Earth heritage

The geological and landscape conservation magazine

Geological Conservation Review: a new era

Throwing new light on rare Chalk exposure

ISSUE 47
Spring 2017

Blurring the line between Arts & Science

English Coast Path lays geology open to all

INSIDE

COVER - the Man Engine excites the crowds that thronged Penzance to see the spectacular celebration of mining heritage. See page 25.
Photo by Sarah Manning / Natural England

EDITORIAL

This bumper *Earth Heritage 47*, **including** *Earth Heritage Extra 4* **and** *5*, **brings you a broad array of geoconservation news and comment, including some innovative and colourful approaches to publicising and celebrating our geodiversity.**

Despite its rich content, *Issue 47* **is also a less positive milestone. Due to increasingly difficult financial circumstances, the country conservation agencies (Natural England, Scottish Natural Heritage and Natural Resources Wales) presently find themselves unable to guarantee future funding of** *Earth Heritage*. **They have funded the magazine and its predecessors – the Nature Conservancy Council's** *Information Circular* **and** *Earth Science Conservation* **– continuously since 1968. However, Earth Heritage Editorial Board is unanimously agreed about the importance of the magazine and the need to keep producing it.** *Earth Heritage* **has been a key tool for developing the geodiversity and geoconservation agendas over many years; it has a loyal readership within the geoconservation community and has become the sector's mouthpiece; in addition, it sets a benchmark for the statutory and voluntary geoconservation sectors working together. Consequently, the Editorial Board plans to compile, edit and digitally produce** *Issue 48* **(using generous interim financial contributions from the Geologists' Association and Quaternary Research Association) and to maintain free online access to the** *Earth Heritage* **archive. However, a more sustainable and resilient model for future production is needed - potential sponsors please be aware! We will keep you posted.**

We are also sad that we will be losing the long partnership with our Production team, Seabury Salmon & Associates. Seabury started producing *Earth Heritage* **in 1995 (***Issue 5***), and developed the magazine into a more accessible publication, firmly establishing the** *Earth Heritage* **'brand'. Continual development has ensured that today's** *Earth Heritage* **is a publication fit for the digital age and an increasingly diverse readership. Through Seabury we have reached out to many people who before had no real interest in the wonders of our geological world, nor an understanding of the need to conserve our geoheritage. The Editorial Board is extremely grateful to him and his partner Shirley for their efforts and skills over the years and for making the title's production such a pleasure for us.**

The *Earth Heritage* **Editorial Board is actively planning** *Issue 48* **and is already looking forward to celebrating the 50th anniversary of the magazine and its forerunners in 2018! As ever, we want to hear your views and to learn of new projects. To contribute, please contact the most appropriate editor (***below***).**
– Stewart Campbell, Managing Editor

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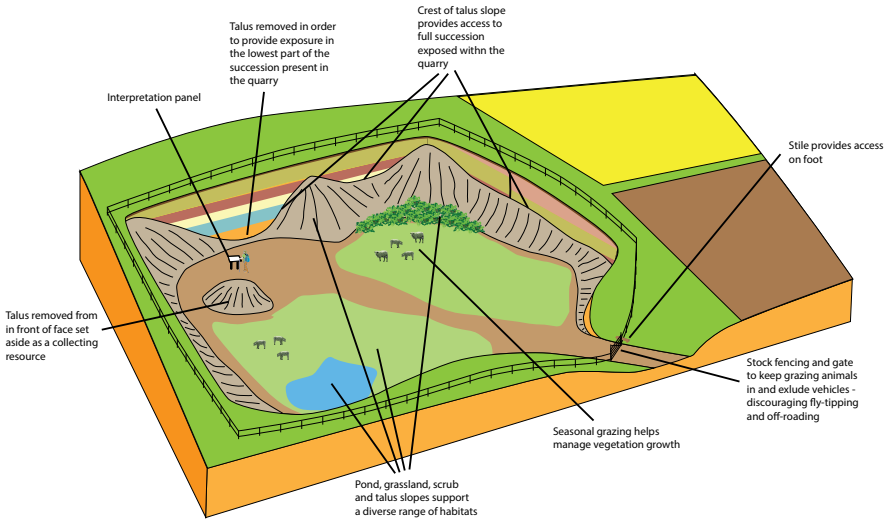
This and back issues can be downloaded free as pdf files from www.earthheritage.org.uk. You can also purchase a full-colour, laser-printed, A4 hard copy of any issue via the website. We thank all those who have assisted in preparing the publication, including many in the voluntary geoconservation sector who are major contributors. The opinions expressed by contributors are not necessarily those of the above organisations.

Site management handbook receives 10-year update

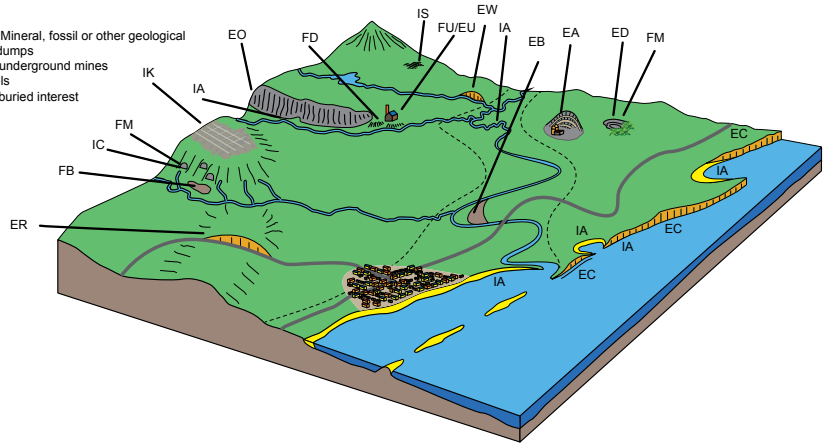
Work should be completed in 2017 on *Geoconservation: a review of successful approaches*, **a major revision of** *Geological Conservation: a guide to good practice*, **the decade-old, go-to reference for practical management of geological and geomorphological features.**



Features in the Landscape

EA Active Quarries
ED Disused Quarries
EC Coastal cliffs & foreshore
EW River & stream sections
EO Inland Outcrops
EU Exposure underground mines and tunnels
EB Extensive buried interest
ER Road,Rail and Canal Cuttings
IS Static fossil geomorphological
IA Active Process geomorphological
IC Caves
IK Karst
FM Finite Mineral, fossil or other geological
FD Mine dumps
FU Finite underground mines and tunnels
FB Finite buried interest

The new volume has digitally redrawn diagrams for clear viewing.



The 2006 'good practice' book set out to build on the earlier (1990) version, *Earth Science Conservation in Great Britain: A strategy* and its appendices *A handbook of Earth science conservation techniques* with particular emphasis on the practical aspects of conserving geological and geomorphological features, based on the experience of the intervening 16 years.

It is hoped the updated work will be available as a hard copy but it will be primarily in a digital format for download as a pdf. This will make subsequent revision easier and provide a platform for re-use of the content for a variety of other purposes. All the diagrams have been redesigned and redrawn in a digital format for the same reasons. Where appropriate, generic site-based management advice has also been updated to reflect the experiences of the intervening years and include more recently developed techniques. Some of the original case studies have been retained and updated, others are new, and again reflect more recent experience. Not all the case studies have positive outcomes, but they provide experience and learning.

The revised handbook also reflects significant changes that have taken place in the last 10 years including reference to the expansion of the Global Geoparks movement, Geodiversity Action Plans, the challenges of climate change, and opportunities that may arise from initiatives like Ecosystem Services.

The 'good practice' book founded its approach on a revised Earth Science Conservation Classification (ESCC; *see Features in the Landscape*, above left) and provided management guidance for each site type illustrated by a series of case studies. It also advised on site safeguarding, and threat deflection and management. The handbook has been widely used and applied in the UK and beyond. Despite not being aimed at the scientific community, it has been cited in papers across Europe and in China, Australia, Africa and South America. We hope this revision will prove as useful as the previous versions.

