

Earth heritage

HERITAGE

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The geological and landscape conservation magazine



A new dinosaur
discovered in Wales



SSSI demonstrates
research value

ISSUE **44**
Summer 2015

Geoheritage
and planning



Growing the value
of geotourism

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COVER



A new exhibition at the National Museum Wales in Cardiff showcases the remains of a small, plant-eating dinosaur recently discovered in South Wales (see page 7).

Illustration by Bob Nicholls, © Amgueddfa Cymru



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EDITORIAL

Cause for optimism

If policy makers and politicians are ever to treat geodiversity and geoconservation as inseparable from biodiversity and nature conservation, our subjects need more prominent status, particularly at international level. This issue of *Earth Heritage* reports encouraging developments. Firstly, the International Union for Conservation of Nature (IUCN) has adopted resolutions that affirm geodiversity and geoheritage as an integral part of natural diversity and natural heritage (pages 32-34). Secondly, the Global Geoparks Network, which includes seven Geoparks in the UK, will likely soon benefit from closer ties with UNESCO (page 35).

While these achievements may seem rather worthy and 'dry', they constitute hard evidence that the subject of geoheritage is increasing its traction throughout society. Elsewhere, this issue brims with examples of how other disparate audiences are absorbing geodiversity and geoconservation messages – through education initiatives, through tourism, through exhibitions and a range of other means. Momentum is growing. About time, you may think, because the bedrock underpinning everything on our planet really is quite important!

As ever, we want to hear your views and to learn of new projects. To contribute, please contact the most appropriate editor (below).

Enjoy your reading!

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GA support for geoconservation continues to strengthen

The past five Geologists' Association presidents have all been highly supportive of geoconservation, with four of them authors of Geological Conservation Review volumes. Many GA local and affiliated groups are involved in geoconservation and hold events around the country (<http://tinyurl.com/ovxn3uf>).

This support will continue to strengthen with the appointment of Colin Prosser of Natural England as the GA's new president elect. Colin will succeed Haydon Bailey as president in May 2016 and hold office until May 2018.

2015 is shaping into another busy year for the GA in terms of initiatives relevant to geoconservation:

- Regular meetings are held between the presidents of the GA and the Geological Society of London. The theme for the June meeting was geoconservation.
- A Geotrails and Building Stones Walks catalogue is now on the GA website (<http://tinyurl.com/o35qn67>). A printed version was on display at the Lyme Regis Festival and will be updated for other public events. In due course the details will be linked to the interactive map on the BGS website, <http://tinyurl.com/nq59hnn>. The BGS holiday geology guides are already there.
- Exposures created for the 2014 field meeting (jointly with the Essex Field Club and the Quaternary Research Association), will be re-cleaned and extended to host an excursion on 6 September to the Purfleet and Swanscombe geoconservation sites in the Lower Thames (see *Earth Heritage* 43). There will be a separate visit to Swanscombe (13 September) by the European Society for Human Evolution.
- The GA's Halstead Medal, awarded annually for work of outstanding merit deemed to further the objectives of the Association, was awarded in May 2015 to Peter Oliver. Peter's voice has been a powerful one in the field of geoconservation, particularly in Herefordshire and Worcestershire. Over several decades he has given

Marble, such as this at Birmingham Museum and Art Gallery, is on the itinerary for field visits within the GA annual conference programme in October.



Photo by Gordon Walkden,
University of Aberdeen

his time, ideas, energy and personal resources to inspire enthusiasm for geology.

- A symposium is being sponsored in Ludlow, Shropshire, on 2-4 October on the theme *The Geology of the Marches - Murchison to the Modern Era* (<http://geo-symposium.eu/>). It is hoped to draw groups from several European countries including Poland, Greece and Germany, who are involved in geoconservation and other community-based initiatives, to build on the successful *Geovillages* pilot project.
- The GA annual conference for 2015 will be held on 9–10 October at the BGS, Keyworth, themed on building stones. A day of lectures will be followed by a day of field visits (Building stones of Nottingham or Devonshire marbles of Birmingham interiors) <http://tinyurl.com/pq9ts9x>.
- A new GA Devon Marbles guide will be published in September, with launches planned for September in Torquay, at the October Building Stones conference and the Festival of Geology in November.
- The venue and topic for the 2016 GA annual conference is likely to be the Jurassic Coast.

– DAVID BRIDGLAND, Geologists' Association

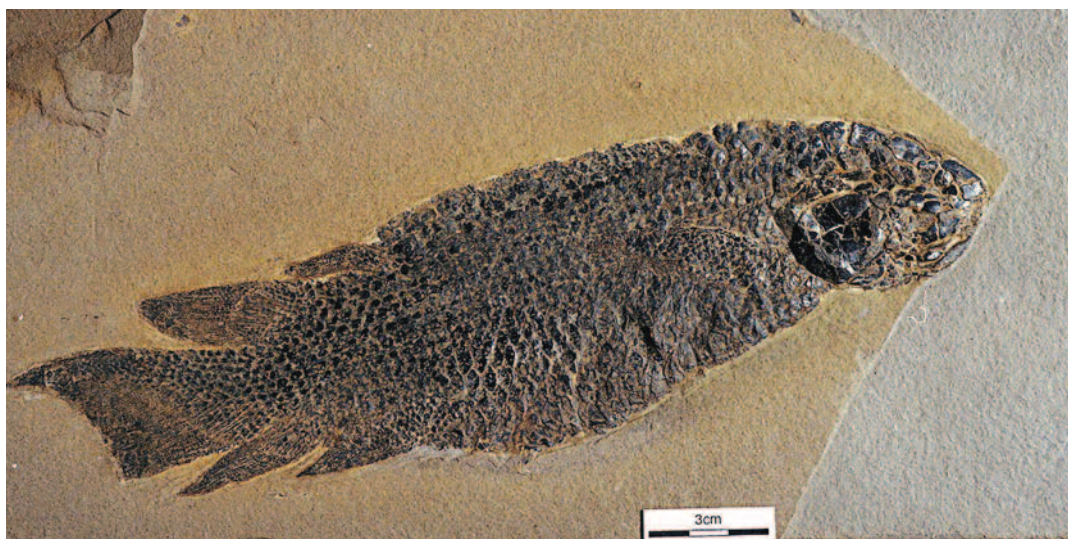
Scotland's favourite fossils revealed

The winners of the Scottish Geodiversity Forum's Fossil Five Poll covered a fantastic array of lifeforms from different time periods, demonstrating the astonishing diversity of Scotland's fossil record.

The poll ran online for six months, inviting the public to choose five of their favourite fossils from a selection which aimed to promote and celebrate Scotland's fossil record. From giant sea scorpions to early land plants, dinosaurs and metre-long

amphibians to beautiful curled ammonites, the choices caught imaginations of the public, young and old alike.

The overall winner of Scotland's Fossil Five are the Devonian Fish: beautifully preserved fossils from the 'age of fishes' found across Scotland, recording a time when life flourished in seas and lakes. Second were the Jurassic dinosaurs of the Isle of Skye, where evidence in the fossil record recently led to the identification of a new



A stunning example of a *Dipterus*, a Devonian fossil fish from Achanarras Quarry in Caithness

Photo by Nigel Trewin

Ichthyosaur. Third were early tetrapods, the fossils which are helping scientists piece together the missing links between amphibians and the earliest land-living reptiles. Fourth were trilobites, woodlouse-like creatures found in the North West Highlands and Midland Valley. Fifth were fossil trees, remnants of ancient dense rainforests that covered the central belt of Scotland in the Carboniferous Period.

The winners' event in the main hall of the Hunterian Museum in Glasgow was well-attended by a wide range of enthusiasts, from academics and professional geologists to local politicians and dignitaries. Certificates were awarded by Councillor Phil Greene, Bailie of the City of Glasgow.

The Fossil Five Poll announcement was made at the Hunterian Museum in Glasgow. Councillor Phil Greene presided over the awards, which were also attended by Sandra White, Member of the Scottish Parliament for Glasgow Kelvin.

Angus Miller, chair of the Scottish Geodiversity Forum, said: "The public response to our poll was terrific. It gave the palaeontological community in Scotland, including museums and university researchers, the opportunity to interact with the public and share amazing recent discoveries. We are delighted that the winners cover such a diverse and fascinating spread of lifeforms across our fossil record."

– LARA REID, freelance geoscience writer

Photo by Tom Reid





Intertidal features, like the famous Hugh Miller Reptile Bed on the Isle of Eigg, may be vulnerable to loss due to sea-level rise caused by climate change.

Photo by Colin MacFadyen

Climate change and geology sites

The Scottish Government-funded Centre of Expertise on Climate Change, or 'ClimateXChange', aims to deliver independent, authoritative evidence to support Scottish Government work on climate change mitigation, adaptation and transition to a low-carbon economy.

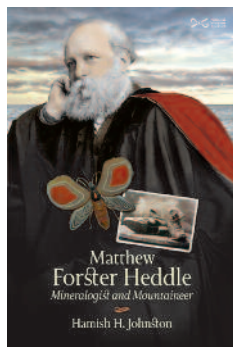
Over the last two years, ClimateXChange has looked at vulnerability to climate change of natural heritage features in protected areas, including more than 650 notified Earth science features in Scotland's Sites of Special Scientific Interest (SSSI). Scottish Natural Heritage has taken a lead role, alongside the James Hutton Institute, Aberdeen University and Dundee University. Factors including fragility, location and extent have been taken into account. Coastal changes such as sea-level rise and increased storminess are factors likely to affect many vulnerable sites most significantly. However, decrease in freeze-thaw processes, river flooding and erosion, and decreases in rainfall leading to drying out of environmental record sites could also damage important features. Currently 67 SSSI features have been ranked as likely to be at high risk from climate change, as well as 11 Geological Conservation Review (GCR) sites that lie outside any SSSI. This work will continue in 2015, and consider suitable mitigation and adaptation measures.

<http://www.climatexchange.org.uk/>

<http://tinyurl.com/orjlulg>

– RACHEL WIGNALL, Scottish Natural Heritage

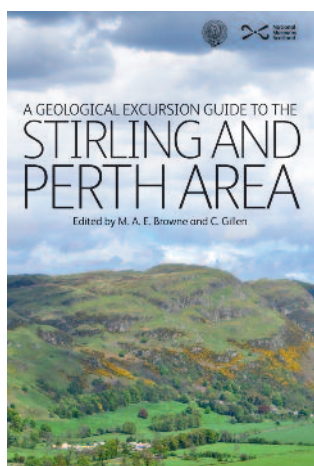
New publications



Matthew Forster Heddle: Mineralogist and Mountaineer

Hamish H. Johnston, 272pp + 2 x 8pp art sections, paperback, £14.99
978 1 905267 98 9

Orkney-born Professor Matthew Heddle (1828-1897) was a larger-than-life character and one of Scotland's most famous mineralogists. His rich legacy includes: *The Mineralogy of Scotland* (published posthumously in 1901 and still the classic work on the subject); 5,700 specimens now in the collections of National Museums Scotland; a mineral named after him (Mattheddleite); a fossil fish (*Heddleichthys*); 10 children; and a mountaineering record admired by Sir Hugh Munro. This is an account of his life by his great-great-grandson.



A Geological Excursion Guide to the Stirling and Perth Area

edited by M.A.E. Browne & C. Gillen, 240pp, illustrated throughout, paperback, £15.99
978 1 905267 88 0

After an illustrated summary of the geology of the area (Dalradian/The Highland Border/Devonian/ Carboniferous/Quaternary), there are 18 outings including walking excursions to look at the wonderful selection of building and facing stones used in the construction of Stirling and Perth.

This is the latest in this popular series, following *An Excursion Guide to the Moine Geology of the Northern Highlands* (Strachan et al.), *Geological Excursion Guide to Rum* (Emeleus and Troll) and *Geological Excursion Guide to the North-West Highlands* (Goodenough & Krabbendam). All titles are published by NMS Enterprises Limited – Publishing, National Museums Scotland, in conjunction with Edinburgh Geological Society. All are available from bookshops and www.nms.ac.uk/books



Voluntary effort still needed to conserve Skye's fossils

Earth Heritage 42 reported on a public meeting in May 2014 in Portree to try to establish voluntary activity on Skye, and the neighbouring island of Raasay, to help safeguard and promote the islands' fossil heritage. A year on, important first steps are being taken to encourage voluntary conservation activity.

