through the reservoir with down-hole, real time tools that give fantastic resolution; particularly the measured physical properties so important to evaluation & production. We know there are commonly facies variations across reservoirs – no surprise there. But do field studies inform us on the best way to make reservoir fluids flow?

Continuing Personal Development (CPD) is an important aspect to everyone's careers and companies' success. I would venture that the amount spent on Nautilus-type field training by energy sector companies when seen against everything else they put into individuals' development approaches insignificance.

For our geological pioneers, field study was indeed essential. But they also rode around on horses and had no electric light. Times change. I like a day in the fresh air as much as the next person, so can't we just be honest & say we go into the field because we enjoy it, rather than it being 'essential or integral' to being a good geologist?

Now, where's my ice cream?

P M A Carruthers

A Stratigraphical Basis for the Anthropocene

There is little doubt that human activity has drastically changed the face of the Earth, and this has led to the suggestion that we are now living in a new geological epoch - the Anthropocene.

The Holocene was a time of gradual increase of humans and human influence, and the Anthropocene began with level of geologically-significant global change.

Anthropogenic changes to the lithosphere, biosphere, chemosphere, (and now 'technosphere') have overtaken the geological agents with which most of us are familiar. Humans have now overtaken nature as producers of minerals and sediments, outpacing sediment routing systems. Extinction is usually the result of competition and evolution, not overfishing; and artificial radionuclides obscure the classic volcanics for dating recent deposits.

With this new era of significant processes there is a need to move from an informal chronological concept to formally-defined stratigraphic unit, the Anthropocene, which needs a definition based on markers. This volume compiles evidence from a wide range of disciplines to help constrain the Anthropocene. In doing so it ambles deftly from formal stratigraphic definitions and discussion through to a wide range of indicators of anthropological activity which may be used to define the epoch.

In addition to discussing the familiar indicators of stratigraphic definition (ice, volcanic markers, geomagnetics, index fossils), the editors have given space to uniquely Anthropocene considerations from archaeology to anthropogenic radionuclides. The chapter 'Coral reefs in the Anthropocene' makes for a frank (albeit grim) assessment of reef decline but doesn't necessarily contribute to the book's overall objective of considering the stratigraphical basis for the epoch. However, the excellent speleology chapter 'Anthropocene viewed from the underworld' is a holistic appreciation of multiple markers and their interrelations.

Overall, the publication treats Anthropocene stratigraphy as more of a journey than a destination. Much discussion is given to marker methodology, but the basis for some of these markers for stratigraphy is often condensed into a few final paragraphs rather than being considered as an integral part. The reader is given substantial and fascinating instruction on decay of isotopes from nuclear weapons testing, but is left with more questions than answers about how to use these as a basis for stratigraphy. This is a shame, given the volume's ambitious title. Given that the authors are such proponents of the Anthropocene (albeit with sensible caution) it is a shame the volume doesn't quite 'go the final mile', from detailing the controversies and methodologies to suggesting their more concrete application to formal stratigraphy.

Reviewed by ***Nathan Allen***

A STRAPHIGRAPHICAL BASIS FOR THE ANTHROPOCENE BY C N WATERS, J A ZALASIEWICZ, M WILLIAMS, M A ELLIS & A M SNELLING
2014. GSL Special Publication #395; 321pp, hbk; ISBN 9781862396289. **Geological Society Bookshop**

The Climates of the Geological Past

All geologists will have heard of Alfred Wegener. Few will have heard of his father-in-law, Wladimir Köppen, one of the founders of modern climatology. In his early work Wegener applied the principle of the primacy of climatic zones to reconstruct continental positions through time, capitalizing in a way on Lyell's notion that a shifting of the continents across climate zones might explain the global distribution of fossils and the location of past climate-sensitive deposits. Meeting Köppen, whose climate classification system matches temperature and precipitation to patterns of vegetation and soils, Wegener found an ideal collaborator.

Their magnum opus was published in German in 1924. It featured the first comprehensive suite of global palaeoclimatic maps (displaying the distributions of climate sensitive indicators) for the Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene, Miocene, and Pliocene + Early Quaternary, all made without the benefit of palaeomagnetic observations. Salt and gypsum deposits were found to be common where such evaporites are found today, in the arid belts north and south of the equator. Cretaceous corals characterized the equatorial zone between the 30th parallels, just like today. Glacial indicators clustered around the poles. And coals occurred under temperate humid conditions, and in the humid tropics.

For their Quaternary chapter, Köppen invited a contribution from Milutin Milankovitch, who had just begun using celestial mechanics to explain climate change over the past 65,000 years. Milankovitch graciously allowed the use of his published calculations in the book, and added some new unpublished features. As the book's editors point out, this made it possible for the first time "to establish a precisely defined time scale of Late Cenozoic glacial-interglacial history".