– Dave Evans, Natural England

60 years of National Nature Reserve marked with 'geoblitz'

Professor Richard Fortey celebrates 60 years of the Wren's Nest NNR.

Photos by Nicola Beckley

The Wren's Nest in Dudley, West Midlands, was declared a National Nature Reserve (NNR) in 1956, recognising the international significance of its Silurian (Wenlock) limestone, in particular its diverse fossil fauna. To mark its 60-year NNR milestone, the Friends of the Wren's Nest NNR organised a birthday party to bring together many of the people associated with the Reserve over the last few decades.

Rob Broadbent (Wren's Nest NNR Friends Group), Professor Richard Fortey (world trilobite expert and life-long advocate of the Wren's Nest), and Graham Worton (Dudley Museum and Art Gallery) charted the NNR's history, from the Silurian to the present, and reflected on what makes the Wren's Nest a special place.

Therafter, the Wren's Nest's first 'Geoblitz' took place. The aim was to see how many different fossil species could be recorded (the target, 60 species for 60 years). Some *in situ* reef locations were identified where bedding planes and reef were carefully photographed and fossils recorded. Alongside this, bulk samples from associated scree slopes were taken and returned to the warden's base to be washed, sieved and picked for fossils. Over 70 species were identified and the analysis still continues, notably the microfossils from the bulk samples.

What is clear is that the Wren's Nest NNR never stands still: a decade on from its 50th anniversary much has happened. Highlights include the community-changing Wrosne performance in 2008 (*see page 22*) and the 'Ripples through time' Heritage Lottery-funded project, completed in 2011, bringing new sculpture, improved access, and trails to the Reserve. Ian Beech joined the Reserve as senior warden in 2012 and is, as always, supported by wardens Rob Earnshaw and Dave Hill, and volunteer Trevor Conroy who between them have over 75 years of Wren's Nest experience.

New research and discoveries also continue to emerge. As part of stabilisation works, access to underground sections has shed new light on the NNR's geology. A detailed log of the Step Shaft Tunnel was completed, spanning the Coalbrookdale and Much Wenlock formations. Analysis of bentonites from here (and on the surface) has not only revealed a largely undocumented scolecodont microfauna (annelid jaw elements) but also a revised date for the base of the Wenlock Series (*c.* 427 Ma) through analysis of zircon isotopes.

'Geoblitz' fossil collecting at the Wren's Nest

The Wren's Nest NNR is now the 'star' site in the current bid to achieve Black Country UNESCO Global Geopark status. The result will be known in spring 2017 and will hopefully set the direction for the next 60 years of the Wren's Nest NNR.

– Jonathan Larwood, Natural England

Further reading:

Prosser, C.D. & Larwood, J.G., 2008. *Conservation at the cutting edge: the history of geoconservation at the Wren's Nest NNR, Dudley, England*. From: Burek, C.V. & Prosser, C.D. (eds), The History of Geoconservation, Geological Society, London, Special Publications, 300, 217-235.

Much to learn from dual geopark conferences

The seventh UNESCO Global Geopark conference was hosted by the English Riviera Global Geopark in Torquay, Devon in September 2016 and was preceded by the European Geoparks Network meeting in the same location.

European Geoparks Network

There are 69 Geoparks in 15 European countries. A second-edition book on the European Geoparks was due out in December 2016 ahead of new geoparks to be announced in April 2017 by UNESCO. This is an important difference – UNESCO will in future assess/reassess and decide if applications are suitable for the new designation UNESCO Global Geopark. Thus the bar has been raised. However, the aims and ethos of the geoparks remain the same.

The European Geopark Network has seven thematic groups and the British geoparks participate in most. They are the National Fora with co-ordinator Melanie Border (English Riviera); Volcanics; Fossil; Mining; Coastal; Intangible; and Funding. GeoMôn Geopark has suggested a possible European Islands Geopark group which could include Shetland, GeoMôn, Lesvos, Lanzarote, El Hierro, Azores, to address the special opportunities and difficulties faced by small island communities. It was stressed that 2017 is the UN year of sustainable tourism – something we must take on board to promote our geoconservation and geotourism. Another discussion, in places heated, centred on the inevitable fees rise, especially as UNESCO will take a proportion for administration of the Global designation.

The next European Geoparks meeting is in the Burren and Cliffs of Moher Geopark from 22-26 March 2017. The 14th European Geoparks conference is in the Azores UNESCO Global Geopark, Portugal in September 2017.

WORLD GEOPARK COUNT	
Continent	Geoparks (2016)
Europe	69
Asia Pacific	46
Africa	1
Latin & South America	2
North America	2

7th International Conference on UNESCO Global Geoparks

UNESCO was present for the first time at the Global Geopark Network conference, having given its backing to the Geopark designation in November 2015. This is the first global designation that UNESCO has recognised since World Heritage Sites in 1972 and Man and Biosphere Programme (Global Biosphere Reserves) in 1973. Today (2016) there are 120 Global Geoparks in 33 countries. The UK has seven.

Over 700 delegates from over 63 countries (with over 200 from the People's Republic of China) gave over 200 presentations. Proceedings were opened by the Mayor of Torquay. Celebrations started with a spectacular geological opera entitled *Earth Echoes*, played by the Bournemouth Symphony Orchestra with acting by a few professionals supported by community people with ages ranging from 8-80. Streamed live on the English Riviera website, it told the story of geological time, stratigraphy and the part we play in the stewardship of the planet. After seven sessions of 12 parallel presentations, a field-trip day and a typical British street party in the rain, we were told by Marko Pogacnik (UNESCO goodwill ambassador and artist for Peace) that we were at war not between ourselves but between people and the planet. The title of the conference was *Health and well-being* and we should not just think of this in an anthropocentric way but ecocentrically.

A geological opera entitled *Earth Echoes* was a spectacular opener.
Photo by Cynthia Burek

Post-conference excursions took in visits to the iconic Kent's Cavern, Devonian type sites, a cruise along the Torbay coast and Torquay Museum.

This thought-provoking conference showed the importance of having UNESCO on our side. It put the Geopark movement into the global context for us all and showed the diversity of approaches towards geotourism, funding and research.

– Cynthia Burek, Univesity of Chester & UKRIGS

GA conference celebrates glories of the Jurassic Coast World Heritage Site

Conference delegates visit the Steve Etches Collection.

All photos by Jonathan Larwood

The Geologists' Association 2016 annual conference was hosted on the Isle of Portland with a spectacular view across the Jurassic Coast World Heritage Site. The conference explored the theme of geoscience and education on the Jurassic Coast and took the opportunity to celebrate the 15-year anniversary of the Jurassic Coast World Heritage Site inscription.

Over 115 people joined the conference which took a stratigraphical approach to exploring advances in geoscience across the site. This goes far beyond the Jurassic to include Triassic, Cretaceous and Quaternary interests and, critically, the growth in our understanding of coastal change and the geomorphology of this coastline over the last 15 years. How this science and research is more widely interpreted and presented has been an area that the Jurassic Coast Team has particularly developed since inscription with great success and innovation. Communities and schools across the Jurassic Coast have become increasingly aware and involved in their geological heritage but the reach is far greater. Through the Big Jurassic Classroom initiative (**http://jurassiccoast.org/big-jurassic-classroom/**) primary school teacher Ashley Cahill was able to take the Jurassic Coast to his school in Stockport and, through his unbounded enthusiasm for all things geological, he changed his Year Six class view from 'but, rocks don't do anything' to 'I love rocks, they're awesome!'. A special publication of the *Proceedings of the Geologists' Association* is planned to capture the work and research presented during the conference.