It became apparent at the meeting that securing voluntary help was not going to be straightforward. The difficult economic climate has been one factor in a disappointing level of voluntary effort to assist with tasks such as monitoring fossil hotspots and promoting adherence to the Scottish Fossil Code.

Now, Scottish Natural Heritage (SNH), in partnership with other stakeholders, is using limited outreach and educational resources to convince local communities that their fossil heritage is of great scientific, educational and touristic value and is worth looking after. Working with local schools is one way to increase awareness of the significance of fossil material and its vulnerability.

Scottish Natural Heritage has also published guidance on its website (<http://tinyurl.com/o3z4mvo>) to encourage people to report potentially important fossil discoveries. Drawn from the Scottish Fossil Code, the guidance also recommends appropriate actions when dealing with irresponsible collecting. A bookmark (left) featuring some of Skye's dinosaur heritage has been prepared and is being widely distributed in the Skye and Lochalsh area.

Within the guidance, there are details of individuals and organisations that can offer advice on suspected significant finds. The initiative has the support of many stakeholders, including major landowners, Highland Council Rangers, local and national museums, Northern Constabulary and Scotland's dinosaur experts. The next step is to secure more involvement from local communities.

These actions follow years of effort to step up the safeguarding of Skye and Raasay's fossil heritage, given that the Jurassic rocks of both islands contain a rich heritage of fossil material. This includes dinosaur remains on Skye, dating from the Middle Jurassic, which have been susceptible to irresponsible collecting. This is particularly concerning given the comparative rarity worldwide of Middle Jurassic dinosaur fossils. Skye today is continuing to reveal dinosaurian material of international importance. Watch this space...

COLIN MACFADYEN, Scottish Natural Heritage



A particularly good example of *Xenostephanus*, a Jurassic ammonite from Skye. Ammonites and belemnites are the typical fossils to be found on some of Skye's beaches. However, among these reasonably common finds there are rarer dinosaurian remains. Reporting the discovery of these is the main aim of SNH's *Looking after Skye's Fossils* campaign.

**Photo by
National Museums Scotland**

New Welsh dinosaur is chip off an old block

CAROLINE BUTTLER

Amgueddfa Cymru – National Museum Wales

Dinosaur fossils are rare in Wales, so the discovery of the partial skeleton of an Early Jurassic theropod – yet to be named – is remarkable.

In spring 2014 this ‘discovery of a lifetime’ was made at Lavernock beach in the Vale of Glamorgan by two brothers originally from Llantwit Major. Nick and Rob Hanigan are keen amateur fossil collectors and noticed that several blocks brought down from cliffs by recent storms appeared to contain fossilised bones.

After carefully preparing the blocks, Nick and Rob realised they had something unusual. They got in touch with Cindy Howells, a palaeontological curator at

Amgueddfa Cymru, who contacted dinosaur experts from the universities of Portsmouth and Manchester. The team analysed the bones and established that they were from a theropod dinosaur, and that it was a new genus and species. The skeleton is incomplete, with about 40% of the bones represented, but this is enough to reconstruct its appearance. Beautifully preserved claws and teeth were found and the animal appears to have been a juvenile as some of its bones are not yet fully formed.



The skeleton was found in five slabs of rock. Some bones were in skeletal position but most had been separated by the actions of scavenging fish and sea urchins. The rocks are of marine origin, containing echinoid remains that suggest the animal was swept out to sea after dying on the shore or falling into a river.

This new Welsh dinosaur lived at the very beginning of the Jurassic Period, 201 million years ago, making it one of the earliest Jurassic dinosaurs. It was a small, agile animal, approximately 50 cm tall, with a long tail to help with balance. It had blade-like, serrated teeth which suggest that it would have eaten insects, small mammals and other reptiles. It is related to the theropod *Coelophysis* found in rocks dating from 203 to 196 million years old from the south-western part of the USA.

continued overleaf



An artist's reconstruction of the newly discovered dinosaur

Illustration by Bob Nicholls
© Amgueddfa Cymru

The exquisite preservation of the skeleton, such as the bones of the theropod's hand shown above, has enabled palaeontologists to describe the dinosaur as a juvenile because some of the bones are not fully formed.

Photo © Amgueddfa Cymru



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Amgueddfa Cymru commissioned a reconstruction of the animal from the palaeoartist Bob Nicholls. He came to Cardiff to examine the bones before beginning the work. His image shows a coating of simple proto-feathers which are now known from theropod dinosaurs. These would have provided insulation. The animal may also have had simple quill-like structures for defence.

This new specimen is the first skeleton of a theropod found in Wales. Isolated teeth and bones of other dinosaurs are known from South Wales and a piece of jaw bone containing several teeth, belonging to a relative of *Megalosaurus*, was found near Bridgend. Other evidence may be seen on the exposed surfaces of Triassic rocks at the coast near Barry where dinosaur footprints occur. The majority are small three-toed prints probably made by a small theropod, similar to the new dinosaur. In the 1950s a partial dinosaur skeleton was discovered in Triassic rocks near Cowbridge. This was also a juvenile, and is named *Pantydraco caduci*. It was a small, plant-eating sauropodomorph related to *Thecodontosaurus*, found in rocks of a similar age near Bristol. This specimen is housed in the Natural History Museum.

The new Welsh theropod will be on display in the main hall of National Museum Wales in Cardiff until the end of August 2015 and it is hoped it will go on permanent display there in the future.

A close-up of one of the slightly curved teeth shows the sharp, serrated edges.

Photos © Amgueddfa Cymru

The opening of the exhibition attracted media attention from across the globe. At the launch, wildlife television presenter Dr Rhys Jones enthused pupils of Ysgol Gymraeg Melin Gruffydd about the importance of the new dinosaur.



Smith's enduring map legacy on show

TOM SHARPE

Lyme Regis Museum and Cardiff University, and formerly Curator of Palaeontology and Archives, Dept of Geology, Amgueddfa Cymru – National Museum Wales

Geological maps are fundamental tools to a geologist. Displaying the distribution of different types and ages of rocks, they are the first step to understanding the geology of an area and key to the search for raw materials. Today, the whole of Britain has been mapped, largely through the official agency, the British Geological Survey.

But 200 years ago, geology was a new science and the Survey had not been established. The Industrial Revolution was in full swing and the demand for coal, iron and limestone was huge. Landowners, keen to find coal on their properties, were being exploited by itinerant surveyors who, through greed and ignorance, persuaded them to fund searches where coal was never likely to be found.

William Smith, a surveyor from Oxfordshire, realised that a map showing where different rock strata came to the surface would be of value to both landowners and surveyors, not just for locating coal but also for agriculture, showing the different rocks and soils. It would take him almost 15 years to complete.

Smith was born on 23 March 1769 in the Cotswold village of Churchill where his father was the blacksmith. He had a limited schooling but at the age of 18 he was taken on as an apprentice surveyor in the practice of Edward Webb in Stow-on-the-Wold. He showed an aptitude for measurement and mathematics and an eye for the shape of the land. In 1791 Smith was sent to survey and value coal mines in the Somerset coalfield south of Bath, and two years later was appointed to survey the route for a new canal to transport coal from the mines.



National Museum Wales holds the world's largest collection of beautifully hand-coloured William Smith maps. This allows comparison of the different iterations as Smith continually altered the map as new information became available.

Image © Amgueddfa Cymru

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During the six years that Smith worked on the Somerset Coal Canal, he made two fundamental discoveries. The canal was to be constructed in two branches in adjacent valleys and Smith noticed that the sequence of rock layers was not only the same in each valley but that the layers were always tilted towards the south-east. During his travels to examine other canal routes, Smith realised that the strata of southern England always occur in a regular order and all were tilted in the same direction. His other discovery was that certain fossils were associated with particular strata, meaning that he could use the fossils to identify where a layer of rock lay in the strata sequence.

The practical application of these discoveries was immediately obvious to Smith. Coal occurs in association with grey mudstone, but such rocks appear in several places in the sequence, both far below and above the coal. Using fossils, he could identify which grey mudstones were part of the coal beds and which were not, and with his knowledge of the sequence of strata, he could construct a map showing where the different rocks were present at the surface and where coal could be found.

When Smith explained his work to friends Joseph Townsend and Benjamin Richardson on 11 June 1799, they persuaded him to publish his discoveries in order to receive credit for them and, possibly, reward. That evening, he dictated the order of the strata to his friends and soon handwritten lists of the sequence of rocks from the coal up to the Chalk were in circulation. Soon afterwards, Smith sketched a map showing the rocks of the Bath area and a small map showing some of the rock outcrops extending across England. In 1801 he published a prospectus of his intended great work on the strata of England and Wales.

Over the course of the next 15 years, Smith travelled widely across the country, working on commissions as a land surveyor and drainer. As he travelled, he took note of the landscapes and the rocks, gradually accumulating the information needed for his map.

The map was eventually published late in 1815 by John Cary, a leading London mapmaker. *A Delineation of the Strata of England and Wales, with part of Scotland* was a monumental work. At a scale of five miles to the inch, it was huge, over eight feet tall and six feet wide. It was spectacularly (and expensively) hand-coloured. It sold at prices starting at five guineas for the map in 15 sheets, plus an index map and an accompanying Memoir. But although Smith's Memoir listed over 400 subscribers to his map, few had paid in advance, and as his map had taken so long to complete, some subscribers had died. We do not know how many maps were sold, but it may have been only about 350. *continued overleaf*



A portrait of English geologist William Smith (1769-1839) by French painter Hugues Fourau (1803-1873)

Photo by Wikimedia Commons

Smith also further developed the use of the geological cross-section to illustrate the relative relationship of the strata to each other. The cross-section below covers the area from Snowdonia (left) to London (right).



Image © Amgueddfa Cymru

EXHIBITIONS

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During the years of its production, Smith continually altered the map as new information about the distribution of the strata became available. There are at least five different issues.

Within five years, Smith's map was eclipsed by another, in places more detailed, map, the product of the collaborative effort of members of the Geological Society of London under its first President, George Bellas Greenough. And within 20 years of the publication of Smith's map, detailed geological mapping came within the remit of a new, government-funded Geological Survey of Great Britain.

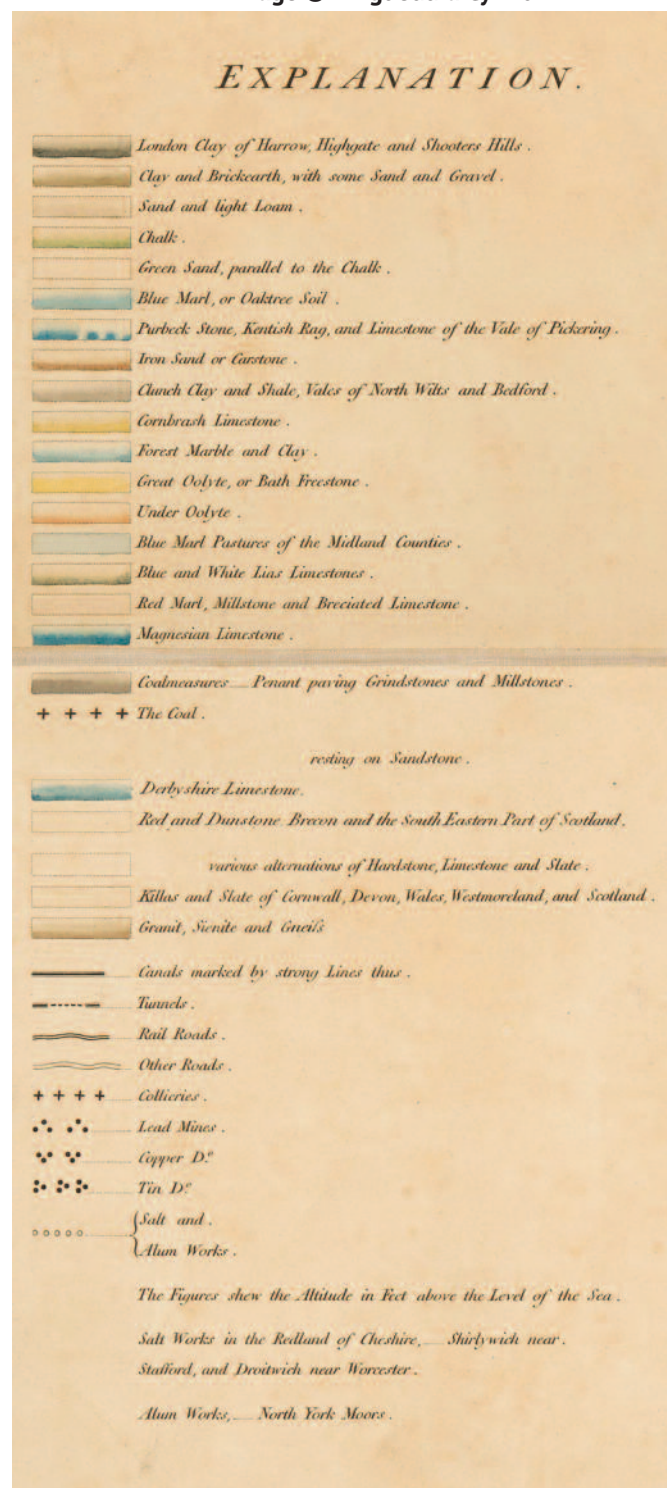
Smith's beautifully coloured map, however, remains an icon of the science of geology and is widely regarded as the first true geological map of any country. It is also the more remarkable in that it represents the work of one man, who single-handedly mapped, for the first time, over 175,000 square kilometres of Britain.