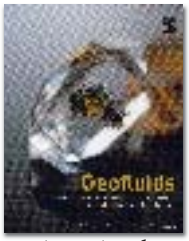
Where Köppen and Wegener went wrong was in thinking that differences in the positions of the fronts of past ice sheets in Europe might also reflect the wandering of the Quaternary pole, whose positions would not be established for another 25 years. Even so, they did make clear that the peak of the last Ice Age - the Last Glacial Maximum – occurred about 20,000 years ago. Köppen, the great climatologist, convinced Milankovitch that the key to creating a glaciation was the duration of summer warmth, not winter cold. Milankovitch's data showed that the latest peak in insolation and summer warmth occurred about 10,000 years ago. Since then, Köppen reasoned, orbital change cooled northern hemisphere summers – a process that is still going on today.

Despite the limitations, this is a historical masterpiece and well worth the purchase.

Reviewed by ***Colin Summerhayes***

THE CLIMATES OF THE GEOLOGICAL PAST / DIE KLIMATE DER GEOLOGISCHEN VORZEIT BY KÖPPEN, W, AND WEGENER, A,
Borntraeger Science Publishers, Stuttgart 2015, edited by J Thiede, K Lochte and A Dummermuth. ISBN 978-3-443-01088-1.
W: www.borntraeger-cramer.com/9783443010881

Geofluids



The interdisciplinary nature of research undertaken to understand the role of fluids in geological environments, coupled with rapid developments in new non-destructive analytical techniques, has meant that the production of a single current and practical

reference or data source on geofluids / palaeofluids has proved problematic – a situation familiar in other burgeoning areas of geoscience. 'Geofluids' is a commendable attempt to address this shortcoming in the literature.

Introduced with overview chapters summarising the general characteristics of geofluids, their phase diagrams and equations of state, the main sections (with supporting appendices) cover both direct (fluid inclusion microthermometry, Raman and infrared spectroscopy) and indirect (fluid thermodynamics and stable isotopes) techniques that are currently applied to routinely analyse and interpret geological problems. An additional chapter on miscellaneous spectrographic and chromatographic methods is also included.

Topics are presented through a practical step-by-step approach, describing the theoretical background of each method, sample preparation, measurements, analysis and the interpretation of data appropriate to mineral – fluid – melt equilibria. Most chapters include relevant worked examples derived from both theory and a range of specific case studies, many in the form of solved 'Problem Boxes' within the main text.

The appendices contain extensive equations of state data, stable isotope fractionation equations and Raman spectroscopic analysis tables (including Raman analytical data for 548 mineral phases and fluid species arranged by both vibrational energies and phase/species name) that underpin the identification of fluid inclusion daughter minerals and associated dissolved compounds.

The volume provides an excellent synthesis of current geofluid research methodologies and their application. Authored by a team of highly experienced researchers in the field, the book is written in a clear and concise style, with numerous figures, data-tables, graphical drawings and photographs that appropriately supplement the accompanying text. Many are presented in colour and enhance the understanding of the textual details.

The expected readership are graduate students and professional academic and industrial geoscience researchers specialising in fluids and fluid flow in the Earth's crust and mantle, fluid–rock interactions, hydrothermal geochemistry and mineral, oil and gas exploration. An overdue treatment of the subject, this book is recommended and will, I expect, become established as a standard reference work.

Reviewed by ***Mark Griffin***

GEOFLUIDS – DEVELOPMENTS IN MICROTHERMOMETRY, SPECTROSCOPY, THERMODYNAMICS AND STABLE ISOTOPES BY VRATISLAV HURAI, MONIKA HURAIOVÁ, MAREK SLOBODNÍK AND RAINER THOMAS.
Published by: Elsevier. 2015. ISBN 978-0-12-803241-1. Sbk. 489pp.
List Price: £100.00, www.store/elsevier.com

Patterns in Stonework: the Early Churches in Northern England

In his recent book *The Road to Little Dribbling*, author Bill Bryson remarks: "If you tried to visit all the mediaeval churches in England – just England – at the rate of one a week, it would take you 308 years". The indefatigable John Potter, in his continuing quest to prove Mr Bryson wrong, has now followed his surveys of the churches of Ireland, and of Early Welsh Churches (2013, reviewed 2014) with this survey of England's northern counties. This is part A – Part B, covering Northumberland, Nottinghamshire, Staffordshire, Westmorland and Yorkshire, is expected in 2016.

Once again, Potter uses his geologist's eyes to help archaeologists (whose lithological observations are generally spurious) recognise 'Anglo Saxon' (pre-Romanesque) building work where no classically recognised architectural details survive, using such features as 'patterned' use of stone (alternating 'long and short' work in the quoins) as touchstone.