Two field visits were organised on the second day. A short walking tour of Portland was led by Alan Holiday (Dorset GA Group). This took in views of Chesil beach, Purbeck and the Weymouth Anticline (once the mist dispersed) and examined the Portland Stone and associated quarries including the sculptures of Tout Quarry. A second group visited the Kimmeridgian and were welcomed to the Museum of Jurassic Marine Life which houses the spectacular Steve Etches Collection of Kimmeridge fossils (**www.theetchescollection.org/home**). The conference was privileged to visit the museum on its opening day and to be guided by Steve. The day concluded with a visit to the Lower Kimmeridge Clay sequence of Kimmeridge Bay led by Simon Penn.

The conference was organised by the Geologists' Association, the Jurassic Coast World Heritage Team and Natural England with support from the Dorset Geologists' Association Group and the Steve Etches Collection. Sponsorship was provided by Elsevier and the Primary Science Teaching Trust. Full abstracts and a conference programme can be found at: **www.geologistsassociation.org.uk/conference2016.html**

– Jonathan Larwood, Natural England

Below, delegates go fossil collecting in Kimmeridge Bay.

Below right, Chesil Beach as seen from the conference venue on Portland.

Professor Worsley led discussion about the formation and evolution of the Thames Valley from a vantage point high above the Goring Gap. The field trip leader and the *Earth Heritage* correspondent both came dressed as William Whitaker (inset, the original William Whitaker).

Inset photo from the Geologists' Association Carreck Archive, permission British Geological Survey. Other photos by Diana Clements and David Bridgland

GA takes to the water for a taste of the past

No fewer than 110 friends and members of the Geologists' Association, some in period dress, enjoyed a cruise up the Thames from Reading to Goring and back, in June 2016, in a re-enactment of an 1895 excursion led by William Whitaker and J.F. Blake and reported in the *Proceedings of the Geologists' Association* of that year.

The 2016 meeting was led by Peter Worsley, Professor Emeritus at Reading University, who provided commentary during the voyage and was the guide for a geological walk into the countryside overlooking the Goring Gap, during which there was discussion about the evolution of the Thames Valley and how it came to cut through the Chilterns Chalk escarpment to allow drainage into the London Basin from Oxfordshire and the Cotswolds.

The reports of such excursion meetings in the *Proceedings* are a long tradition of the Association. Numbering at least 1,300, they are important resources for students of the history of geology and the progression of geological thinking. In this they can be supplemented by photographs and other records in the GA Carreck Archive, now conserved at the British Geological Survey and soon to be available online (see *EH 42*). This archive includes unpublished photographs and other memorabilia from these and other types of meeting throughout the history of the organization. In recent years field meeting reports have generally migrated into the GA Magazine, where they form a valuable part of the (paper and electronic) archive.

Jonathan Larwood, the GA Archivist, notes that before about 1930 GA meetings of this sort were generally termed 'excursions', becoming 'field meetings' after that.

– David Bridgland, Geologists' Association

Celebrating Miller's achievements

A conference entitled *The Old Red: Hugh Miller's Geological Legacy* will be held in autumn 2017 in the Black Isle village of Cromarty to honour the pioneering work of local hero Hugh Miller (1802-1856). It is being organised by the charity The Friends of Hugh Miller and will be held in the Victoria Hall, High Street, Cromarty, on 9-10 September 2017.

A focus will be the presentation of a paper by Professor Ralph O'Connor and Dr Michael Taylor concerning publication of a new edition of Hugh Miller's great work, *The Old Red Sandstone*, following 10 years of research. A keynote speaker will be palaeontologist and author, Professor John Long, from Flinders University, South Australia. Gavin Berkenheger, a young Black Isle-based gold prospector, whose entire career was directly inspired by Hugh Miller, will also be on the presentation line-up, which will also include talks on Miller's Jurassic and mineral explorations and news of recent fossil specimens that would no doubt have interested Miller.

The conference will be followed by an excursion to Miller's famous Devonian fish bed. Delegates will be offered a three-day post-conference field trip to Achanarras Quarry, Sutherland. The event is envisaged as an important contribution to Visit Scotland's Year of History, Heritage and Archaeology 2017.

More conference information and more about the Friends of Hugh Miller are on the Friends' website at **www.thefriendsofhughmiller.org.uk**

– Martin Gostwick, The Friends of Hugh Miller

Taking the world's first Geodiversity Charter beyond 2017

Scotland's five-year-old Geodiversity Charter – the world's first – will be reviewed and refreshed in 2017 and relaunched at a conference in November 2017.

Geodiversity affects all our lives in many different ways from energy provision and mineral resources to underpinning habitats and species. The iconic landscape and tourist attraction of the Dog Rock near Oban, an old sea stack composed of Devonian conglomerate, underscores the role of geodiversity in our cultural development.

Photos by Lorne Gill/SNH

The charter has attracted the support of 60 organisations, of all sizes, from across Scotland. It sets out a vision that 'Scotland's geodiversity is recognised as an integral and vital part of our environment, economy, heritage and future sustainable development, to be safeguarded and managed appropriately for this and future generations'.

Has the Charter worked? Yes and no! Certainly we've had no problem in persuading organisations that geodiversity is valuable and needs more attention. While some sectors such as industry are poorly represented, generally organisations have seen its value and been happy to support it. Having led the way with the world's first geodiversity charter, it is great to see similar initiatives coming through elsewhere in the UK. The biggest successes have been when promotion of geodiversity has brought together organisations and individuals to work for the first time on projects that celebrate and promote geodiversity – such as the Hugh Miller Writing Competition (*Earth Heritage 46*), and the Fossil Five Awards (**www.scottishgeology.com/geo/scotlands-fossils/poll**). We've had no trouble in picking out 20 recent case studies for the refreshed Charter – there is a lot going on.

However, the Charter hasn't quite developed in the way we anticipated. Partly this is due to other events! At the time of the Charter launch we realised that the government would be looking in other directions for a year or two while the question of Scottish independence was settled. The distractions continue with no end in sight. At the same time, while local authorities have made significant progress in identifying Local Geodiversity Sites, carrying out audits and developing action plans, this has been against a backdrop of continued severe financial pressure where geodiversity has just not been a priority. Looking through the proposed 'actions' in the original Charter, we can easily identify sectors where we haven't gained much traction, alongside areas where there have been many positive developments.

So the challenge for the next five years will be to widen the reach of the Charter, engage more with biodiversity organisations and industry, and keep plugging away at local authorities and the Scottish Government to raise the profile of geodiversity and the benefits it brings to our society. But we shall also celebrate that a small band of committed volunteers, with strong support from national organisations such as Scottish Natural Heritage and the British Geological Survey and the backing of a wide range of individuals and small organisations, has raised the profile of geodiversity and developed plenty of interesting projects and initiatives.
The work goes on! See the Charter at **https://scottishgeodiversityforum.org/charter/**

– Angus Miller, Scottish Geodiversity Forum

The value of understanding geodiversity is exemplified by these nesting Sandwich Terns at Sands of Forvie National Nature Reserve. The dunes are a dynamic geodiversity feature that will be affected by climate change. By more fully understanding linkages between geodiversity and biodiversity we will be better placed to plan for and cope with habitat change in such environments.

Brookfield students learn about Pangea using large continent cut-outs to replicate past plate movements.

Photos by GeoBus

GeoBus heads out of Scotland to deliver schools project to London

Earth Heritage 40 **highlighted the innovative GeoBus outreach project, launched in 2012 to bring interactive and hands-on Earth science workshops to schools across Scotland. Since its inception, GeoBus has seen over 46,000 students in over 200 schools across Scotland.**

Now, a new and exciting chapter of the GeoBus project is under way, a similar outreach programme in London. Shortly before the Scottish project, running from St Andrews University, celebrated its fifth birthday in January 2017, the London roll-out began with an official launch at Brookfield Primary School in Camden.

Based on the success and popularity of the Scottish project, a proposal was written into the NERC Deep Volatiles project for a similar programme in the English capital. The proposal was accepted and funding for an English GeoBus was granted, with the project running from University College London, working in partnership with St Andrews.