Today the map is much sought-after by collectors and commands serious prices (currently there is one for sale in London for over £90,000). The number of extant copies is being researched, but it is likely to be around 150. The Department of Geology (now Natural Sciences) in the National Museum of Wales uniquely holds nine complete or partial copies of the map, more than any other institution in the world, thanks to the foresight of its first keepers, Frederick J. North, Douglas A. Bassett and Michael G. Bassett. North, in particular, rapidly established the Geology Department's map and archive collections as some of the most important in the country and they have been built upon by his two successors. The National Museum is the only place in the world where almost all the different issues of the map can be examined side by side.

To commemorate the bicentenary of the publication of Smith's map, lectures, events and exhibitions are being held around the country. Smith's maps will be the focus of a new exhibition *Reading the rocks: the remarkable maps of William Smith* opening in the National Museum Wales in Cardiff on 26 September and running through to 28 February 2016. Admission is free.

See also *Earth Heritage Extra 1* (included as an addendum at the back of this issue of *Earth Heritage*).

Even the keys to Smith's maps were painstakingly hand-coloured.
Image © Amgueddfa Cymru





Scotland Rocks with generous sponsors

RACHEL HAY

Royal Scottish Geographical Society (RSGS)

The third 'Scotland Rocks' conference for Higher Geology and Geography pupils and teachers was again a resounding success. Held in Perth, 45 pupils attended from 12 schools across Scotland, including Alness Academy, Larbert High School, Perth High School, Robert Gordon's College, Speyside High School, St Margaret's School for Girls, Torry Academy and Ullapool High School.

The 2015 conference was generously supported by the Mining Institute of Scotland Trust, the Institute of Materials, Minerals and Mining, Edinburgh Geological Society, Education Scotland, the University of Dundee and the Open University.

As in previous years, the conference field trip, run by Ruth Robinson and the GeoBus team from the University of St Andrews, was based around the Carboniferous outcrops in St Monans, Fife. 50 pupils and teachers braved the cold and wet weather to map the spectacular sedimentary rocks, an anticline, and the impressive basalt intrusion and pyroclastic deposits on the wave-cut platform around St Monans Kirk. The 'geological treasure hunt' enabled everyone to focus on finding particular geological features, including many fossils, bringing some of the Higher Geology course material to life.

Pupils and teachers had time to warm up before attending Hermione Cockburn's inspiring keynote presentation in Perth. Hermione spoke enthusiastically about her career progression, from studying geomorphology at university, to presenting *Fossil Detectives* for the BBC, to becoming the new Scientific Director of Dynamic Earth in Edinburgh. She eagerly promoted the study of Earth sciences and took the audience on an epic journey through geological history and theory, including (of course!) mention of James Hutton and Alfred Wegener. Hermione closed by encouraging pupils in the audience to find what inspires them and to do what they love.

Geology-related documentary presenter Dallas Campbell, with autograph hunters! Dallas's presentation encouraged the audience to be curious about the world, and to seize opportunities to learn about, and find inspiration from, the natural world.

Photo by Peter Buckley

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From preceding page

Later, while teachers discussed their experiences of delivering the new National qualifications, pupils heard from a range of people who have careers related to geology and physical geography. Enthusiastic presenters included Addy Pope from ESRI, Ronan McGarry from the Ordnance Survey and Rebecca Murray and Sally Homoncik from the British Geological Survey. This was followed by a 'careers speed-dating' session.

An evening reception at the RSGS HQ in Perth gave pupils, university students, academics, workshop organisers, and RSGS staff and volunteers a wonderful opportunity to meet, chat and explore the collection and exhibits in the RSGS's visitor centre. RSGS President Iain Stewart sent a pre-recorded video message welcoming everyone to the RSGS and encouraging them to make the most of the conference.

Dallas Campbell's infectious enthusiasm for his work on geography- and geology-related documentaries, including *The Treasure Hunters*, *Supersized Earth*, and the new *Britain Beneath Our Feet*, got the following day off to a great start. Dallas encouraged the audience to be curious about the world, and to seize opportunities to learn about, and find inspiration from, the natural world. Unfortunately, technology failed Dallas during his talk, but one teacher later commented that, "Dallas proved that you don't need ICT or video when you can passionately convey how exciting, relevant, important and fun Earth science is." Dallas' enthusiastic and amusing presentation was a real highlight of this year's conference.

Pupils then attended three pre-selected workshops, and teachers attended two workshops and a discussion about the future of Earth sciences, including geology, in the curriculum. Participants found out about minerals and grew their own crystals under the microscope, heard from current undergraduates and postgraduates about their experiences of studying geography and geology, developed adaptation plans for the increasing flood risk in a changing climate, and examined a sediment core from eastern Scotland to identify sea-level changes and past tsunamis. Some pupils went outside to learn about soil fieldwork techniques, whilst others learned about the use of Geographical Information Systems (GIS), a geologist's perspective on climate change, or links between rock type, landscape and people.

It was an action-packed weekend, which celebrated the study of physical geography and geology. Teachers expressed great disappointment that 2015 was the last year of the geology exam in Scotland. The RSGS is keen to continue discussions with the Scottish Qualifications Authority regarding a replacement for Higher Geology, so that Scottish pupils will still have the opportunity to learn about rocks and landscapes in Scotland, the cradle of modern geological thinking.



Hannah Stott gives school geology students a guided geological tour of the coastal geology at St Monans on the Fife coast.

Photo by Peter Buckley

Education – a cornerstone of GA objectives

CHRIS GREEN
Geologists' Association

The Geologists' Association came into existence in the mid-19th Century, a time when the benefits of a broadly based education were being widely recognised for the first time. The GA was founded by people who aimed to educate one another in the science of geology.

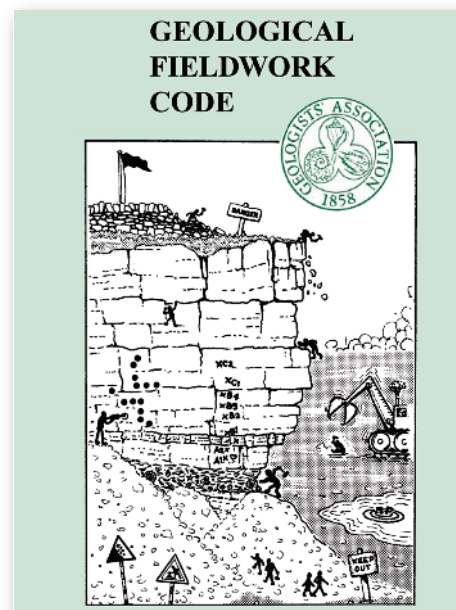
In its Rules, the objective of the GA is unambiguous – *To promote the study of Geology*. Throughout GA history, life-long learning has been an essential part of being a member; but more recently the Association has developed a wider vision that has included two areas of educational outreach – the education of the young, and the education of the wider public (including the education of the wider geological community). Indeed, one of the first GA initiatives to have an educational purpose was the *Code for Geological Fieldwork*. Within a year of publication, over 85,000 copies had been distributed – to regional geological and natural history societies, to local museums, national parks, field-study centres, the Open University, and to 25 regional education authorities for onward circulation to schools and colleges.

In 1986, the GA's ability to play a positive, practical role in the wider community was enhanced by the establishment of the Curry Fund. Since its formation, the Curry Fund has made over 600 individual awards and disbursed about £613,000. Almost all the awards could be seen as educational by promoting the study of geology and making geological information more freely available, especially at the local level and in language accessible to the public, through leaflets, trail guides, way-marking and interpretative boards. However, Curry Fund support has also been given to geology within the more formal field of education. Grants have been made to supply study guides, maps, equipment and rock and fossil samples, and to promote geology within schools, colleges and universities. Since 1986, about 50 grants totalling just over £42,000 have been made to educational institutions or to provide educational resources.

Substantial grant funding

When the GCSE Examination was introduced in 1988, substantial grant funding was awarded to the Earth Science Teachers' Association to provide workbooks to support teaching of the new GCSE Geology course. More recently, grants have been awarded to the Earth Science Education Unit based in Keele University and to the Earth Science Education Forum. Support has been offered at all levels within the formal education system. Student initiatives have been supported at several universities. For instance, Bristol received grants to fund annual summer schools for visually impaired students and the Open University received grant support for its *Earth Heritage Conservation* course book, published in 1994. At the other end of the education pathway are two primary schools in which children learn about geology from geological gardens created within their school grounds, made possible by Curry Fund

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Within 12 months of its publication, more than 85,000 copies of the *Geological Fieldwork Code* had been distributed.

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grants; and not just primary schools – the National Botanic Garden of Wales attracted a grant to develop a geological garden, illustrating plants of the Palaeozoic and Mesozoic using modern analogues.

Local authority education departments have also received grants. In 2003 the fund paid for 42,000 leaflets to be distributed by Durham County Council to its primary schools to promote *Jurassic*, a local geological exhibition and events programme; and in Devon the fund enabled the County Council to create a register of educational fieldwork localities.

Outside the formal education system, initiatives by RIGS groups, field centres, museums and others have been supported, to provide teaching material, in print, online or hands-on. The Rock Circus in the village of Box, near Bath (www.boxrockcircus.org.uk), is a striking example of such an initiative aimed at young children.

Online resources

As might be expected, recent support has often been for online initiatives. The Durham University PubVolc.net website is a literature database of recent volcanology articles; the earthlearningidea.com website provides a store of innovative resources for teaching geology and physical geography to all ages from early years to A-level; and Mike Tuke's earth-science-activities.co.uk website 'gives you a thousand and one ideas to enliven your geology teaching'. Curry Fund grants awarded to educational institutions are not always directly related to day-to-day teaching. Several university conferences and workshops have been supported and funding has been provided for the conservation of museum and teaching collections.

The support for geological education offered by the Geologists' Association is not limited to the grants offered by the Curry Fund. Using other resources, it now has four separate awards of between £600 and £2,000 for students following degree courses in the Earth sciences at undergraduate or MSc level (geologistsassociation.org.uk/awards). In addition, when the Joint Association for Petroleum Exploration Courses (JAPEC) was wound up in 2002 its residual funds, totalling £50,000, were gifted to the GA to form a special fund for the purpose of promoting geology among young people.

For both specialists and the wider public to understand, enjoy and respect the natural world around them, there has to be a place for geology wherever education is offered. The GA has a distinguished record of providing the resource to further this objective.



The Rock Circus at Box, near Bath, is a striking example of an initiative outside the formal education system.

Photo by Geologists' Association



A decade of telling the Anglian geoheritage story

TIM HOLT-WILSON

With its subdued relief, East Anglia lacks the dramatic features of upland, hard-rock Britain, but from an imaginative point of view it is blessed with raw material for Earth heritage interpretation. It has rich sedimentary archives of Pliocene and Pleistocene wildlife; award-winning early Cretaceous rock exposures at Hunstanton Cliffs; abundant lowland glacial deposits and landforms; an extremely dynamic coastline; and fascinating evidence for earliest human settlement.

The last half century has seen major advances in our understanding of East Anglian geology, particularly Plio-Pleistocene stratigraphy and ecology, and has seen several significant Palaeolithic excavations. It is increasingly possible to produce coherent interpretative projects based on these discoveries. Accordingly, the last two decades have seen a surge in Earth heritage interpretation in the region.