Identifying lithologies in early churches is no simple matter even for an experienced geologist like Potter. In Wales, he found himself faced with its less-than-forthcoming Palaeozoic limestones and greywackes, rendered (pun intended) even more intractable by the lamentable local habit, encouraged by CADW, of limewashing. Here, he faced a different problem.

Lower Cretaceous rocks of Lincolnshire are poorly exposed and difficult to identify. In church walls (sampling, of course, not permitted!) and in their weathered state, they are virtually impossible to name accurately. This problem is not unique to this region, where Lower Cretaceous – Jurassic ironstones can hardly be distinguished without fossils. Middle Jurassic oolites of the 'stone belt' pose similar problems. Potter asks – could there be a case for professional geologists being allowed to sample? Perhaps minor chips, following a formal application? He suspects (with good reason) that the answer would probably be no.

The hundreds of churches surveyed are illustrated in crisp B&W photos within the text, accompanied by perceptive descriptions of their stonework. Potter draws attention to the fact that Cheshire and Lancashire, with negligible 'Anglo Saxon' remains, contrast markedly with the riches of Durham and Lincolnshire. He suggests that while this may reflect contemporary population size, it may also be a function of the availability of good stone. Local rock types in Cheshire and Lancashire are inappropriate for building and not durable; early churches, if they existed, would almost certainly have been completely rebuilt later.

Potter's survey endorses the existence of distinctive 'patterned' stonework seen elsewhere in pre-Norman building, while Norman and later churches display changes in building fashion similar to those noted in his previous studies. At £55, this volume represents excellent value and can be highly recommended to serious amateurs of ecclesiastical architecture everywhere.

Reviewed by ***Ted Nield***

PATTERNS IN STONEWORK: THE EARLY CHURCHES IN NORTHERN ENGLAND – A FURTHER STUDY IN ECCLESIASTICAL GEOLOGY PART A: THE COUNTIES OF CHESHIRE, CUMBERLAND, DERBYSHIRE, DURHAM, LANCASHIRE AND LINCOLNSHIRE
by JOHN F POTTER 2015 BAR British Series 617 ISBN 978 1 4073 1393 1
List price: £55.00 W: www.barpublishing.com 314pp

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! The Destruction of Sodom - a scientific commentary** by Graham Harris. Lutterworth Press 2016191pp, pbk.
- **NEW! Tectonics of the Himalaya** by Mukherjee et al (Eds) Geological Society of London 2016 Spec Pub #412 323pp 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.

◆David Cronan

has recently been awarded the Moore Medal of the International Marine Minerals Society,its highest award,"for excellence in documenting the geochemistry of sea floor minerals worldwide".

◆ Colin Summerhayes'

book *Earth's Climate Evolution* - an expanded and updated version of the GSL Climate Change Statement - was published in October. He has now given several lectures about it, not only at Burlington House but also to regional groups and affiliates (e.g. Irish Geological Institute, Dublin), and local geological societies (Mole Valley, Horsham, and Farnham). Groups interested in hosting the lecture should contact Colin at E: cps32@cam.ac.uk.

◆ Paul Younger

has been elected a Fellow of the Royal Society of Edinburgh. Holding the Rankine Chair of Engineering (University of Glasgow) he is also Professor of Energy Engineering. Paul has combatted pollution from the extractive industries and developed fresh approaches to sustainable geo-energy. He has founded five companies and remains a Director of two, in the water and energy sectors. His book – *Energy: all that matters* – appeared in November 2014.

Publications night 2016

The Publishing House played host to Editors of Society publications at Burlington House on 29 February, writes **Dawne Riddle**

William McCarthy (University of St Andrews)

Dr Quentin Crowley (Trinity College, Dublin), outgoing Chief Editor, JGS, presents the JGS Young Author of the Year Award for 2015 to William McCarthy (University of St Andrews) for his part in the co-authored paper 'Distinguishing Diapirs from inflated plutons: an integrated rock magnetic fabric and structural study on the Roundstone Pluton, Western Ireland' JGS 172 (5) 550-565. (by McCarthy, Petronis Reavy and Stevenson)

Catherine M Hirst (Durham University)

Catherine M Hirst (Durham University) accepts the W Dearman Award 2015 from QJEGH Chief Editor Eddie Bromhead, for her role in the co-authored paper 'The late field life of the East Midlands Petroleum Province; a new geothermal prospect?' (QJEGH 48 (2) 104-114. (by Hirst, Gluyas and Mathias)

Photos: Ted Nield

The annual occasion, held to thank all Editors of Society publications for their hard work, also included the presentation of 'young author' awards by both the Journal of the Geological Society and the Quarterly Journal of Engineering Geology and Hydrogeology, by their respective Chief Editors.