Staff and students from UCL were at the launch, as well as colleagues from St Andrews. The launch started with Brookfield students learning about Pangea using large continent cut-outs to reconstruct past plate motions. The dynamics of these motions were then explored using cornflour and bionic putty to simulate mantle convection. Finally, the students had a go at constructing some earthquake-proof buildings out of K'Nex and Blue Tac before getting them tested on the shake table. The students came up with many creative designs in the hope of withstanding an earthquake and ended the day learning about the construction of real earthquake-proof buildings. Students and teachers alike had a great day.

The UCL GeoBus project is available to visit primary and secondary schools across London to expand student interest and uptake in Earth sciences by using many of the resources already available in Scotland, plus new ones developed in collaboration with staff from UCL.

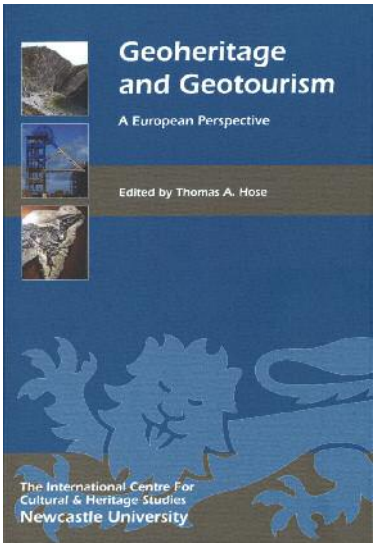
Visits are free for schools with all costs being covered by our sponsors so that we are an all-inclusive project. All workshops relate to the National Curriculum to highlight the links to students between what they are learning in school, real world context and current research in universities. The idea is to help inspire the next generation of Earth scientists by showing them just how inter-disciplinary the subject is.

– Charlotte Pike, University College London

The GeoBus arrival created plenty of excitement at Brookfield Primary, Camden.

Students put one of their creations to the earthquake-proof test on the shake table.

Heritage Series gains a volume devoted to geoheritage and geotourism



Geoheritage and Geotourism – A European Perspective
Edited by Tom Hose
ISSN 1756-4832

This new volume is part of the *Heritage Matters* series that addresses the issues confronting the cultural heritage sector across the globe. The previous 18 volumes have discussed a wide range of subjects including metal detecting and archaeology, safeguarding intangible cultural heritage and public participation.

The volume aims 'to describe and critically examine the conservation, promotion and popularisation of Europe's geoheritage' – an ambition that appears to have been achieved. The first nine of the 18 chapters introduce the reader to the development of not only geotourism and geoheritage, but also geodiversity and geoconservation as important and standalone concepts. Each chapter is well referenced, often with a comprehensive further reading section. In introductory sections, the reader receives a quick guide to the geological history of Europe, history of how the geodiversity was mapped, the development of museums from private collections and their importance in teaching the fledgling science of geology.

The chapter on *Geoheritage in the Field* highlights some of the forgotten challenges faced by the pioneering Victorian geologists. Although the development of railways in Britain brought opportunities to travel farther, there were the challenges posed by different companies having independent ticketing systems and unconnected timetables. It was also interesting to note that the first recorded excursion by the Geologists' Association in April 1860 was by train from London to Folkestone. It took some 3 hours 30 minutes. According to National Rail Enquiries, today it can take you somewhere between 53 minutes and 2 hours 37 minutes!

One of the book's case studies is Anglesey's UNESCO Global Geopark, GeoMôn. Ynys Llanddwyn, above, is one of the island's most important geosites, attracting thousands of tourists and educational parties to see the world-class Precambrian pillow lavas and mélange, here cut by a Palaeozoic dolerite dyke. Photo by Stewart Campbell

Chapters 7 and 8 home in on geoconservation and geotourism respectively. The chapter on *Geoconservation* provides the reader with a comprehensive background to the subject and finishes with a call that should be at the top of the list of much of our work – a need to widen and strengthen awareness of geodiversity and its value and importance to people and the environment. Chapters 9–17 provide a series of informative geoheritage case studies around Europe: the Isle of Wight; GeoMôn, Anglesey; Ruhrgebiet National Geopark, Germany; Andalucia, Spain; Scotland; Canton Valais, Switzerland; Danube Region, Serbia.

This is a very informative book and it is welcomed that the *Heritage Matters* series now has a volume specific to our subject area. *Geoheritage and Geotourism – A European Perspective* is useful for all readers of *Earth Heritage*, not only in terms of looking at things in a European context, but highlighting the important threads of our work – geoconservation, geoheritage and geotourism.

– Raymond Roberts, Natural Resources Wales

It is hoped that prominent access signage like that above will deter the sort of illegal large-scale fossil collecting that has taken place within the remote Shiel Burn SSSI (below). Operating outside the Scottish Fossil Code and without landowner permission constitutes little more than vandalism and theft. However, it is difficult to control or police.
Photo by Peter Kelly/SNH

Signage response may help deter irresponsible fossil collectors

The gently rolling hills of the South Lanarkshire/Ayrshire border host many features of nature conservation interest protected as Sites of Special Scientific Interest (SSSI). Amongst these are internationally important fossil sites in the Lesmahagow/Douglas area which yield a large diversity of rare early jawless fish. These fossils have been collected for over a century for research on vertebrate evolution.

Evidence suggests that while generally across Scotland collectors stick to the Scottish Fossil Code, in remote locations irresponsible collecting continues to be an issue. Signage is therefore required to remind collectors that the Code applies – even in the most difficult to access areas.

As highlighted in *Earth Heritage 46*, inappropriate and damaging sample collecting is an infrequent but recurring problem on protected sites. Uncontrolled collecting activities pose a significant threat through the misappropriation of scientifically valuable specimens for commercial profit or private collections, thus limiting the data retrieved and restricting the amount that can be learnt from these exceptionally important sites.

Undoubtedly the best way of dealing with this issue in the long-term is through ongoing promotion of the Scottish Fossil Code and by continuing to increase awareness within the geological community of the importance of responsible collecting. However, the small number of rogue collectors targeting remote sites remains a challenge.

The South Lanarkshire/Ayrshire border SSSI are often difficult to access, far from the nearest public road and away from public view. While these sites are regularly monitored, monitoring cannot identify or deter those who disregard the sites' legal protection. In an initial effort to make SNH's presence more noticeable, we have been installing signage at access points. The hope is that this will deter the less determined, opportunistic rogue collector.

Such signage has been installed at Shiel Burn SSSI near Glespin, south Lanarkshire, with its rich assemblage of Silurian–age early vertebrates in the Glenbuck Group within the Fish Bed Formation. A monitoring visit revealed that several hundred kilos of bedrock had been excavated from the *in situ* exposure. While prospective collectors are encouraged to register with the nearby landowner, the local landscape means the system can be easily by-passed by those wishing to collect anonymously and illegally.

Following identification of the damage in May 2016, a contract to make and erect the signs was swiftly arranged. With the agreement of the relevant landowners, the signs were installed in June. Their effectiveness will need to be monitored and will inevitably depend on the determination of rogue collectors. The hope is that irresponsible large-scale collecting will eventually become a thing of the past.

– Peter Kelly, Scottish Natural Heritage

Views of nationally important exposure at St John's Church SSSI, Ballachulish before (*left*) and after clearance of invasive non-native 'rhodie'. Volunteer action organised by Lochaber Geopark has helped to ensure the favourable condition of the SSSI. Photos by Jim Blair

Rolling back the 'rhodie' brings geological features back to light

Money is tight and some landowners may have little interest in maintaining odd geological patches with no commercial or other value. One result is that without active management *Rhododendron ponticum* can creep in, along with self-seeded forestry trees like sitka spruce. Such takeovers may smother native flora and the geology.

St John's Church Site of Special Scientific Interest (SSSI) is a section of about 300 metres, between the A82 and the sea, west of Ballachulish. Designated for its Dalradian structural geology, the site is so overgrown that access is difficult and you can hardly see a thing!