A life-size puppet replica of the West Runton Elephant by Tin House Arts catches imaginations on West Runton beach, Norfolk in August 2014. The replica celebrated the 1990 discovery of the 600,000-700,000-year-old bones in the West Runton Freshwater Bed – type locality of the Cromerian Interglacial.

All photos by Tim Holt-Wilson

Interpretation draws on a different skill-set from science. 'The map is not the territory', as Alfred Korzybski famously said. While geoscientists are busy investigating and mapping the 'territory', communicators wrestle to interpret the 'map' of their findings for wider society. Earth heritage interpretation is still unfamiliar for most people, so it needs to make links with facets of biological and cultural heritage if it is to engage wider, non-specialist audiences. This is likely to mean partnership working between organisations, and imaginative methods of delivery to catch people's imaginations. Tried and tested media include books, leaflets, trails, websites, podcasts, museum displays and outdoor panels. Developments in technology offer new opportunities, particularly digital animation techniques, 3-D printing and augmented reality applications that bring contextually linked content directly to smartphones. The limitless field of the creative arts can be harnessed to bring imagination to environmental interpretation (for state-of-the-art practice visit the Landesmuseum Natur Und Mensch at Oldenburg, Germany).

Here are some examples of geoheritage communication projects for non-specialist audiences in East Anglia over the last decade, or that are currently underway.

Blakeney Esker Explored

Interpreting this glacialigenic landform with an online set of teaching aids supported by outdoor information panels created by the British Geological Survey. It makes the links between geology and local wildlife. <http://tinyurl.com/q4e7q4d>.

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Breckland Geoheritage

A new interpretative project in Breckland, 2015-2016. Under the *Breaking New Ground Landscape Partnership* initiative funded by the Heritage Lottery Fund, it has four strands:

- An Earth heritage trail, leaflet, website and smartphone 'app', covering 20 sites.
- A series of three 'Ice Age Brecks' day schools
- A church stones day school
- A day school on Earth heritage for land managers

<http://tinyurl.com/p2a26rm>.

Chalk East – Valuing chalk landscape and geodiversity in the East of England

A website explaining chalk geodiversity, created to support projects run by members of Geo-East in 2009-2010.

<http://tinyurl.com/orxdzzq>.

Discovering Doggerland

A creative arts project by Waveney and Blyth Arts, Suffolk, 2015, drawing on the evidence for coastal changes in the North Sea area since the last Ice Age to produce work touching on a theme of lost landscapes. <http://tinyurl.com/o8au2mu>.

The Great Estuary Story

An animated video by the Broads Authority, 2013, interpreting the origins of the Great Estuary that underlay the Broads area 2,000 years ago.

<http://tinyurl.com/qfg62o5>.

Humans in Ancient Britain

An exhibition at the Time and Tide Museum in Great Yarmouth (to September 2015) interpreting the story of earliest human settlement using museum collections and 3-D printouts of early Pleistocene human footprints from Happisburgh.

<http://tinyurl.com/me46m7b>.

Mousehold Heath Earth Heritage Trail

An 18-point trail around Mousehold Heath, Norwich, exploring the links between glacial geology, biodiversity and industrial history, with a supporting website at <http://tinyurl.com/ls6yfp6>. See also *Earth Heritage* 43.

The Naze Education and Visitor Centre

A new interpretation centre at Walton-on-the-Naze opens in 2016, with 50% of the displays focused on local Red Crag geology. <http://tinyurl.com/qfchns5>.

The Pliocene Forest

An arboretum of Pliocene tree genera created by GeoSuffolk at Sutton Knoll, near Woodbridge - a classic site for Pliocene geological research. See broadsheet at <http://tinyurl.com/qcqeamg>. Also see *Earth Heritage* 42.

The Suffolk Mammoth Trail

Outdoor panels at seven publicly accessible sites interpreting Pleistocene wildlife from Norwich Crag times to the Devensian cold period. <http://tinyurl.com/qd8fblx>.

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Flint knapper John Lord making an Acheulean-style handaxe as part of the Ice Age Brecks day school, April 2015.



A video Interpreting life and death in the Cretaceous chalk sea at the Stockwood Discovery Centre, Luton.

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'Tides of Change – 2 million years on the Suffolk Coast'

A 30-page colour booklet interpreting the story of coastal change seen through Suffolk's rocks and landforms. Available in printed or PDF formats via <http://tinyurl.com/oqyxu3a>.

Whitlingham Lime Burn

A demonstration lime-burning project at Whitlingham Country Park, Norwich, 2010, with associated historical walks and talks; delivered as part of Chalk East project work. <http://tinyurl.com/qfmleq2>.

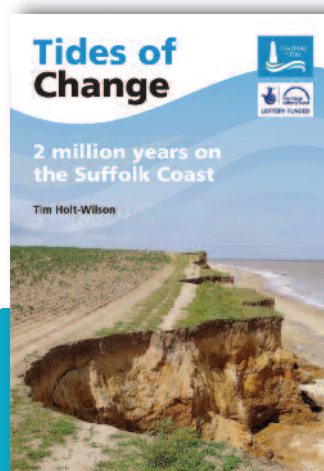
Looking to the future

Potential growth areas for geoheritage communication in East Anglia include:

- Geotourism, particularly in the AONBs on the Norfolk and Suffolk coasts and perhaps linked to the GeoPark concept;
- Education work relating to the recently revised National Curriculum in geography, with opportunities related to climate change, glaciation and coastal processes, backed up with field trips;
- Arts projects exploring creative responses to evidence for environmental change over deep time;
- Expanded use of digital technology and social media.

As technology changes and geoscientists and archaeologists make further discoveries in the region, the potential for creating ever-more interesting geoheritage communication projects will grow.

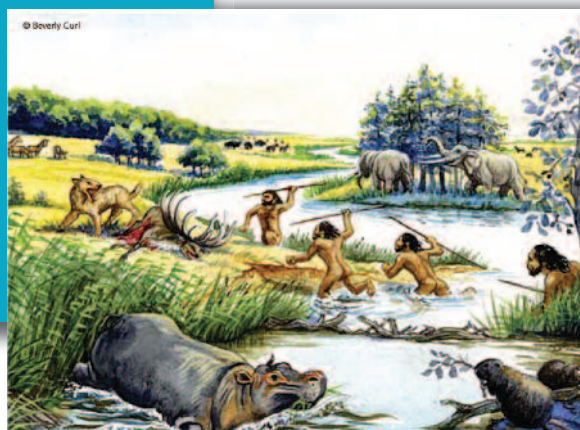
Dr Roger Dixon explaining aspects of local geology on a panel beside the public footpath at Sutton Knoll, Suffolk. The 'Pliocene Forest' tree nursery can be seen in the background.



Suffolk's coastal geology explained

"The Suffolk coast is a frontier landscape where the North Sea recycles land, a process which has been happening for million of years." These are the opening words of a richly illustrated new booklet, *Tides of Change*, introducing the coastal geodiversity of Suffolk to a broad audience. Through visiting a range of publicly accessible geological features and landforms, the booklet delves into two million years of Earth history.

Photographs, maps and illustrations abound, and a comprehensive glossary provides more details of geological terms to interested readers. Written by Tim Holt-Wilson and published by the HLF-funded *Touching the Tide Landscape Partnership* programme in the Suffolk Coast & Heath AONB area. *Tides of Change* is available as a free downloadable pdf at <http://tinyurl.com/ok9zesd>, or to buy as a paperback direct from the project at www.touchingthetide.org.uk/contact-us.



Maximising geology in the tourism package

BECKY SHAW and MAREN EBELING
Scottish Natural Heritage

Scorching deserts, erupting volcanoes, mountains the height of the Alps, active geological faults, kilometre-thick ice sheets and deep-ocean floors – all a world-away from Scotland, or so you might think. But if you look at the rocks and landscapes of Scotland today, the geological evidence for all this and more is there to be seen. Despite landscapes being a key part of what visitors come here to experience, geology is still often neglected as a Scottish tourism ‘product’. Geodiversity Familiarisation trips run by Scottish Natural Heritage (SNH) are one way to turn that around.

In order to raise tourism professionals’ confidence in ‘talking geology’ with visitors and to promote geodiversity tourism, SNH has taken tourism providers (guides, accommodation providers, information centre staff) to some stunning sites. In tandem with museums which captivate visitors with objects that tell the stories of the world, interpretation of our geological heritage can unlock visitor understanding and enjoyment of a landscape.

SNH has run two geology-themed familiarisation trips thus far this year, in the stunning surroundings of the North West Highland Geopark and on the island of Bressay, part of Geopark Shetland. Both attracted interest from local tourism businesses and VisitScotland staff, keen to find out more about the geology on their doorstep, its value as a tourism asset and how it could be more effectively utilised.

The trip around the North West Highland Geopark started at Knockan Crag National Nature Reserve where Laura Hamlet, the NWH Geopark information officer, explained the historical significance of the Moine Thrust fault in world geology. The group stopped to look at the newly revamped interpretation in the *Rock Room*, complete with multi-lingual, talking Peach and Horne statues – beloved of small children and bigger children too, it seems!

Then the group headed up the Crag to reach the Moine Thrust, where huge footprints show you how to stand either side of the fault. Many of the group had been there before but without the benefit of a guide. The presence of enthusiastic geologists helped convey the key stories.

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Earth
heritage



Sue Agnew, SNH Area Officer, describes the interpretation in the *Rock Room* at Knockan Crag National Nature Reserve.

Below, Peach and Horne appealing to a younger visitor, on a noticeably warmer day. Photos by Becky Shaw/SNH



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From Knockan Crag, the group ventured north, following parts of the *Rock Route*, the interpretative trail throughout the geopark, stopping to view some fascinating landscapes from the roadside (which was greatly appreciated in the weather conditions!). In Unapool, by Kylesku, in a setting which could scarcely be more dramatic, the group enjoyed a look at the *Rock Stop*, a brand new exhibition and interpretative space which will open in summer 2015 (*see following page*).

Our guides to the Geopark, Laura and Pete Harrison, were delighted to answer questions during the day. Looking at the landscape through their eyes brought a whole new understanding to the incredible landforms.

An equally informative event took place in Shetland. This group got feet (and everything else) wet by exploring the geology of the island of Bressay from the sea, the highlight being a swim into a sea cave at Muckle Hell (Scots/Norse for 'big rocky place'). Due to breeding shags, the time in the cave was kept to a minimum, but it was an impressive experience to see the sandstone crags from the water level. Back on dry land, Shetland's Geopark officer, Robina Barton, and SNH's Jonathan Swale took the group on a walk to explain the island's fault lines and volcanic vents which provide evidence of a turbulent geological past. Bressay is a sandstone island and the group saw evidence of that, not only in the rock formations but also in the drystone dykes and croft buildings which testify to the importance of the island's geology to communities over the centuries.



The Bressay Coastline in Geopark Shetland

Photo by Billy Fox Photography

Familiarisation trips are useful for introducing the tourism business to geotourism. However, these two trips also demonstrate the benefit of knowledgeable guiding in inspiring interest and engagement, something for tourism businesses, and those promoting geotourism experiences, to consider. It raises the possibility of groups of businesses organising guided walks rather than relying solely on business derived from self-guided tourism. There is therefore plenty of scope for discussion at the *Sharing Good Practice on Geotourism* event in November being organised by SNH and the Scottish Geodiversity Forum.

Good practice on geotourism

Sharing Good Practice on Geotourism, Battleby Centre, Perth, 25 November 2015

In partnership with the Scottish Geodiversity Forum, Scottish Natural Heritage will be running a Sharing Good Practice event entitled *A world-class visitor attraction – Scotland's landscape, fashioned by geology*, at Battleby Centre, Perth on 25 November 2015. Commencing with an assessment on the level and state of geology-based tourism in Scotland, the event will explore how the sector could develop and be expanded. VisitScotland will be a partner at the event which is designed to encourage participation of existing tourism facility providers and others keen to utilise Scotland's geodiversity resource. For further information visit <http://tinyurl.com/nc6bxy9>.

Earth science visitor facility unveiled

In the summer of 2015 the North West Highlands is due to be the first Geopark in Scotland to have a dedicated Earth science visitor facility. Dubbed *Rock Stop*, the facility is perfectly located for those exploring the *Rock Route*, the driving trail established by Scottish Natural Heritage to link together key geodiversity sites in the North West Highlands.

Sited at Unapool, in Glencoul, the *Rock Stop* occupies one of the most scenically dramatic places in Britain. A deep fjord carved through stunning landscape here gives a great section through the classic geological structure known as the Glencoul Thrust, one of the most photographed features in world geology.