IN MEMORIAM WWW.GEOLSOC.ORG.UK/OBITUARIES

THE SOCIETY NOTES WITH SADNESS THE PASSING OF:

Armitage, John *
Bishopp, David *
Colley, H *
Davis, Robert Vincent *
Flood, Raymond Edward *
Gorsline, Donn *
Grinly, David *
Haddow, Douglas *
Hawkins, Alfred Brian *
Kilpady, Sripadrao *
McNicholas, J B *
Terris, Alexander P *
Theokritoff, George *
Wood, Christopher J *

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**.

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

DISTANT THUNDER *Modest proposals*

As geologist and science writer Nina Morgan* can testify, scientific modesty can cloud conclusions

When it comes to reporting the results of scientific studies, scientists and science journalists often find themselves at loggerheads. The journalist hopes for a good story with a clear conclusion. The scientist, meanwhile, is only too well aware of the misunderstandings such a simple summary might engender. As a result, the Conclusions sections of many scientific papers are hedged with so many caveats that it can be difficult for the uninitiated to discover what, if any, conclusion was actually reached.

This 'hedging of bets' has a long history. Joshua Platt [c. 1696 – 1776], writing in the Philosophical Transactions of the Royal Society in 1759, where he identified himself as 'Your ever obedient, and most humble servant', provided a virtuosic example of such scientific diplomacy with his account of a fossil thigh bone from Stonesfield, Oxfordshire:

"If I may be allowed to assume the liberty, in which fossilists are often indulged, and to hazard a vague conjecture of my own, I would say it [the fossil thigh bone] may probably have belonged to the hippopotamus, to the rhinoceros, or some such large animal, of whose anatomy we have not yet a competent knowledge."

In modest footsteps

A century later, mineralogist David Forbes' [1828 – 1876, younger brother of Professor Edward Forbes 1815-1854], followed Platt's self-deprecating example. In an article entitled 'The Microscope in Geology' published in 1867 in The Popular Science Review, he extols the value of studying rocks in thin section under a polarising light microscope, then confesses:

"It is with great hesitation and only after much solicitation that the author of these remarks has now ventured into print, with the hope that by once breaking the ice, others more capable than himself may be induced to communicate the researches on the same subject."

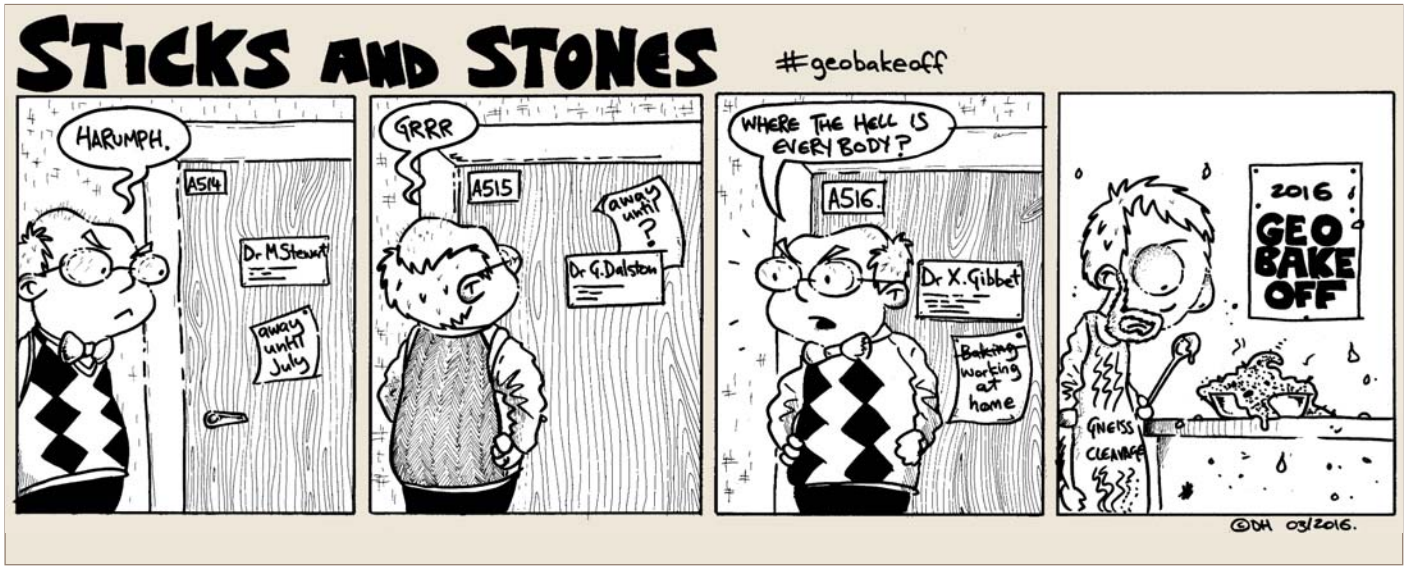
Tell it like it is

But in Forbes's case, the description 'obedient and humble servant' did not really apply, at least among his peers. Forbes's relationship with some of his colleagues could best be described as combative. A straight-talking Manxman, he was not averse to forthrightly expressing unfavourable opinions of his peers in the correspondence columns of prominent scientific journals.