So Lochaber Geopark consulted Derrick Warner, the local Scottish Natural Heritage (SNH) officer, who agreed that some 'cautious scrub and rhodie clearance' would be appropriate. This ticked several SNH boxes – action on invasive species; locally addressed in *The View from the Road* SNH report, 2008; and helped to ensure the favourable condition of the SSSI. Landowners gave approval for the Geopark to carry out some practical management.

Enter the Lochaber Geopark volunteer Hit Squad. Five volunteers started cutting back undergrowth on a small headland at the eastern end of the site. Heavy going, but the 'little and often' approach started to show progress and geological features started to emerge. However, progress was slow, so we called in the cavalry. The local Criminal Justice Community Payback squad was finishing its seasonal grass-cutting work and agreed to help. Brilliant! The team cut back the scrub and then the volunteers hauled it away, chopping it up for firewood or the BBQ.

Yes, we have a long way to go at this site, but you can now start to access and study the nationally important structural geology, as well as see the 'native' wood for the trees!

SNH's Derrick Warner explained, "This example of co-operation between the landowners, the Geopark, and the Criminal Justice Team has made a real difference to the SSSI while also contributing towards a number of other projects. They've done a fantastic job and will hopefully go on to do more."

– Jim Blair, Chairman of Lochaber Geopark

Delegates flock to Eurospeleo celebration of British caving

The 5th European Speleological Congress (Eurospeleo) in August 2016 was also a week-long celebration of British caving, attended by about 1,300 delegates from 36 countries around the world. 75 delegates also attended pre- and post-congress camps in the other caving regions of England and Wales.

The main event was held in the Yorkshire Dales at the Dalesbridge Centre near Austwick. Six kilometres of rope provided by Spanset and Teufelberger was used to rig 176 pitches in over 30 of the Yorkshire Dales' finest caves. They were rigged for the duration of the event by over 30 caving clubs from across the UK.

Almost 700 caving trips took place around the Dales with an estimated 400 km being fixed with prusik loops during the week. In addition, the Craven Pothole Club set up its winch over the impressive Gaping Gill and transported delegates up or down the 100 m from the main chamber 400 times. Even with all this activity no cave rescue callouts were required.

Aside from the caving, 110 lectures and 11 field trips took place with a large range of talks on discovery, science and archaeology by speakers from all over the world offering something for everyone. The photo, art and survey salons attracted a very high standard of work.

Delegates on the ECPS field trip to Scoska Cave, Littondale

Photo by Andrew Hinde

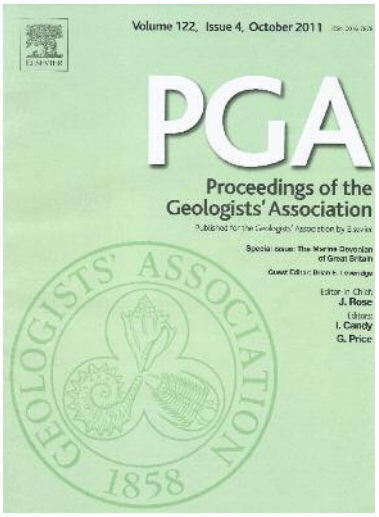
Eurospeleo2016 also hosted the European Cave Protection Symposium (ECPS). The theme for presentations and workshops was *Cave Protection under EU Law* and featured some of the many cave monitoring procedures used across European karst areas. British delegates made useful contributions in spite of the Brexit dilemma. Headline speakers included Colin Prosser, President of the Geologists' Association, and Balazs Horvath of the European Environment Bureau. The symposium concluded with a biological monitoring field trip to Scoska Cave. This was probably the most productive element of the symposium and generated a good Q&A session with some of the leading biospeleologists in Europe. The Congress was not all work. Each evening was filled with entertainment, including bands, discos and quizzes – and over 118 barrels of beer were consumed!

The overall scale of the event can be further measured from the facts that 1,050 m of security fencing was erected; 2,489 m of electric cable was installed and 375 m of water and waste pipe was laid. The work was done by the regular Hidden Earth team, who were amazing – especially in the appalling weather that preceded and followed the main event. For most of the week itself, the sun shone!

– Robin Weare, British Caving Association and **Andrew Hinde, Natural England**

Geological Conservation Review: a new era

Eleanor Brown, Natural England
Jim Rose, Royal Holloway University of London, British Geological Survey and Editor in Chief, *Proceedings of the Geologists' Association*
Stewart Campbell, Natural Resources Wales
Colin Prosser, Natural England and Editor, *Proceedings of the Geologists' Association*
David Bridgland Durham University



The cover of *The Marine Devonian of Great Britain*, **a** *PGA* **Special Issue edited by Brian Leveridge, 2011.**

In Great Britain, geological and geomorphological Sites of Special Scientific Interest (SSSI) are identified through a national audit called the Geological Conservation Review (GCR). To date over 3,200 GCR sites have been identified (*Prosser, 2013a***).**

The GCR was not intended to be a Domesday Book of geological sites. Instead, it was envisaged that sites could be removed or updated and new sites added as science moves forward, making the GCR evolve over time. Here we look at where the GCR has come from, how it is operating and future plans.

A brief history

The GCR was launched in 1977 by the Nature Conservancy Council (NCC), and was instigated to review the original site series designated under the leadership of William Macfadyen, driven by the 1949 National Parks and Access to the Countryside Act (*see Prosser, 2012; 2013b*). The GCR was continued by the Joint Nature Conservation Committee (JNCC) when the NCC was divided into separate agencies for England, Scotland and Wales in 1991.

The publication of the GCR began with *Quaternary of Wales* (*Campbell and Bowen, 1989*). Between 1989 and 2010, a further 36 volumes (out of the 45 originally planned) were published as impressive hard-bound books that would look good on any bookshelf. The full list of GCR volumes, a link to all the sites contained in them and a summary of the GCR site selection criteria were provided by Ellis (2011).

In 2010, JNCC withdrew from overseeing the GCR publications programme and that role was taken on by the Geologists' Association. In *Earth Heritage 45*, 2016, Colin Prosser explained how geoconservation had become a significant part of the publication profile of the *Proceedings of the Geologists' Association* (*PGA*), the long-running and internationally important journal of the Geologists' Association. Since 2011 *PGA* has published GCR volumes on The Marine Devonian of Great Britain, The Non-marine Lower Cretaceous Wealden Strata of Southern England, and the Dalradian Rocks of Scotland (*see further reading, below*). The publication format in the *PGA* was changed to make the content more accessible electronically and available globally, with each GCR volume being produced as a Special Issue of the *PGA*. It is a great measure of success that GCR and geoconservation papers are now among the most frequently cited and downloaded from the *PGA* (*see Geoconservaton Papers panel on next page*).

From 2011, the responsibility for managing the scientific audit aspects of the GCR has been taken by the three Great Britain nature conservation agencies – Natural England, Scottish Natural Heritage and Natural Resources Wales.

Continued overleaf

This small quarry, on the north slope of Tom Buailteach near Easter Balmoral in Deeside, is one of 48 GCR mineralogy sites that will be featured in a forthcoming Special Issue of the *Proceedings of the Geologists' Association*. **Following a recent scientific review, it was added to the Mineralogy of Scotland GCR network as an extension to Dalnabo GCR site where the mineral vesuvianite (formerly known as idocrase) was first described by Mathew Heddle in 1882. Both quarries are an excellent source of well-formed and beautiful mineral specimens, most notably vesuvianite.**
Photo by Andrew Highton

Geoconservation papers in demand among *PGA* readers

The five most cited papers in the *PGA* since 2013, listed below in alphabetical order by author, are all geoconservation papers. One is a Dalradian GCR paper and the others all appeared in the *Special Issue Geoconservation for science and society* published in 2013. Five other geoconservation papers, including three Dalradian GCR papers, feature in the list of the top 20 cited papers.