Visitors can enjoy this view from the coffee shop and learn about it in the exhibition. The British Geological Survey has helped produce a video explaining the ethos of geoparks and the links between culture, wildlife and the incredible geology in the North West Highlands. This provides the perfect introduction to interactive exhibits on mountain building, glaciers and beaches. Visitors can also shop for crafts provided by local artisans. The concept for an Earth science visitor facility was discussed with local people in a survey in 2014.

The Geopark exists to Explore Deep Time, Evoke a Sense of Place and Encourage Stewardship. This means encouraging adventures for everyone, to help people connect with the land and feel responsible for maintaining its beauty, wildlife and resources. It is currently implementing a five-year plan to continue landscape interpretation, adventure activities and educational projects. Long-term goals are a climbing centre in Lochinver and a new geocentre in or near Scourie – the Eden Project of the North West Highlands!

LAURA HAMLET, North West Highlands Geopark



North West Highland Geopark's *Rock Stop* visitor facility at Unapool above Loch Glencoul.

Photo by Laura Hamlet

Geopark café draws on link to Darwin

Lochaber Geopark has named its new café and visitor centre, *Darwin's Rest*, to commemorate the visit of Charles Darwin to Glen Roy in 1838. He came to view the puzzling Parallel Roads landscape. Darwin had seen raised marine shorelines in earthquake-prone Chile during his world voyage on HMS Beagle. He had been most impressed and thought that the Glen Roy features were marine shorelines that had also been uplifted from sea level. However, two years later a Swiss geologist, Louis Agassiz, came to study the shorelines. With his alpine experience, he recognized many features to be of glacial origin and proposed that the shorelines were created by ice-dammed lakes, the Glen being blocked by advancing glaciers, the lake water levels controlled by the heights of overflow spillways.

Today, there is an excellent viewpoint in Glen Roy from which to view the Parallel Roads. Lochaber Geopark recently placed interpretation panels on a rebuilt plinth, originally installed by Scottish Natural Heritage. The short climb up the hillside from the viewpoint enables the visitor to observe just how precise the shorelines still appear, how exactly the various hillside shore sections line up. As well as feasting on the landscape, visitors can now refresh themselves at Darwin's Rest café seven days a week, 10-4, with lunches, locally baked cakes and coffee made by the Lochaber Geopark barristas!

JIM BLAIR, Chairman, Lochaber Geopark



Boards provide knowledge about the origins of the Parallel Roads while (below) visitors can refresh themselves at the Darwin's Rest café.

Photos by Colin MacFadyen



Coal's legacy: science, education and tourism

MIKE BROWNE and GRAHAM LESLIE, BGS Scotland

With a history dating back to at least the 13th Century, shallow and deep mining for coal ceased in Scotland in 2002. However, coal is still quarried and up until 2010 accounted for a third of the UK opencast coal production. Since then, and by April 2013, changes in world coal markets precipitated the financial collapse of two of the main Scottish opencast coal operators. After the liquidators had completed their work, a residue of seven unwanted sites remains in Ayrshire and Lanarkshire, all lacking the necessary funding for full restoration that would normally include infilling all rock excavations.

Turning what might be regarded as an environmental disaster into a potential asset, there is a unique opportunity to deliver permanent geoconservation sites, geological education and research at two of the seven sites, Spireslack in East Ayrshire and Mainshill Wood in South Lanarkshire. Both currently present unique, stunning and dramatic exposures in Scottish Carboniferous coal geology.

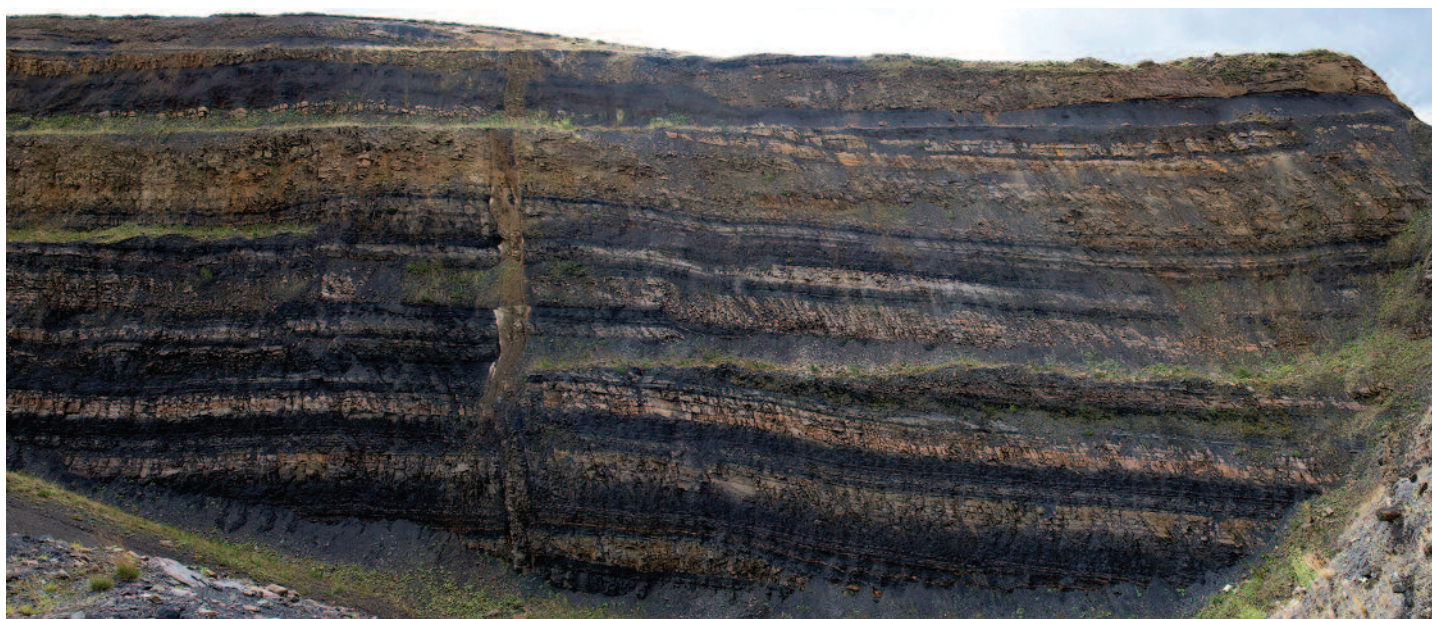
Bedrock in Central Scotland is often concealed by thick unconsolidated Quaternary deposits. Accessible and informative exposures of the important Carboniferous coal-bearing sedimentary strata are rare and limited in scope, even in Sites of Special Scientific Interest such as the Garpel and Kennox waters in East Ayrshire and South Lanarkshire. The orphan opencast workings therefore provide an unrivalled opportunity to conserve, see and understand the geology of these economically and nationally important rocks.

Spireslack presents a semi-continuous, one kilometre-long, vertical high-wall section through a thickness of over 130 m of Carboniferous strata (*below*).

continued overleaf

Part of the high-wall section in the Spireslack 'canyon' through Carboniferous strata belonging to the Limestone Coal Formation and into the lower half of the overlying Upper Limestone Formation. The pavement below the Muirkirk Six Foot Coal can be seen in the lowest part of the excavation; the vertical basaltic dyke (left centre) is Palaeocene.

Image by Brian McIntyre, BGS
– P914257



QUARRIES & GEOCONSERVATION

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These belong to the uppermost Lawmuir Formation, Lower Limestone Formation (Hurllet and Hosie limestones), upwards through the whole of the Limestone Coal Formation and into the lower half of the overlying Upper Limestone Formation (up to the Calmy Limestone). The Limestone Coal Formation is one of the main coal-producing units in Central Scotland. Evidence of earlier 19th/20th century mining practice is still visible in the high-wall face where an intact but somewhat crushed part (stoop) of the Muirkirk Nine Foot Coal is juxtaposed laterally with packed mine waste (in collapsed-room or short-wall working).

When originally deposited, the Spireslack strata would all have been in horizontal beds. Now, after broadly compressional deformation in the mid- to late-Carboniferous, they dip south-eastwards at c. 30-40° across the canyon, and are now arranged on one limb of a broad synclinal fold. Folding was accompanied by faulting, the effects of which are clearly seen on the Hosie Limestones pavement on the north-west back wall of the site. At least five narrow basaltic dykes cut through the Carboniferous strata, intruded around 60 million years ago (in the Palaeocene).

Mainshill Wood presents a continuous vertical and lateral section through a thickness of over 400 m of Carboniferous strata. These belong to the Limestone Coal Formation (above the McDonald Coal), the overlying Upper Limestone Formation and then most of the Passage Formation. It is most unusual to see such a thickness of Carboniferous strata in one excavation. This is because a large proportion of the strata is now arranged vertically or nearly so, in itself a unique feature. Unlike Spireslack, the section is so disturbed by faulting and folding that the significant and principal feature of interest for conservation at Mainshill is geological structure rather than the succession, though the latter includes at least 11 locally named coal seams. Many of these are not exposed at surface anywhere else. The Upper Limestone Formation section exposes all the main limestones, namely the Index, Huntershill, Lyoncross, Orchard, Calmy and Plean limestones as well as the Ellenora and Gill coals.

The section in the Passage Formation is utterly unique and known otherwise only from the records of a few boreholes drilled to prove deep coal seams. The key features are the four thick Manson Coal seams (*right*), and associated marine mudstones with conspicuous shells.

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The four thick Manson Coal seams and associated marine mudstones exposed at Mainshill Wood; there are no natural exposures of the Manson strata anywhere else in Scotland.

**Image by Brian McIntyre, BGS
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It is more usually the case in Central Scotland, that the Passage Formation typically only contains a few coal seams up to about 30 cm thick. The fact that unusual thicknesses of coal-bearing strata could be accommodated in the depositional basin suggests perhaps an area of more active localised subsidence at the time, but away from the influence of river channels delivering sand.

Characteristic Carboniferous sedimentary rock types accessible on the two sites include marine limestone with visible fossil shells, marine and lacustrine mudstone, burrowed siltstone and sandstone, cross-bedded sandstone, flat-bedded siltstone and sandstone and rooted seat-rocks (soils), and coal. Ironstone also occurs as thin beds and nodules in the mudstone and as nodules in the rooted seat-rocks. The rock types can be read to show cycles of environmental change from shallow tropical seas, to advancing deltas and floodplains as sea-level fell across coastal areas, river channels, tropical soils and finally to tropical swamp forest. These 'cyclic' changes were symptomatic of sea-level changes occurring at a global scale at this time in the Carboniferous, some 330 to 315 million years ago.

Geoconservation potential now a focus

In October 2007, Spireslack 'canyon' had been put forward as a potential local geodiversity site (LGS) for The Glenbuck Geopark by the then operators, in discussion with Strathclyde GeoConservation Group, GeoConservationUK, East Ayrshire Council and BGS. These discussions have now re-surfaced when the Scottish Mines Restoration Trust (SMRT) set out to discover and help implement a solution that would deal with the seven orphan sites for Scottish Government. The geoconservation potential of Spireslack and Mainhill Wood is now a particular focus.

Those two sites provide a very strong link to the local natural and cultural heritage of Douglas and Muirkirk; synergy of these with the geological heritage should be viewed as a complete package. Spectacular exposures in the former opencast sites at Spireslack and Mainhill Wood can be held in trust for future generations and a rich geological story told. BGS and SMRT will work with others to unlock more of the secrets of both sites, and potentially others, through modern digital data and video accessible to all.

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Neglected footprints step towards new life

SUE BEARDMORE, Elgin Museum

The Hopeman Sandstone of Permian age from Clashach Quarry on the Moray Coast has been excavated for building stone since the mid-19th Century. Over the years, it has gained a reputation as a first-class building stone, being more resistant to weathering than other sandstones from Scotland. It has been used to build the Museum of Scotland in Edinburgh and other landmark buildings.

The same sandstone yields the main evidence for ancient life in the Moray area 250 million years ago, in the form of relatively abundant trace fossils, including many trackways. The first was discovered in 1852 and approximately 300 more have been recorded since. Variation in preservation runs from amorphous blobs to characteristic pits associated with crescent-shaped mounds or detailed outlines including toes, claws and tail drags. Some of the tracks are similar to those from contemporaneous sites in Germany and America while others are unique. Most are thought to have been made by reptiles scabbling up moderately sized sand dunes, which are indicated by the extensive cross-bedding in the sandstones.