James Geikie [1839 – 1915], an assistant at the British Geological Survey and younger brother of Archibald Geikie [1835—1934], was one of those who received a public pen-lashing at the hands of Forbes. In a series of letters published in 1867 in the Geological Magazine, Forbes dismisses James Geikie's publications about a possible metamorphic origin for granites and other igneous rocks, citing the "rather startling statements embodied in these papers" and asking if "the papers here under consideration come up to the mark [since the] substance of the papers themselves does not prove the author to be much at home either in chemistry, mineralogy, petrology or physics". Presumably the UK's now notoriously wide-ranging libel laws did not then apply!

Acknowledgement
Thanks to Philip Powell of the Oxford University Museum of Natural History for drawing my attention to the modest remarks made in print by Joshua Platt and David Forbes which inspired this vignette. Other sources include: David Forbes FRS (1828-1876): A chemist and mineralogist who advocated for thin section microscopy by Helen Kerbey, Geological Curator, 9 (10), 2014, pp. 515-525; the entry for David Forbes by W H Brock in the Oxford Dictionary of National Biography, and An account of the Fossile Thigh-Bone of a Large Animal, Dug up at Stonesfield Near Woodstock, in Oxfordshire by Joshua Platt (Phil Trans Roy Soc, vol 50, 1757-1758, pp. 524 -527).

***Nina Morgan** is a geologist and science writer based near Oxford. Her latest book, The Geology of Oxford Gravestones, is available via www.gravestonegeology.uk



OBITUARY ALEC KENYON-SMITH 1932-2015

Distinguished sedimentologist, academic leader and founder of the magazine Geology Today

Alec Smith died on 12 November 2015 following a heart attack. He was born in Wakefield but his family moved to Wales in 1934 where he grew up. Married first to Joan, he had a son and a daughter. In 1990 he married Anita, who survives him, and changed his name to Kenyon-Smith.

He won the John Hughes Open Scholarship to UCW Aberystwyth (1950-53) and graduated with 1st Class Honours in Geology. He stayed on to research the Aberystwyth Grit Series. There he learned how to interpret turbidites and understand their formation and was awarded a PhD (1956).

University of London

Then began his a 35-year career in the University of London. In 1957 he was appointed lecturer in Geology at UCL and 10 years later was promoted to Reader. During that period he focused on the submarine geology of the English Channel, in collaboration with Bristol University and discovered that the Channel had been formed as a result of at least two catastrophic floods.

Alec was very active in studying sedimentary geology of various regions of Japan (1972-92) and was Visiting Professor at Tokai University, Japan (1975-80) and participating sedimentologist with the DSDP, Leg 87, Nankai Trough (1980-85). He was also fascinated by ikaite, which he worked on with Doug Shearman.

> "HE PUBLISHED OVER 100 PAPERS AND WAS AUTHOR OR CO-AUTHOR OF FOUR BOOKS"

In 1977 Alec was appointed Professor and Head of Department at Bedford College. In March 1980 we had to respond to the Swinnerton-Dyer 'Committee on Academic Organization', set up with a view to rationalisation. Each with a small department potentially at risk, Alec and I (as head of Geology, Chelsea College) agreed to keep all options open.

Alec hit on the idea of sending a telegram to Senate House saying that our two Departments wished to amalgamate and asking how the University could help. His initiative succeeded beyond all expectations, but it took until May 1982 for Bedford College to agree to move to Egham, and only in February 1984 was agreement reached for the Geology Departments of Chelsea and King's Colleges to join Bedford there.

In 1985 Alec was appointed Foundation Professor of Geology and Head of Department. His enlightened leadership created a style that has endured successfully for the past 30 years. He retired in 1992, assisting the Principal at Royal Holloway until 1995.

Geology Today

Kenyon-Smith organised several national and international conferences: was Treasurer (1971–77) and Vice-President of the Geological Society, London (1990); President of the Geologists' Association (1980–1982); Chairman, Greenwich Forum; Chairman, Watt Committee on Energy; Chairman, Geological Grants Committee, NERC; President, Section C (Geology) BAAS, (1991–92); Geological Advisor to Kuwait University, (1991–92); and creator of *Geology Today* (1985).

He received: The Coke Medal (Geological Society of London, 1990); was made Fellow of the Society for Underwater Technology; and of Royal Holloway University of London (1998). He published over 100 scientific papers and was author, or co-author, of four books: *Geology* (1974); *Exclusive Economic Zones - British Dependencies; Geology of England and Wales, Geological Society* (1993) and *The Evolution of Clastic Sedimentology* (2005).