- Erikstad, L. 2013 *Geoheritage and geodiversity management – the questions for tomorrow*. 124, 713-719.
- Gray, M., Gordon, J.E. & Brown, E.J. 2013 *Geodiversity and the ecosystem approach: The contribution of geoscience in delivering integrated environmental management*. 124, 659-673.
- Prosser, C.D. 2013. *Our rich and varied geoconservation portfolio: The foundation for the future*. 124, 568-580.
- Stephenson, D., Mendum, J. R., Fettes, D.J. & Leslie, A.G. 2013 *The Dalradian rocks of Scotland: An introduction*. 124, 3-82.
- Stewart, I.S. & Nield, T. 2013 *Earth stories: Context and narrative in the communication of popular geoscience*. 124, 699-712.

Four of the above are also amongst the top 10 most downloaded papers from the *PGA* since January 2012. In this they are joined by:
Gordon, J.E., Barron, H.F., Hansom, J.D. & Thomas, M.F. 2012
Engaging with geodiversity – why it matters. 123, 1-6.

Three further geoconservation papers, including two Wealden GCR papers, feature in the top 20 downloads.

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The GCR today

Although no new GCR volumes have appeared recently, several are in progress: The Quaternary of East Anglia and the Midlands, The Quaternary of Southern England, Mineralogy of Scotland, Pleistocene Vertebrates of Great Britain, and Jurassic–Cretaceous Boundary Rocks in England (see further reading below).

Today, for GCR Special Issues in *PGA*, what had been chapters in the earlier hard-bound books have now become papers in an academic journal. Each paper is self-contained with its own references, and full colour is available for maps, diagrams and photographs in the electronic version of the journal, although colour is only available for selected illustrations in the printed journal. GCR Special Issues begin with an up-to-date overview paper which provides an authoritative summary of the research topic. Subsequent papers in the Special Issue deal with the site selection criteria followed by the specific topics identified by the editors; these topics will start with a brief overview before giving detailed information on each GCR site. Each is considered systematically. An introduction outlines the site's importance without technical jargon. This is followed by the detailed description and interpretation. A short conclusion corresponds to the all-important GCR Statement of Interest – which later forms the legal basis of the GCR site's notification as a SSSI. The individual site reports are accompanied by references and figures, which can include maps, diagrams and photographs. The PGA website (**http://tinyurl.com/z9rnlkf**) provides further details of individual GCR volumes and individual papers in the volumes . ***Continued overleaf***

Slade Brook SSSI in Gloucestershire is one of the best examples of a stream with actively forming tufa dams. Until now, sites with actively forming tufa or relict inactive tufa sites demonstrating a geomorphological process, have been significantly under-represented in the GCR. Following a comprehensive scientific review initiated by Natural England, 10 more tufa sites are being proposed as additions to the Karst GCR block.
Photo by Anna Wetherell, Natural England

To view one of the GCR site maps, click this link.

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In the new format, GCR papers are placed on the Elsevier Science Direct Website (**http://tinyurl.com/hm55598**) as soon as corrections to the proofs have been implemented, making them accessible worldwide. At present (2016) the overview chapter of each volume of the GCR published in the *PGA* can be downloaded free. This is no trivial offer when you consider the first chapter of the Dalradian GCR volume is a massive 79 pages and that some previous hard-bound GCR volumes in the Chapman & Hall series cost £150!

The country agencies are now responsible for reviewing areas of the GCR where science has moved forward or where there are identified gaps in the original site coverage. With this in mind, the country agencies met in May 2016 to review how the GCR is operating now that JNCC has officially handed over the reins.

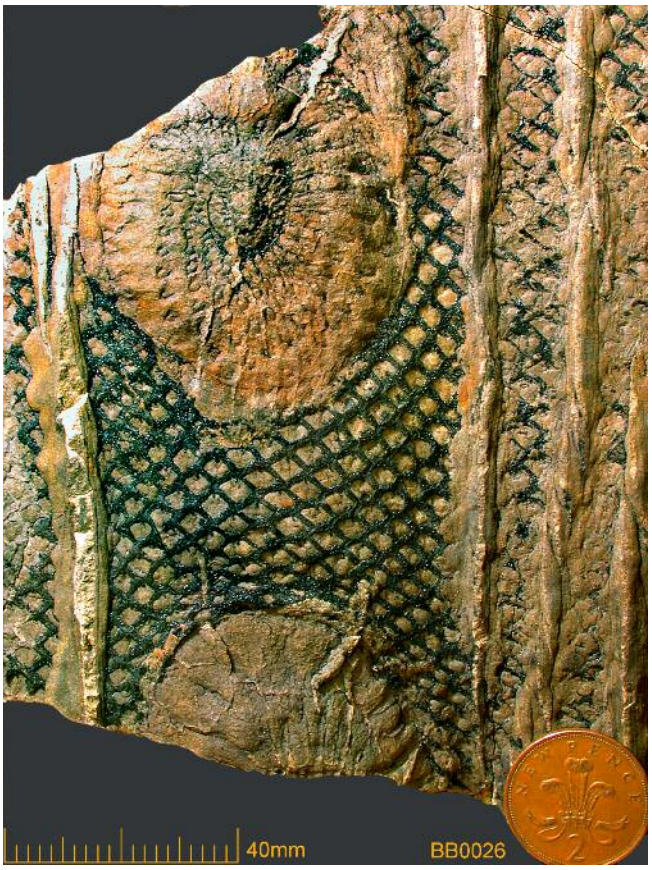
Developing the GCR

Geological science is constantly changing; new sites are being discovered and existing sites are re-interpreted. Inevitably, there will be new geoconservation imperatives. Work to update priority areas of the GCR coverage is ongoing and Natural England has already commissioned scientific reviews of actively forming tufa sites and the network of Quaternary sites with Palaeolithic evidence in England. There are plans for reviewing further priority subject areas in the GCR in England should resources allow. Large multi-disciplinary, cross-organisation research projects such as BRITICE-CHRONO (**www.britice-chrono.group.shef.ac.uk/**) are also producing large volumes of new data and potentially significant new GCR sites (**http://tinyurl.com/j2qs9ul**). Given this, discussions are taking place between the *PGA* and the country conservation agencies to ensure that the publication process remains live and provides an important service to science and society.

New GCR papers for *PGA* can go into the publication process as the GCR is updated. Publishing the GCR in *PGA* means in future it will be possible to publish single, one-off papers on new or revised GCR sites as a result of new discoveries and advances in the science.

In future, the engagement of the scientific community in helping to review the GCR is essential to ensure that it continues to be a comprehensive audit of nationally and internationally important geological and geomorphological sites in Great Britain, and a scientifically robust foundation for our Earth science SSSI. Although the three country agencies are effectively custodians of the GCR, the GCR is really 'owned' by the scientific community – which participates in the site selection and publication process and which in turn relies on the conservation of sites for teaching and research. Ongoing knowledge exchange between the country conservation agencies and both individual scientists and large research projects is needed more than ever, given the resource constraints in the conservation sector. The role of the Geologists' Association and *PGA* as the publisher of the GCR is also indispensable, and illustrates how important partnership working between academics, geological societies and conservation groups is to achieve effective geoconservation.

We would like to acknowledge the outstanding work of Neil Ellis, formerly of JNCC, who managed the GCR for nearly 20 years and oversaw the publication of a large number of GCR volumes. His legacy not only guarantees that the GCR continues to contribute to the scientific literature, but ensures that it is also available for those who rely on it to deliver successful conservation of our nationally and internationally important geological heritage on the ground. ***Continued overleaf***



Following the discovery of an exceptionally preserved Lower Carboniferous plant assemblage at the former Brymbo Steelworks in 2005, the site was registered as a RIGS by members of NEWRIGS. This created the impetus for the local planning authority and landowners to work with NEWRIGS to conserve the site. However, due to the national, if not international, importance of Brymbo, the site was subsequently reviewed for GCR status in the Palaeozoic Palaeobotany 'block' of the GCR. Following support from National Museum Wales, the BGS and key palaeobotanical experts, the site was confirmed as a GCR site in 2012. Coedwig Ffosil Brymbo Fossil Forest SSSI was notified in 2015. The photo shows branching scars on *Ulodendron majus*, one of the many exceptionally preserved lepidodendron fossils found at Brymbo.
Photo by Peter Appleton

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Further reading

Allen, P., Lewis, S. and Keen D.H. (eds) (*in prep*). The Quaternary of East Anglia and the Midlands. *Proceedings of the Geologists' Association*.