The unprecedented range in size and form of trackways led to the setting up of the 'footprint amphitheatre' in 1999 through a collaboration between Moray Stone Cutters (operators of Clashach Quarry at the time), Carol Hopkins (a University of Aberdeen researcher), and staff at National Museums Scotland and Scottish Natural Heritage. The interpretative facility, at the entrance to Clashach Quarry, consists of a short looping path bordered by large sandstone slabs displaying different types of trackway. It won a Lasmo Geological Challenge award and demonstrated how quarrying activities can bring to light ancient animals and the worlds they lived in.

In 2007 the interpretative facility was still in relatively good condition with the slabs easily accessible. Only a few years later, it has become overgrown with aggressive gorse that obscures many of the slabs and even the amphitheatre entrances. The original interpretative panel came away from its plinth and is lost, leaving no explanation of the slabs, their importance or even that the display is there at all!

continued overleaf

The interpretative reptile footprint amphitheatre at Hopeman, Moray, in its heyday, around 2000.



Photo by Colin MacFadyen/SNH

The footprint amphitheatre now – overgrown by gorse and devoid of any interpretation.

Photo by Sue Beardmore



QUARRIES & GEOCONSERVATION

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While some deterioration of outdoor monuments is expected, the state to which this site has descended is especially poor. Frustratingly, the importance of the display has simultaneously grown, as there has been no recent systematic investigation of the quarried rock in Clashach Quarry for further fossils and the organised safeguard of finds. There are concerns now that the rock is being crushed for road stone. How to restore the amphitheatre and protect it into the future continues to be an issue. Attempts to clean the rocks of lichens have been ineffective, and it is too late to apply water-resistant treatments. Roofing the site, if affordable, would reduce weathering but the growth of lichen and algae would probably increase, and good light is necessary to see the imprints. A management group is needed to reactivate the interest and involvement lost through changing personnel and activity at the quarry and the moving away of the local researcher.

The good news is that such collaboration is being tentatively reinstated. At a meeting in April 2015, between the new lessee, staff at Elgin Museum (www.elginmuseum.org.uk) and Scottish Natural Heritage, it was reported that quarrymen are again finding footprint fossils in Clashach Quarry, suggesting there is still interest on their part. The stone is not immediately being crushed as feared, but sits as blocks in the quarry and cutting yard for several days, a time that could potentially be used to investigate and record new fossils. The next step is to find volunteers to undertake this task.

While the above is good news, the problems regarding the amphitheatre itself are no closer to being resolved. The hope is that interest and publicity generated through discovering new fossils might again raise local support, and, crucially, the funding necessary to ensure that the display, perhaps using new examples protected from weathering from the outset, remains a point of interest on the Moray Coast.

This block of Clashach Sandstone within the working quarry, quarried in 2011, shows two reptile trackways running parallel to each other. With the quarry operators once more setting aside such finds, there is again scope for adding to the footprint amphitheatre.



Photo by Colin MacFadyen

Conference celebrates Moray's heritage

Over 80 people attended the *Moray Geology: Past, Present, Future* conference at Elgin Museum in March to celebrate and promote its Scottish Government-recognised collection of Devonian fish, Permian and Triassic reptile and Permian trackway fossils. Mike Benton (University of Bristol) and Nick Fraser (National Museum of Scotland) were among the speakers and as well as fossils on display, there were illustrated letters from Hugh Miller and models of Devonian fish and early tetrapods. The weekend was concluded with visits to Cuttie's Hillock, known for dicynodont and rare reptile trackways, Lossiemouth, where the reptiles *Stagonolepis*, *Brachyrhinodon*, *Leptopleuron* and *Saltopus* were excavated, and the Moray Coast that offers stunning insight into the hot, arid, desert environment in which the reptiles left their tracks and traces 250 million years ago.

Elgin Museum is open Mon-Fri 10am-5pm and Sat 11am-4pm.

Probing mineralisation beneath Leicester SSSI

ADAM TAYLOR, University of Leicester

Gipsy Lane Brick Pit Site of Special Scientific Interest (SSSI), in north-east Leicester, is a remnant of one of the many quarries in the area which extracted clay of the Upper Triassic Mercia Mudstone Group. Here, an unusual occurrence of red-bed-style mineralisation of uranium, arsenic, copper, vanadium, nickel and cobalt minerals, with organic-rich nodules, is associated with gypsum beds.

In an area with extensive cover of Quaternary sediments, such as Leicester, it is easy to overlook the underlying geology. The Precambrian metamorphosed volcanic and sedimentary rocks of Charnwood Forest in north-west Leicestershire, world renowned for hosting *Charnia* fossils, are well exposed and readily accessed. However, the overlying Triassic sediments are rarely observed in natural outcrop.

Indeed, much of the study of the Triassic of the East Midlands is conducted via boreholes and temporary geological exposures unearthed during quarrying and in laying foundations for buildings. This is one reason for the conservation of this SSSI, along with conserving the unusual mineralisation hosted here.

During the Permian and Triassic periods, the UK experienced an arid climate. Following the Variscan Orogeny at the end of the Carboniferous (c. 300 million years ago), which was responsible for folding and deforming rocks observed in Cornwall and South Wales, rivers flowed north from these southern mountains. Subsequent Earth movements resulted in several north-south-oriented rift basins where sediments from these rivers accumulated. Towards the end of the Triassic the influence of these north-flowing rivers diminished, resulting in widespread deposition of mudstone, gypsum and halite of the Mercia Mudstone Group. The tectonic events of the time and the arid environment were essential precursors to the mineralisation.

At Gipsy Lane, a 2.5 m stratigraphy of near-horizontal mudstone with three principal gypsum beds is exposed.

continued overleaf

Geoconservation at Gipsy Lane

In the late 1990s Gipsy Lane Pit formed part of a large area of waste ground and was often subject to fly-tipping. In addition the site was fairly overgrown and the floor of the quarry often flooded. As part of the development of a new link road and light industry, the SSSI was protected by a metal fence and padlocked to prevent fly-tipping, the quarry floor was flattened and raised to reduce standing water. Fly-tipped rubbish was removed.

However, a new conservation problem has emerged. Due to the quarrying, the gypsum beds are now at the surface, where they naturally dissolve due to contact with surface water.

Natural England recently commissioned a drainage study which identified two causes of erosion:

- a steep embankment to the south of the gypsum exposure from which rainfall quickly runs-off.
- immediately above the exposure there is an area of ground which has slumped, due to partial dissolution of the underlying gypsum beds where surface water has pooled and then slowly infiltrated the gypsum beds below.

Management of this water is needed to conserve the SSSI, although given that gypsum naturally dissolves at surface, finding a long-term solution may be difficult.

– HANNAH TOWNLEY, Natural England



In the early 2000s Gipsy Lane Pit was overgrown and subject to fly-tipping and flooding.

Photo by Hannah Townley

From preceding page

The rocks are mostly red, owing to widespread iron oxide cement. However, they're not all red! Green colouration to the mudstone is common, caused by the reduction of red ferric iron (Fe^{3+}) to grey-green ferrous iron (Fe^{2+}). Within this green reduced clay are mineralised black spheroids, ranging between organic-rich and organic-poor endmembers. The organic-rich spheroids represent the primary mineralisation, and comprise coffinite (uranium silicate) and solid aromatic hydrocarbons, with rare inclusions of copper sulphides. Progressing to organic-poor spheroids, organic matter is replaced by secondary safflorite (CoAs_2) and chalcocite (Cu_2S) to form a replacement spheroid of copper sulphide and cobalt-nickel arsenate.

Red-bed-style mineralisation typically involves low to moderate temperature hydrothermal brines. During early diagenesis in arid environments, oxidised brines help decompose sedimentary minerals, releasing any contained metals. Red iron oxide cements are also formed.

The solubility of different metals and the degree of adsorption of elements to clay and iron oxides depends on groundwater conditions (chiefly oxidation state, pH, and salinity). Certain metals may dissolve into or be precipitated from the fluid, depending on conditions. This accounts for the wide variation in metal enrichments within similar deposits worldwide.

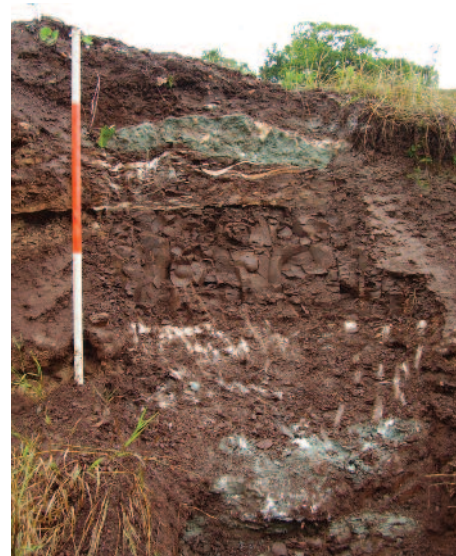
Redox (reduction-oxidation) reactions are essential in the formation of these deposits. The contact of oxidised metal-bearing fluids with organic matter creates reducing conditions where many metals (for example Cu, Pb, Zn) are less soluble, and are often an essential trigger for the precipitation of ore. The deposits at Alderley Edge SSSI in Cheshire are one example. Here, copper-dominated mineralisation is hosted within grey-coloured reduced sandstone adjacent to a fault. The ore formation involves the mixing of metal-bearing brines with hydrocarbons (sourced from the underlying Carboniferous Coal Measures).

At Gipsy Lane, Coal Measures also underlie the Triassic strata so coal hydrocarbons probably helped mineralisation here. Organic-rich mineralised spheroids represent bitumen which solidified from migrated fluid hydrocarbons, by oxidation, bacterial metabolism and radiation (from uranium in hydrothermal fluids). The change in oxidation state to more reducing conditions brought on by these hydrocarbons, caused the initial precipitation of copper sulphides and the green colour in the clay.

Arsenic is the most abundant element in the secondary mineralisation, replacing the initial organic spheroids. Unlike copper, arsenic is insoluble in oxidised solutions yet highly mobile in moderately reduced organic-rich solutions. Arsenic was therefore able to migrate towards sites of mineral precipitation around the initial bituminous spheroids, where bacteria were probably influential in forming safflorite (CoAs_2).

Copper, uranium, arsenic and cobalt are all likely to be derived from groundwater solutions whilst nickel and vanadium were possibly introduced through the hydrocarbons. Oils from many world production fields are rich in these elements. Remobilisation of these metals during the breakdown of organic matter probably led to their enrichment in the secondary organic-poor spheroids.

Similar organic-rich and organic-poor mineralised reduction spheroids are common throughout Britain; for instance in the cliffs along the south Devon coast at Budleigh Salterton. However, the research on Gipsy Lane is significant, as a clear genetic link is established between organic-rich and organic-poor spheroids. This is something which is not commonly observed. It will hopefully pave the way for future research.



One of the sections after clearing of the rock face. Lower and upper green clay beds containing abundant gypsum nodules are now visible. It is within these beds that the highest abundances of mineralised black spheroids are observed. Sections on pole are 0.5m. See also *Coal's legacy* – p.22.



A mass of multiple black spheroids on the surface of a rain-washed gypsum block in the west corner of the site. A mass of pink erythrite (cobalt arsenate) encloses the black spheroids. Thumb for scale.

Photos by Adam Taylor

Further reading

Bateson, J.H. & Johnson, C.C. (1992). *Reduction and related phenomena in the New Red Sandstone of south-west England*: British Geological Survey Technical Report WP/92/1, 16pp.

Faithfull, J. & Hubbard, N. (1988). *Coffinite from Gipsy Lane brickpit, Leicester*: Journal of the Russell Society, 2, 25-28.

Naylor, H., Turner, P., Vaughan, D., Boyce, A. & Fallick, A. (1989). *Genetic studies of red bed mineralization in the Triassic of the Cheshire Basin, northwest England*: Journal of the Geological Society, 146, 685-699.

Evidence gathering vital to good geoconservation

COLIN PROSSER, Natural England

Decision making about what to do, how to do it, who to do it with and in what order, is usually far better when informed by the evidence available. This is certainly the case with the conservation and management of geodiversity and the wider natural environment.