The Earth Sciences Department at Royal Holloway is his legacy.

By **Derek Blundell**
A (much) longer version of this obituary is available online *Editor.*

HELP YOUR OBITUARIST The Society operates a scheme for Fellows to deposit biographical material. The object is to assist obituarists by providing contacts, dates and other information, and thus ensure that Fellows' lives are accorded appropriate and accurate commemoration. Please send your CV and a photograph to Ted Nield at the Society.

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

ENDORSED TRAINING/CPD

COURSE	DATE	VENUE AND DETAILS
Introduction to Micromine	17-18 May	Micromine, Challoner House, 19 Clerkenwell Close, Clerkenwell, London, EC1R 0RR. Fees: £110. **Contact E:** mmuk@micromine.com. See website for details.
Resource Estimation in Micromine	19-20 May	Micromine, Challoner House, 19 Clerkenwell Close, Clerkenwell, London, EC1R 0RR. Fees: £110. **Contact E:** mmuk@micromine.com. See website for details.
Geocience Education Academy 2016	27-30 May	**Venue:** Burlington House. Free training for UK teachers. Includes field trips. Supported by BP. See website for details and registration.
Lapworth's Logs	n/a	'Lapworth's Logs' is a series of e-courses involving practical exercises of increasing complexity. **Contact:** info@lapworthslogs.com. Lapworth's Logs is produced by Michael de Freitas and Andrew Thompson.

DIARY OF MEETINGS 2016

MEETING	DATE	VENUE AND DETAILS
Fossils of South East England SE Regional	10 May	**Venue:** The Bell Inn. Godstone. **Speaker:** Ken Brooks, Hastings & District Geological Society. **Time:** 1800 for 1830
The Impact of Water on the Geology of Mars Engineering Group	11 May	**Venue:** Burlington House. Speakers TBC. **Contact:** Richard Ghail **E:** r.ghail@imperial.ac.uk. **Time:** 1730 for 1800
14th Groundwater Modellers' Forum and Darcy Lecture Hydrogeological Group, GMF	16 May	**Venue:** Burlington House. Registration online – deadline May 6. **Speaker:** Professor Ty Ferré (University of Arizona). **Contact:** Corinna Abesser **E:** cabe@bgs.ac.uk
Southern Wales: Cardiff Ground Source Heat Map Southern Wales Regional	17 May	**Venue:** LT 1.40, Cardiff University. **Speakers:** David Boon (British Geological Survey), David Tucker (WDS Green Energy), David James (Cardiff Harbour Authority). **Contact: E;** swales.rg@geolsoc.org.uk
What Coal Mining Hydrogeology Tells us about the Real Risks of Fracking GSL London Lecture	18 May	**Venue:** Burlington House. A London Lecture. For details, see advert, page 06
Field Meeting 2016 QRA	20-23 May	**Venue:** Isle of Skye. See website for details and registration. **Convener:** Colin Bllantyne (St Andrews) **E:** ckb@st-andrews.ac.uk
Arthur Holmes Meeting 2016 - The Wilson Cycle: Plate Tectonics and Structural Inheritance During Continental Deformation GSL, Geol Soc Canada, Tectonic Studies Group	23-25 may	**Venue:** Burlington House. Conference with field trip. For details and registration see website. Fees and discounts. **Contact** Naomi Newbold **E:** naomi.newbold@geolsoc.org.uk
32nd IAS Meeting in Sedimentology IAS	23-25 May	**Venue:** Marrakech, Morocco. See website for details and links for registration. **E:** info@ias2009.com
Moscow International School of Earth Sciences 2016	23 May	**Venue:** Vernadsky State Geological Museum, Moscow. See website for details and links for registration. Contact: Viktor Zaytsev **E:** alkaline.conference@gmail.com
Next Steps for renewable energy in Scotland Scotland Policy Conferences		**Venue:** Edinburgh. See website for details. Contact **E:** info@forumsupport.co.uk
Palaeozoic Plays of Northwest Europe	26 May	**Venue:** Burlington House. For details and registration see website. Fees and discounts. **Contact** Laura Griffiths, **E:** laura.griffiths@geolsoc.org.uk

OBITUARY ALBERT LUDFORD 1913-2016

Committed and an enthusiastic teacher, with a phenomenal memory, who became a Fellow of the Society in 1945

Born in Willenhall, near Wolverhampton, he attended Wednesbury Boys High School. Although chemistry was his initially preference he graduated in 1934 with a good honours BSc in Geology & Geography from Birmingham University, having been awarded the Panton Geological Prize. He taught at a local primary school following completion of a teaching diploma.