Campbell, S. and Bowen, D.Q. (1989). *Quaternary of Wales*. GCR Series No. 2. Nature Conservancy Council, Peterborough, 237pp.

Ellis, N. (2011). The Geological Conservation Review (GCR) in Great Britain – rationale and methods. *Proceedings of the Geologists' Association,* **122**, 353 – 362.

Ellis, N.V. (ed.), Bowen, D.Q., Campbell, S., Knill, J.L., McKirdy, A.P., Prosser, C.D., Vincent, M.A. and Wilson, R.C.L. (1996). *An Introduction to the Geological Conservation Review*. GCR Series No. 1. Joint Nature Conservation Committee, Peterborough, 131pp.

Leveridge, B.E. (ed.) (2011). The Marine Devonian of Great Britain. *Proceedings of the Geologists' Association,* **122**, 537 – 744.

Prosser, C.D. (2012). William Archibald Macfadyen (1893 – 1985): the father of geoconservation? *Proceedings of the Geologists' Association,* **123**, 182 – 188.

Prosser, C.D. (2013a). Our rich and varied geoconservation portfolio: The foundation for the future. *Proceedings of the Geologists' Association,* **124**, 568-580.

Prosser, C.D. (2013b). Planning for geoconservation in the 1940s: an exploration of the aspirations that shaped the first national geoconservation legislation. *Proceedings of the Geologists' Association,* **124**, 536 – 546.

Radley, J. (ed.) (2012). The non-marine Lower Cretaceous Wealden strata of southern England. *Proceedings of the Geologists' Association,* **123**, 233 – 386.

Schreve, D. and Currant, A. (eds) (*in prep*). Pleistocene Vertebrates of Great Britain. *Proceedings of the Geologists' Association*.

Smith, G. and Livingstone, A. (eds) (*in prep*). Mineralogy of Scotland. *Proceedings of the Geologists' Association*.

Stephenson, D., Leslie, A.G., Mendum, J.R., Tanner, P.W.G. and Treagus, J.E. (eds) (2013). The Dalradian Rocks of Scotland. *Proceedings of the Geologists' Association,* **124**, 1 – 410.

Whiteman, C. and Haggart, A. (eds) (in prep). The Quaternary of Southern England. *Proceedings of the Geologists' Association*.

Wimbledon, W. (ed.) (in prep). Jurassic–Cretaceous Boundary Rocks in England. *Proceedings of the Geologists' Association*.

Spoil heaps at Wanlockhead within the Leadhills-Wanlockhead GCR site in Scotland's Southern Uplands. With a record of mining extending back to 1239, this is Scotland's largest ore field. This GCR site was selected for its uniqueness, a rich secondary mineral suite not matched anywhere else in Scotland and the presence of some mineral species known from only a few localities worldwide. Additionally the Leadhills-Wanlockhead site is the type locality for nine mineral species including caledonite and leadhillite. It will be described along with the 47 other Mineralogy of Scotland GCR sites in a Special Issue of the *Proceedings of the Geologists' Association***.**

Photo by Glyn Satterley/SNH

Handaxes – much more than pebbles on a beach

Mark White, Durham University
David Bridgland, Durham University and Geologists' Association

There is a significant overlap of conservation interests between the Earth sciences and archaeology, in particular during the lengthy period of prehistory when early humans made use of stone for tool-making, having not yet discovered metal (although stone use continued after bronze and even iron were discovered).

At the older end of this overlap period are the handaxe industries of the Lower Palaeolithic, collectively termed Acheulian (after St Acheul, in the Somme Valley, northern France). These industries record the making of distinctive double-sided tools (they are also called bifaces) from flint or other suitable stone. The tools are readily identifiable, even by non-experts, as deliberate products of stone-working (knapping), although archaeologists also need to be able to recognize the flakes removed from nodules during the manufacture process, as well as other products of knapping. Indeed, there are older industries that involved flaking, to produce simple sharp-edged tools, from crude 'cores' that may or may not have also had uses as tools; these industries did not include handaxe making.

In terms of conservation there is considerable overlap between the Lower Palaeolithic and geodiversity, in that many Quaternary sediments are sources of archaeological material. Often such material is merely amongst the random components of Quaternary deposits, particularly river-terrace gravels, which were the first recognized repositories of Lower Palaeolithic artefacts. Museums in Britain, northern France and Iberia have large collections of handaxes found in gravel pits in the days of mineral extraction by hand.

Handaxes (and other artefacts) that are mere clasts within a clastic gravel will often show signs of abrasion during transport but, nonetheless, can provide important links with early hominin activity during the warmer episodes of the Pleistocene. At some sites the archaeological resource is richer, representing an integral assemblage showing similar technology. At the very best sites the artefacts can occur in positions that reveal them to have been scattered on the site of ancient stone-tool manufacture; they can sometimes be fitted back together (*see panel, right*). The greatest concentration of Lower Palaeolithic localities in Britain is in the Thames Valley, where the Geological Conservation Review (see GCR Series No. 7 *Quaternary of the Thames*, Chapman & Hall) revealed 13 sites for which artefacts constitute a significant interest.

Continued overleaf

Finds from the Boxgrove Palaeolithic and interglacial raised-beach locality

A typical Boxgrove handaxe. Well-made ovate handaxes like this, with straight edges around their entire circumferences, characterize a number of assemblages from contexts dating from about 0.5 million years ago, including the main assemblage from the Boxgrove raised beach.

Photos by Mark Roberts

Knapping scatter exposed by archaeological excavation at Boxgrove. The shape of the scatter has been formed by flakes falling between the legs of a knapper sitting on the ground, probably with one leg outstretched and the other tucked under his buttocks. The resulting handaxe and a few flakes were taken away.

Refitted flints. The cavity (as demonstrated by casting with plaster of Paris) represents a missing handaxe and some of the larger flakes produced in the reduction of the nodule by Lower Palaeolithic flint knapping.

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Amongst these is the Swanscombe skull site, one of the original pair of National Nature Reserves that had Earth science as the primary reason for notification (*see panel, below*).

The Swanscombe National Nature Reserve, one of Britain's few hominin fossil sites, has been conserved as one of an equally small number of geological NNRs; it is surely worth a greater effort in terms of public outreach in the future. For now we must be content with this modest display in the foyer of the 'Swanscombe Centre' and a stainless steel handaxe statue at the entrance to the NNR.

Photos by David Bridgland

The importance of conserving the collections of artefacts as well as the sites and documentation of their discovery has been underlined by recent advances in understanding of the handaxe industries arising from reappraisal of these resources. After a long period during which it was thought that no meaningful patterns could be discerned from the distribution of different types of handaxe, it is now realised that those assemblages with the greatest integrity can indeed be separated into groups with some chronological significance.

It had long been thought that handaxes with a fairly crude appearance, often thick in profile and made with a minimum number of flake removals, might be older than the rest. These are indeed now thought to be attributable to one of the earliest handaxe-making episodes in Britain, about 0.5 million years ago (**a**), although there are also well-handaxes of similar vintage (**b**). Meanwhile, assemblages with large proportions of handaxes with a twisted edge (**c**) generally date from the latter part of the interglacial represented at Swanscombe (about 0.4 million years ago), seemingly later within that interglacial than another handaxe group dominated by pointed types (**d**).