In order to understand more fully the evidence available to support its work and, just as importantly, to identify the evidence gaps that need to be filled, Natural England has undertaken a series of evidence reviews to identify priorities for evidence gathering. One of these reviews, a *Summary of Evidence for Geodiversity*, sets out an assessment of what is known, what is the subject of active research and debate and what is not yet known. The review will be regularly updated as new challenges requiring new evidence emerge and as the evidence base grows. This may be through targeted research projects, articles in *Earth Heritage* or peer-reviewed publications such as *Geoheritage* and the *Proceedings of the Geologists' Association*; the latter is now regularly publishing descriptions of Geological Conservation Review (GCR) sites, as well as more general papers on geodiversity and geoconservation.

Reviews under way

The *Summary of Evidence for Geodiversity* describes the importance of geodiversity to science and education and in providing ecosystem services that bring wider social and economic benefits. It recognises that the GCR and Local Geological Site series provide strong evidence underpinning the conservation of internationally, nationally, and locally important geodiversity and that monitoring data from these sites provide important, but not complete, evidence about the condition of England's geodiversity. The review acknowledges that much is known about how to conserve and manage geodiversity features and sites. However, some evidence gaps have also been identified (see box, right).

Despite the current economic climate, Natural England hopes that innovative thinking and partnership working will result in the evidence base relating to geodiversity and geoconservation being developed in many different ways and through many different bodies and individuals in the years ahead.

Natural England has already started to review some areas of the GCR, for example tufa and evidence of early human occupation, and is also reviewing the evidence underpinning the conservation and management of geodiversity features and sites. It is hoped that this *Summary of Evidence for Geodiversity* will help drive the process of evidence gathering as well as prompting wide debate about the priorities and how best to meet them.

The *Summary of Evidence for Geodiversity* can be seen at <http://tinyurl.com/qhar2w4>. It is a dynamic document and any thoughts on its accuracy, content, or how existing evidence gaps can be filled, will be gratefully received.



Natural England has started to review tufa GCR sites. Here, tufa barrages are forming at Brook Bottom, one of the potential new GCR sites.

Photo by
Hannah Townley, Natural England

Mind the gaps

Evidence gaps include

- some areas of the GCR, where advances in science mean that some targeted review of the GCR is required;
- the need to have a better understanding of the condition of Local Geological Sites;
- the fact that little is known about important geodiversity features in the wider landscape or in the marine environment;
- the need to know more about how to manage the impacts of new threats to geodiversity sites, such as those arising from climate change or the increasing use of wire mesh to stabilise rock faces;
- the need to assess the effectiveness of the planning system in delivering geoconservation; and
- the need to articulate, far more effectively, the role of geodiversity in providing ecosystem services and in supporting adaptation to climate change.

The wider landscape

GARY CHARLTON, Natural England

Natural England Chair, Andrew Sells, has outlined how a wider understanding of our landscape can help provide some answers to big national challenges.

Heading a list of prominent speakers at a landscape symposium hosted by Natural England, Historic England and Newcastle University, Andrew emphasised that “as well as being an important connection to our past, landscapes are vital to our future. They are living, breathing and evolving systems – shaped both by human hand and natural processes. They provide many of the essential services on which we all depend like clean air and clean water”.

Following Andrew’s opening address, Maggie Roe (School of Architecture, Planning & Landscape, Newcastle University) introduced keynote speaker Carys Swanwick, Emeritus Professor, University of Sheffield. She focused on four key themes:

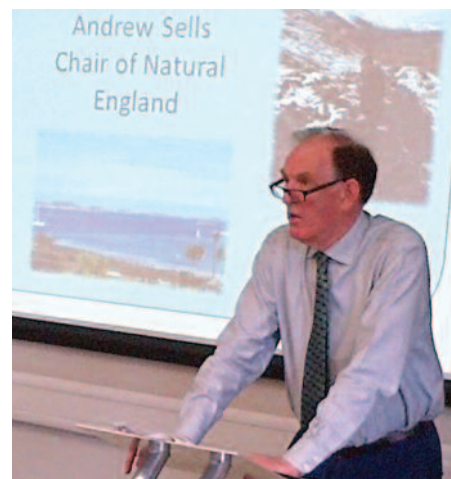
- **In between landscapes – reflecting on several landscapes that Carys had lived in, she described how they have changed and will continue to do so. Many areas are under immense pressure, and change in such areas is not being proactively planned and managed;**
- **Thinking outside the box – Carys urged all to “come up with new ways of doing things and new sources of funds”. There are examples of good practice we can learn from, including the National Forest where a landscape-led approach has helped create the setting for investment;**
- **The language of landscape matters and its use needs to adapt when discussing issues with professionals and local communities;**
- **Future generations – education about environmental values is going to be increasingly important and creative ways of engaging with youngsters are vital.**

Other speakers focused on the fact that ‘all landscapes matter’; on how the European Landscape Convention (ELC) helps set the context for HLF Landscape Partnership bids and projects; and on the usefulness of cost-benefit analysis. Adrian Phillips, freelance consultant, and Jonathan Porter, of Countryside and UK President of the International Association for Landscape Ecology, summed up, concluding that

- **an agenda based around landscape can act as a meeting ground between professionals helping to merge natural and social sciences;**
- **the ELC provides an excellent framework for the management, protection and creation of landscapes;**
- **using landscape and place can be a strong focus for community engagement;**
- **landscape cuts across local authority boundaries and can act as a catalyst for joint understanding and working;**
- **landscape cuts across sectors and can forge new partnerships to shape approaches based around catchments and National Character Areas;**
- **the landscape profession, working with others, needs to share knowledge more.**

The next steps for Natural England and others are to look at the issues raised and to focus on what can be practically developed via a partnership approach. The new Natural England Landscape Advisory Group will help take this forward.

To view all the presentations go to <http://tinyurl.com/ot2apl1f> (clicking on the “outcomes” button on the left hand side). For further information please contact me gary.charlton@naturalengland.org.uk



Andrew Sells, Chair of Natural England, delivers his opening address.

Photo by Colin Maddison



The Lake District with its formerly glaciated valleys is part of a protected landscape.

Photo by Hannah Townley

QRA and geoconservation

JOHN GORDON, QRA Geoconservation Officer

The Quaternary Research Association (QRA) has adopted a position statement on geoconservation (www.qra.org.uk/geoconservation/).

The QRA supports geoconservation, recognising present and future scientific, educational, cultural, aesthetic, ecological and ecosystem values of Quaternary sites and the needs of Quaternary science and society. In particular, the QRA:

- endorses the aims and objectives of Scotland's Geodiversity Charter, the Geodiversity Charter for England and the UK Geodiversity Action Plan (UKGAP);
- advocates the development of partnerships and strategies for designating, maintaining and enhancing Quaternary sites and landscapes; and
- promotes outreach and actions to conserve Quaternary features.

The QRA supports and delivers practical geoconservation action and shares best practice through field meetings, conferences, outreach and publications, and through the activities of its members and its conservation officer.

Climate change during the Quaternary has produced a geological record dominated by landscape modifications under glacial, periglacial and temperate environmental conditions. Learning from the past is essential in understanding and dealing with the challenges of today, such as climate-change adaptation, loss of biodiversity, sea-level rise and sustainable economic development. Quaternary science's benefits for society and the environment depend on the availability of key sites for research and education.

The QRA's commitment to geoconservation is particularly important when Quaternary sites are under increasing pressure from development and other human impacts. There is also growing international recognition of the need to raise awareness of the issues since geoconservation is often underestimated or overlooked in national and local planning and policies for nature and the environment. Conserving Quaternary sites is vital for field-based research to advance the science and education to increase wider understanding.

Geoconservation is not exclusively the responsibility of the statutory conservation agencies. Professional bodies, their members and the voluntary sector also have a significant role. Members of the QRA have made a major contribution to understanding and conserving Quaternary sites (see Brown and others, 2014). In particular, they have:

- co-ordinated and advised on site assessments and written the scientific reports for the Quaternary volumes of the Geological Conservation Review;
- provided expert advice for the practical conservation of key sites, including management actions and planning casework;
- defended important sites when threatened (e.g. as a result of development, inappropriate management or stabilisation and coast protection). Actions have included providing written scientific evidence in support of conservation in relation to planning developments, appearing as expert witnesses at public inquiries and undertaking rescue excavations;
- organised benchmark scientific conferences in partnership with other bodies and advancing our understanding of Quaternary geodiversity;
- promoted conservation awareness through interpretation and outreach, including field meetings.

The QRA and its members will continue to play an important role in site conservation and to provide the scientific underpinning and evidence base to progress the geoconservation agenda in developing areas such as ecosystem services and marine conservation.



Easton Bavents, part of Pakefield to Easton Bavents SSSI, Suffolk. Members of the QRA supported the conservation case when the renotification of the site was the subject of legal challenges in 2008 and 2009.

Photo by Eleanor Brown

Further reading

Brown, E.J., Gordon, J.E., Burek, C.V., Campbell, S., Bridgland, D.R. (2014). *Geoconservation and the Quaternary Research Association*. In: Catt, J.A. & Candy, I. (eds), *The History of the Quaternary Research Association*. Quaternary Research Association, London, 405-431.

IUCN breakthrough for geoheritage

JOHN GORDON, Scottish Geodiversity Forum
ENRIQUE DÍAZ-MARTÍNEZ,
Geological Survey of Spain and Geological Society of Spain
MARGARET BROCX, Geological Society of Australia

In a significant development for the international recognition of geoheritage, the International Union for Conservation of Nature (IUCN) adopted Resolutions 4.040 (<http://tinyurl.com/q8awl2u>) at Barcelona and 5.048 (<http://tinyurl.com/qzd7b4z>) at Jeju, both of which state that geodiversity is part of natural diversity and geoheritage is part of natural heritage.

The use of the term 'nature' is recommended in Resolution 5.048 "to ensure that, when reference is made in the IUCN Programme 2013–2016 to nature in general, preference be given to inclusive terms like nature, natural diversity or natural heritage, so that geodiversity and geoheritage are not excluded". Resolution 5.048 also calls on the World Commission on Protected Areas (WCPA) to promote and support proper management of geoheritage in protected areas. This reflects the IUCN's *Guidelines for Applying Protected Area Management Categories* (<http://tinyurl.com/ounm7rp>) which state clearly that all protected areas should aim where appropriate to "conserve significant landscape features, geomorphology and geology".

In addition, both resolutions acknowledge the scientific, cultural, aesthetic, landscape, economic and intrinsic values of geoheritage and the wider value of geodiversity in underpinning biological, cultural and landscape diversity. They also recognise that both geodiversity and geoheritage must be considered in the assessment and management of natural areas.

IUCN members, whether governments or non-government organisations (NGOs), must abide by IUCN's resolutions, so this represents significant progress in the international recognition of geoconservation principles. Nevertheless, there are still challenges ahead in attaining stronger integration of geoconservation both in national policies and, at a more local level, in practical measures for protected area management.

In 2014, IUCN's WCPA approved the establishment of a Geoheritage Specialist Group (GSG) to provide advice and guidance on geodiversity and geoheritage in the establishment and management of protected areas, to help integrate geodiversity into IUCN's programmes and to promote the links between geodiversity and biodiversity. The GSG will also offer specialist geoheritage advice for assessing World Heritage Site nominations and enable a professional interface between IUCN and geodiversity and geoheritage stakeholders such as UNESCO, the mining industry, national administrations and others.



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The priority tasks of the GSG align with IUCN's Quadrennial Programme (2013-2016) and the Global Protected Areas Programme/World Commission on Protected Areas priorities. They include a chapter on geoconservation (<http://tinyurl.com/nslwnla>) for the first time in IUCN's Protected Area Governance and Management e-book (<http://tinyurl.com/ptw5ura>) and plans for a Best Practice Guideline for Protected Area Geodiversity Management, and a Geoheritage Guidance Statement for IUCN World Heritage Criterion (viii). The chapter provides practical information and generic guidance on the role of geoconservation in protected areas. It outlines the case for geoheritage conservation in protected areas, the threats to geoheritage, how geoheritage fits into the IUCN classification of protected area management categories, and provides generic management guidance and advice on the principles of site conservation. Emphasis is placed on the importance of protecting geoheritage both in its own right and for its wider values. Contrary to common belief, geoheritage conservation is not restricted to Category III (Natural Monument or Feature), but applies across all six protected area management categories. Consequently, there are opportunities to integrate geoheritage much more widely. As a follow-up, the Best Practice Guideline will provide more detailed practical management guidance and case studies.