A strong mutual interest in geology developed with Ellen Seagar (Nellie), whom he married in 1940, continued through the Midland Group of the Geologists' Association, which he joined in 1938. Albert carried out researches in his spare time; firstly into local industrial mineral deposits and then into the Carboniferous stratigraphy of the Pennines in Staffordshire and south-west Derbyshire. Both involved a lot of walking and bicycling.

Royal Artillery

In 1940, he was commissioned in the Royal Artillery and initially served as a battery commander in England, Orkney and Nigeria. Then Albert was seconded as a geologist to the Inter-Services Topographical Department and was involved in the preparation of overlays for soil types in north Germany for tank runs and made visits to Norway, Sweden, Thailand, Singapore and Burma for other projects (detailed in the publications of Ted Rose & co-authors). He was demobbed in 1947 with the rank of Captain.

> ALBERT WILL BE BEST REMEMBERED FOR CHAMPIONING THE INTERESTS OF STUDENTS AND AS A STIMULATING TEACHER

Albert transferred to the Wolverhampton Municipal High School where he taught geography but introduced geology. Also, he was a geology lecturer for the extra-mural department of Birmingham University.

He was awarded the MSc in 1945 for his work on the Carboniferous stratigraphy of the Weaver Hills, which was subsequently published in QJGS. Two fossils are named after him as a consequence of his researches: a Ludlovian Leptaenid brachiopod *Ludfordina pixis* and a Carboniferous goniatite *Pronorites ludfordi*. His Carboniferous researches were extended into Dovedale for the award of a London University PhD in 1972.

In 1955 he was appointed a Lecturer at Luton & South Bedfordshire College of Further Education (now the University of Bedfordshire). Geological resources at Luton for the External London BSc were considerably enhanced through the advent of Norman D'Cruz in 1960. Later, with a rapid increase in undergraduates, further staff appointments were made.

CNAA

At his retirement in 1976, Albert was Principal Lecturer in charge of five geology staff and Deputy Head of the Science Department. Additionally he was a member of the Geology Board of the Council for National Academic Awards and an Examiner for London University External BSc. Nellie and he retired to Malvern where he continued his interests through the local RIGS group. In 2013 he was awarded a University of Bedfordshire honorary DSc.

Encouraged by Albert and Norman the Luton geology section maintained high standards of degree-level teaching that provided a good foundation for the establishment of a university. Albert will be best remembered for championing the interests of students and as a stimulating teacher with great thoughtfulness, consideration and patience. He lived to be the Geological Society's oldest Fellow, a position he held for many years.

By **Gordon Taylor** with help from **Norman D'Cruz** and **Ian Ludford**

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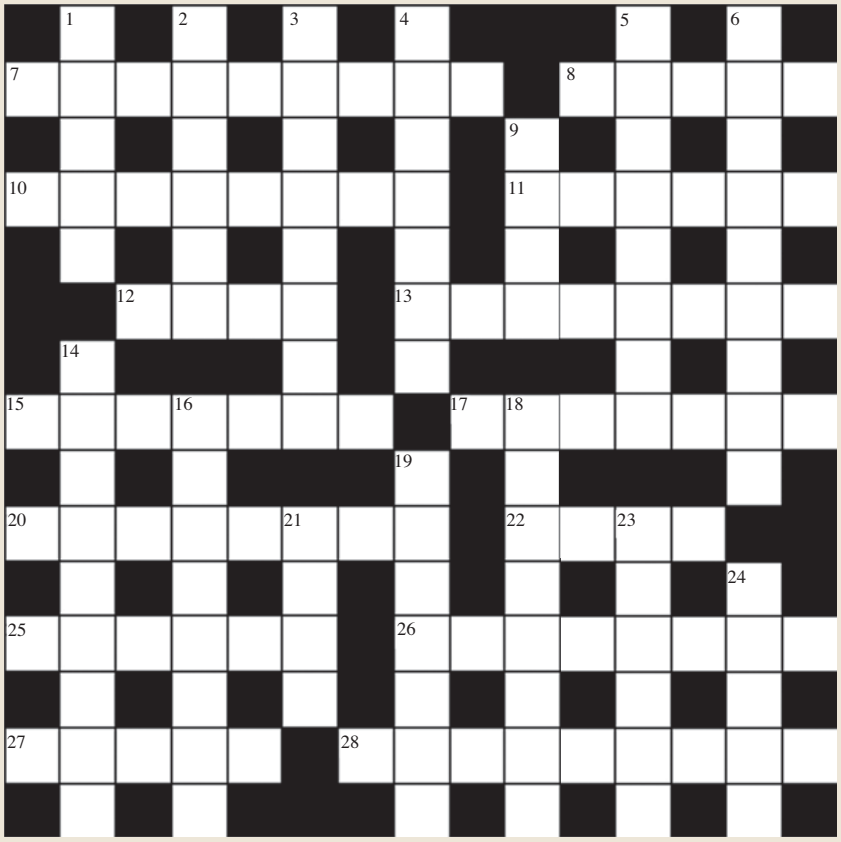
CROSSWORD NO.202 SET BY PLATYPUS