Geoconservation at keystone congress

At the IUCN 6th World Parks Congress in Sydney, Australia, in November 2014, the GSG organised and contributed to several sessions on geoconservation, with support from ProGEO, the Geological Society of Australia (GSA), the Geological Survey of Spain (IGME) and the Wetlands Research Association (WRA). The Congress is a decadal event organised by the WCPA and for the first time included geoheritage and geodiversity. It was an opportunity to promote geoheritage and geoconservation, as well as the roles of the GSG, ProGEO, the Geological Society of Australia, and the Wetlands Research Association among the wider IUCN community of protected area managers, scientists and staff.

Through presentations, posters and an exhibition stand, the geoheritage sessions highlighted the wider values and importance of geoconservation as part of nature conservation, as well as the benefits for society.

The main messages included:

- the relevance of all IUCN protected area management categories for protecting geoheritage interests;
- the wider values of geoheritage (for scientific, educational, cultural/aesthetic, ecological and ecosystem service reasons);
- the relevance of geoconservation principles for sustainable management of natural systems; and the importance of understanding the functional links between geodiversity and biodiversity to maintain ecosystem health as part of an integrated approach that recognises the value of 'conserving nature's stage'.

Continued overleaf

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Many of these issues were discussed and illustrated during a field trip to the National Park and World Heritage area of the Blue Mountains, west of Sydney. With funding from the Korean World Heritage Tidal Flat Promotion Group and VCSRG PL, the excursion, organised by Dr V. Semeniuk (WRA) and facilitated by members of the GSA and WRA, the event was specifically designed for the GSG to illustrate the geodiversity of the region and the relationships of geodiversity to biodiversity. In summary, we hope to have contributed to the better recognition within IUCN of geoheritage as an integral part of natural heritage, and for it to be more formally included in protected area management globally. Further information about the GSG is available at <http://tinyurl.com/ns4peyv>.



Blue Mountains, New South Wales, Australia, is a World Heritage Site originally declared by UNESCO based on its biodiversity. However, it is also an area of geoheritage significance and provides an excellent case study of the links between geology, geomorphology, geodiversity, habitats and biodiversity.

Photo by John Gordon

Further reading

Crofts, R. & Gordon, J.E. (2014). *Geoconservation in protected areas*. Parks, 20 (2), 61-76. Available at <http://parksjournal.com/parks-20-2/>

How to join the Geoheritage Specialist Group as an individual member

The GSG is directed by an international steering group chaired by Professor Kyung Sik Woo, Kangwon National University, South Korea. Membership is open to all interested individuals and organisations. By joining, applicants agree to assist and participate through one or more of:

- contributing actively to the work of the GSG;
- providing useful material and case studies of geoheritage conservation in practice;
- contributing knowledge of the theory and practice of geoheritage conservation within a specialized field (e.g. geomorphology or palaeontology);
- notifying the GSG Steering Committee about available funding sources and partnership opportunities to progress geoheritage conservation in protected areas.

The time commitment involved as a member will be on an individual basis when a 'call to participate' is sent to members, and if you can contribute to various actions and projects announced through the GSG Newsletter.

To join the GSG, please contact the Secretary General, Wesley Hill (wesleyhill@gmail.com).

GeoMôn hosts annual UK Global Geoparks Forum

KIRSTIN LEMON

British Geological Survey & Marble Arch Caves Global Geopark

Members of all the UK's Global Geoparks converged on Cemaes Bay, Anglesey, as GeoMôn hosted the annual UK Global Geoparks Forum (UKGGF).

Delegates from geoparks for the English Riviera, Fforest Fawr, GeoMôn, Geopark Shetland, Marble Arch Caves, North Pennines AONB and North West Highlands attended day one of proceedings, in the Anglesey County Council Business Centre in Llangefni, as did representatives from the UK National Commission for UNESCO, Natural Resources Wales, Natural England, Scottish Natural Heritage, British Geological Survey, Man and Biosphere Reserves and World Heritage. Topics included developing joint projects between the UK Global Geoparks, formalising terms of reference for the UKGGF and benefitting from the new, closer relationship with UNESCO. Representatives from aspiring Global Geoparks, including the Black Country and Peak District, attended day-two presentations to learn more about geopark development and the application process.

Anglesey is the largest of the Welsh islands at 720 km², with 201 km of coastline. Its geology spans four eras, 12 geological periods and 1.8 billion years of Earth history, so with such a spectacular geological heritage, this was an eagerly anticipated meeting.

Field trips provided opportunities to see some of the island's wonderful geological and cultural heritage. Day one of the meeting was concluded with a field trip to Newborough Forest and Llanddwyn Island, led by representatives from Natural Resources Wales and GeoMôn. Delegates had the chance to see Precambrian pillow lavas and mélanges as well as experiencing the wild, yet beautiful coastal landscape. Day two concluded with a field trip to the copper mine at Parys Mountain before heading to Porth Amlwch to see the GeoMôn geoheritage hub and Rock Clock. This was followed by a visit to nearby Llanbadrig to explore the Precambrian rocks of the headland and the cultural heritage of St Patrick who established a church there. The day finished with a trip to the headland in Cemaes Bay to see newly installed geoboards and a Rock Trail on the Village Green. These projects have seen GeoMôn working with Cemaes Bay Community Council, Horizon Nuclear Power, Isle of Anglesey County Council, The National Trust and Natural Resources Wales.

The people of Anglesey have strong ties with their geological heritage and delegates experienced the best of local hospitality. One notable occasion was in the restored Prichard Jones Institute in Newborough, built in the early 20th Century by Sir John Prichard Jones as a library and assembly rooms for the local community.

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Earth
heritage



Delegates to the 2015 UKGGF were able to see classic exposures of Precambrian mid-ocean ridge pillow lavas and associated seafloor sediments (bedded cherts; above) in Newborough Forest, a National Nature Reserve (NNR) and SSSI located at the south-west tip of Anglesey.



Natural Resources Wales NNR Warden, Graham Williams, explained joint work with GeoMôn to improve the extent and accessibility of rock exposures in the forest and to develop trails and interpretation for the public.

Photos by Stewart Campbell

GEOPARKS MEETING

from preceding page

A further memorable event was a reception in the Gadlys Hotel with representatives from the Welsh Government, the Isle of Anglesey County Council and the local communities. This event was made even more special by Trio Canig, a male vocal group who provided music from all four UK regions, as well as some friendly teasing about the superiority of all things Welsh! The evening also saw GeoMôn's new geological guide to the island - *Footsteps Through Time – the Rocks and Landscape of Anglesey Explained* – launched by the Anglesey MP, Albert Owen, and the local AM, Rhun ap Iorwerth, highlighting strong local political support for GeoMôn and the Global Geoparks project.

Hosting the UKGGF in a different UK geopark each year provides a fantastic opportunity for the constituent geoparks to learn from each other. Marble Arch Caves Global Geopark, spanning the border between Northern Ireland and the Republic of Ireland, will host the next UKGGF in 2016.

Below, the Great Opencast at Parys Mountain, on the north of Anglesey near Porth Amlwch, was once the world's largest copper mine. The UKGGF party was able to see the old workings and the ochre hues of this classic mining landscape at its spectacular best. Dr David Jenkins, from the Amlwch Industrial Heritage Trust, gave the party a fascinating insight to the intricate and controversial Kuroko-style mineralisation, and the history of mining dating back to the Bronze Age.

Photo by Stewart Campbell



Edward Greenly (1919) was the first to describe the colourful and chaotic jumble of rock types seen on Llanddwyn Island as 'mélange'.

Photo by Stewart Campbell

Delegates to the UKGGF were able to appreciate these world-class rocks in the warm, late afternoon sunshine.

Photo by Jerry Lynch



An occasional supplement to *Earth Heritage*,
the geological and landscape conservation publication, www.earthheritage.org.uk

Village celebrates 'the map that changed the world'

Janie Hextall, Churchill Heritage Centre

It is 200 years since William Smith (1769-1839) published 'the map that changed the world' and the north Oxfordshire village of Churchill is celebrating this bicentenary of one of its famous sons.

On 22 March 2015, the day before his 246th birthday, a plaque commemorating William Smith's birthplace was unveiled at the Churchill and Sarsden Heritage Centre by Professor Hugh Torrens, Emeritus Professor of History of Science and Technology at Keele University. We are grateful to the Geologists' Association Curry Fund, whose grant has made the plaque possible.

We are delighted that, as part of its mission to help a broader audience understand William Smith's work, The Oxford University Museum of Natural History is curating a special exhibition in the Heritage Centre to mark the bicentenary. The museum has a particular interest because William Smith's nephew, John Phillips, who travelled extensively with his uncle, became an eminent geologist in his own right, wrote the first biography of William Smith, founded what is now the OUMNH and bequeathed to it a collection of Smith's maps and other documents.

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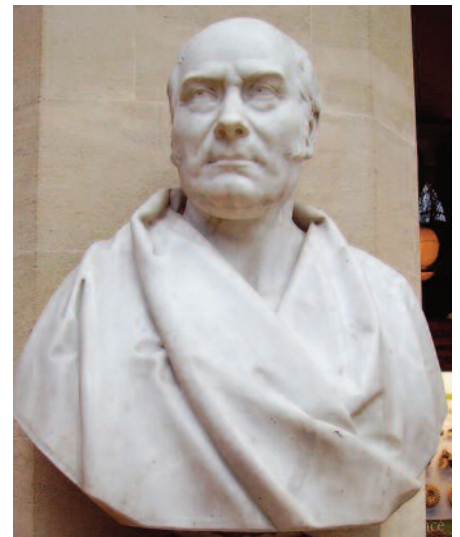


Above, the original William Smith map
Photo CCo 1.0

Left, Hugh Torrens with the plaque unveiled at the Churchill and Sarsden Heritage Centre

Photo Jenny Aston Photography

Below, a bust of William Smith at Oxford University Museum of Natural History Photo Ballista CC BY-SA 3.0



From preceding page

On loan are original maps, diaries and letters, and there are specially commissioned audio recordings giving the background to the story of the famous map and explaining how the William Smith collection came to be archived in the museum in Oxford.

The Heritage Centre is in the chancel of Churchill's medieval church and is all that remains of the original building. It is in a delightful setting, overlooking the Swail Brook valley and the 'lost' village destroyed by fire in 1684. The permanent displays and interactive touchscreens dedicated to William Smith and Warren Hastings, the first governor-general of India (also Churchill born), are still available, together with archive material, village and family records, photographs and maps.

William Smith was born in the village and legend has it that it was the poundstones (echinoids) he found in the local fields that sparked his interest in geology. While working on the construction of the Somerset Coal Canal in the 1790s, Smith noted "regularity in the direction and dip of the various Strata in the hills around Bath". Spotting that rock layers occurred in a predictable pattern, he also realised that certain fossils were characteristic of particular strata and that these fossil assemblages could be used to order strata in terms of relative age – his Principle of Faunal Succession.

Smith produced a pioneering table of the strata near Bath in 1799 and a colour-coded geological map of the area. Then in 1815 he published his landmark hand-coloured geological map of England, Wales and part of Scotland: the first to be created in such detail and scale. This was an incredible feat which challenged current scientific and religious thinking and which he accomplished largely on his own (with support from John Phillips). In 1831 the Geological Society of London awarded Smith the first Wollaston Medal and the President, Adam Sedgwick, referred to him as 'the Father of English Geology'. He had laid the foundation for geological mapping the world over – an astounding legacy for a humble blacksmith's son from a small Cotswold village.

Find out how to visit: www.churchillheritage.org.uk

Rare Smith map on show for first time

William Smith: colours beneath your feet is an exhibition exploring the life of William Smith and the making of his 1815 geological map. The centrepiece of this exhibition is a very rare, canvas-mounted, travelling copy of the map (series b, 22) in pristine condition which will be on public display for the first time from 23 May to 19 September 2015 at Dudley Museum and Art Gallery. The exhibition, like Smith, will travel the country connecting people through science, history and art, 'on a tour of inquiry and observation'.

More details: www.dudley.gov.uk/see-and-do/museums/dudley-museum-art-gallery/



The memorial to Smith in Churchill
Photo Tom Sharpe



The sheer size of William Smith's map is brought home by this photograph.

© Colours beneath your feet

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A close-up of one of William Smith's maps shows the sheer beauty and the work that went in to hand-colouring the maps. The area shown above covers the south-eastern corner of Wales (top left) to the Isle of Wight (bottom right).

Image © Amgueddfa Cymru

Earth Heritage in print

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