ACROSS

7 Wind-sculpted pebble (9)

8 Noble gas, atomic number 18, much used in dating (5)

10 Monoclinic pyroxene, found in ultramafics (8)

11 Absence of the respirable gas (6)

12 Only a small lake (4)

13 Setting mixture of gypsum plaster, Portland cement, and sand (8)

15 Curve on a plane surrounding two foci such that the sum of the distances to the two focal points is constant for every point on the curve (7)

17 Residence of the now eponymous family of Saxe-Coburg Gotha (7)

20 Natural medicinal substance, found in the nightshades (8)

22 One flows through Yorks, another through Sussex and there's a Great one in Northants (4)

25 To break in or invade (6)

26 One of the snakes (8)

27 Incremental stages in a progress (5)

28 It may tumble, as the song says, but isn't 'made of clay'. (9)

DOWN

1 Protective shield of the Gods (5)

2 Treeless grassland in continental semi-arid landscape (6)

3 Publications Secretary, External relations Secretary, for example, in the Society (8)

4 Area in which drilling for oil, for example, is licensed by Government (7)

5 Protected by bony plates - the Placodermi, for example (8)

6 Repeated, penetrative planar feature in metamorphic rock textures (9)

9 Goes the other way from the weft (4)

14 Polymerised lattice with molecular host, such as water with methane (9)

16 Coal quality measure contouring equal sulphur content (8)

18 Line of equal drilled thickness of a rick unit (8)

19 Respiration requiring oxygen (7)

21 A jot or tittle, at least (4)

23 Type of dolomite with pronouncedly curved lattice (6)

24 At the bottom, like the Moine (5)

WIN A SPECIAL PUBLICATION!

The winners of the draw for the 200th Geoscientist Crossword (March) were: John Cubitt of Holt, and William Jones of Retford.

All correct solutions will be placed in the draw, and the winner's name printed in the July 2016 issue. The Editor's decision is final and no correspondence will be entered into.
Closing date - May 20.

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

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

Name .....

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Membership number .....

Address for correspondence .....

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SOLUTIONS MARCH

ACROSS:
7 Ichnology **8** Huron **10** Eruptive/Graphite (wrong clue printed - any or no solution accepted) **11** Oblate **12** Urdu **13** Uniramia **15** Bitumen **17** Aureole **20** Anodised **22** Tusk **25** Slalom **26** Marbling **27** Agate **28** Angstroms

DOWN:
1 Ochre **2** Sniper **3** Altitude **4** Igneous **5** Nucleate **6** Foothills **9** Gobi **14** Limnology **16** Undulate **18** Upthrust **19** Adamant **21** SIMA **23** Sclera **24** Enema

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Image: Entry from 100 Geosites competition
Lundy Island © Steve McAusland

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Queen's University Belfast

2016 YEAR OF WATER

Groundwater in Fractured Bedrock Environments:

Managing Catchment and Subsurface Resources

10 June 2016 **Queen's University, Belfast, Northern Ireland**

Across the UK & Ireland, fractured bedrock aquifers have been traditionally regarded as low productivity aquifers, with only limited relevance to regional groundwater resources. But it has been increasingly recognised that these complex bedrock aquifers can play an important role in catchment management and subsurface energy systems.

At shallow to intermediate depth, fractured bedrock aquifers help to sustain surface water baseflows and groundwater dependent ecosystems, provide local groundwater supplies and impact on contaminant transfers on a catchment scale. At greater depths, understanding the properties and groundwater flow regimes of these complex bedrock environments can be crucial for the successful installation of subsurface energy and storage systems, such as deep geothermal or aquifer thermal energy storage systems and natural gas or CO_2 storage facilities as well as the exploration of natural resources such as conventional/unconventional oil and gas.

In many scenarios, a robust understanding of fractured bedrock environments is required to assess the nature and extent of connectivity between such energy & storage systems at depth and overlying receptors in the shallow subsurface or above ground.

Conference Focus:

This conference will focus on the role of fractured bedrock aquifers in catchment management and in managing subsurface resources.

Convenors:

Dr. Ulrich Ofterdinger
(Queen's University Belfast)

Prof. Alan MacDonald (BGS)

Dr. Jean-Christophe Comte
(University of Aberdeen)

Mike Young (The Geological Society)

Further information:

For further information about the conference please contact:

Georgina Worrall, Conference Office, The Geological Society, Burlington House, Piccadilly, London W1J 0BG

T: 0207 434 0983

E: georgina.worrall@geolsoc.org.uk

Web: www.geolsoc.org.uk/fracturedbedrocks

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