In the following interglacial (about 0.3 million years ago) the Lower Palaeolithic was nearing its end; handaxe-making at that time involved considerable variety, with conspicuous numbers of thin-waisted (ficron / lanceolate) handaxes and cleavers, which were handaxes with a wide sharp edge at their tip, rather than a point (**e**).

There were two later interglacials. During the first (*c.* 0.2 million years ago) humans were present in Britain but used a more sophisticated prepared-core knapping technology, part of the Middle Palaeolithic and involving little if any handaxe making. It appears that humans were absent during the final (last) interglacial (*c.* 0.12 million years ago), although they were present on the nearby continent, in the Somme Valley. They returned to Britain during a warm interval of the last glacial (*c.* 60,000 years ago), still with Middle Palaeolithic technology but now making handaxes again, albeit of a distinctive character and termed 'flat-butted cordates' or bout coupé handaxes (**f**).

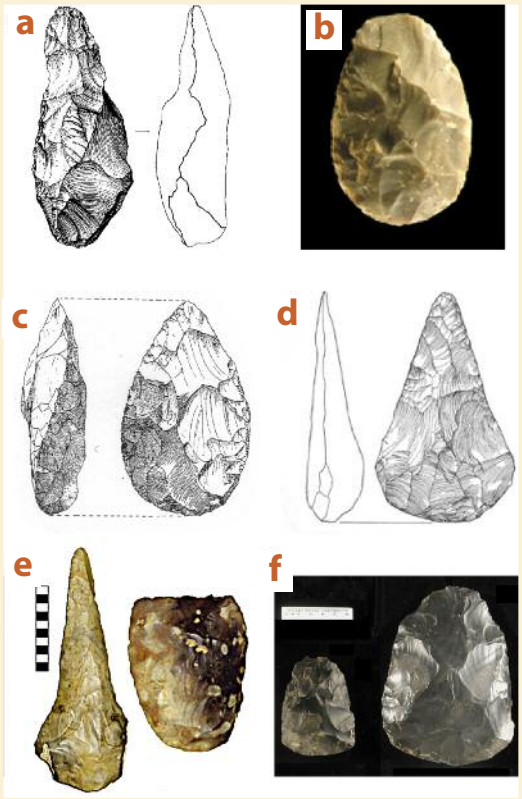

Photo b by Mark Roberts, photo e by Francis Wenban-Smith (in *Lithics* 25, 1–21), photo f by Mark White

Blurring the line between Arts and Science

Sarah Henton De Angelis, Natural England

'Art and science are branches of the same tree'. So said the great Albert Einstein, and from ancient cave paintings to the Crazy Horse Memorial, created from South Dakota's Precambrian basement with the help of dynamite, rocks are an essential medium for artistic expression.

Recent years have seen a rise in creative endeavours that not only use geology, but which actively promote and celebrate our planet's immense geological heritage, often highlighting the intense bonds between geology and our cultural and social history (*e.g.*, the recent adventures of the Cornish Man Engine, p. 25). This photo-essay explores projects that blur the interface between art and science, bringing the joys of geoheritage to the widest possible audience, and in some cases changing lives.

West Runton Elephant

On a summer's day in 2014, a mammoth took a gentle stroll on a Norfolk beach, trailed by over 700 onlookers. His four-metre high bulk was formed from plywood and his legs were propelled by very human energy. This life-sized replica was built to bring renewed life to the West Runton 'Elephant', a behemoth that roamed this corner of the world 700,000 years ago. His skeleton, which was discovered following storm-driven coastal erosion in 1990, is one of the world's most complete.

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The mammoth made a striking sight on a summer's day (right, photo by Suzie Lay) and drew hundreds of curious spectators on a beach walk (below, photo by Erin Patel).

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The Dream

Towering above the M62 traffic thundering between Liverpool to Manchester, a concrete and marble Dream sits atop the old Sutton Manor Colliery, paying tribute to the geo-industrial heritage of St Helens. Rising 20 m from its base (and extending twice as deep below), the contemplative nature of the girl's head symbolises the aspirations of the ex-mining community, while her alabaster skin provides a direct contrast to the black coal below and exemplifies the town motto, *Ex terra lucem* (out of the Earth comes light).

Photos by Sarah Henton De Angelis

Darwin's Wall

Nestled below the iconic hanging valley of Cwm Idwal, the Darwin Wall uses a series of polished rock slabs to recreate 625 million years of Earth evolution, as observed by Charles Darwin on his formative 1831 geological fieldtrip through Snowdonia. Complemented by carved wooden panoramas of the surrounding peaks and wooden benches tattooed with local contour maps, the wall provides a popular spot for hikers to take time out while admiring the majesty of a location so important to geological and mountaineering history.

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Sited in a hugely popular walking district, the wall attracts a stream of viewers.

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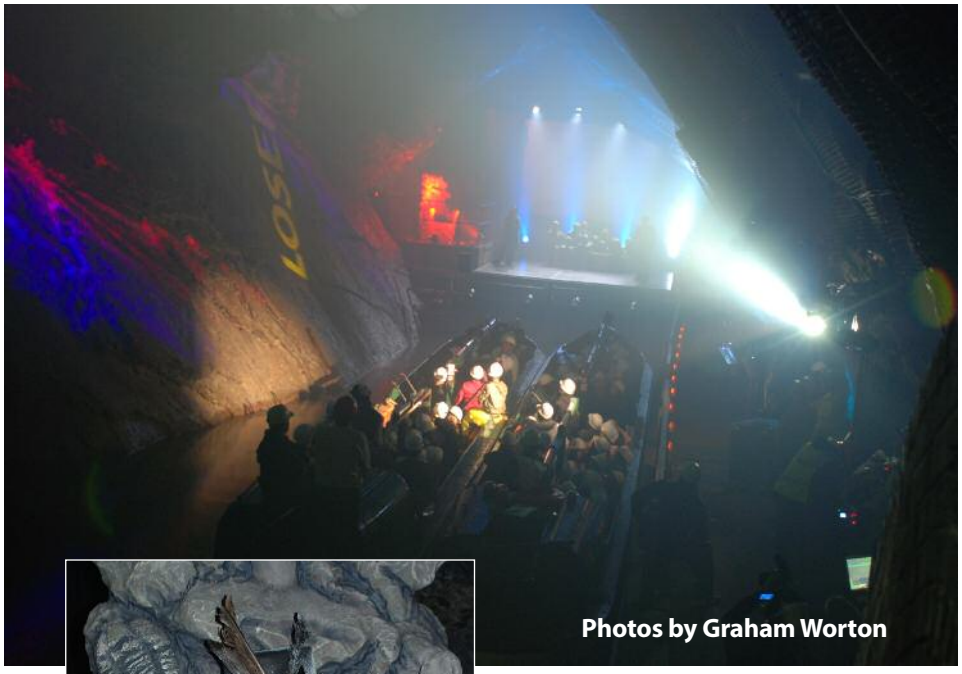
Wrosne Project

Few theatre productions begin and end with a subterranean canal-boat journey, but in 2008 those lucky enough to attend the sold-out Wrosne project performances in caverns of the Dudley Limestone Mines experienced just that. Inspired by the Dudley bug (the trilobite) and world renowned local geology, 60 young people from estates abutting the Wren's Nest National Nature Reserve worked to create a performance rich in light and sound to celebrate the area's internationlly important geo-industrial heritage. The extravaganza made such deep impressions on some of the individuals involved and on the wider community that several participants went on to further education in the performance arts.



Photos by Graham Worton

The canal boats bring the audience to the subterranean theatre (above). Left, a cast member sits on a trilobite throne.

RockBody

RockBody used research seminars, a free exhibition, and performance art to explore the impacts of mineral depletion on rocks and on the bodies of miners and quarrymen; human perceptions of geological time; and issues surrounding labour, commodity production, and consumption. Performance artists worked with Cornish granite, rose quartz, and china clay to explore the slower paces of geological time and environmental change. RockBody was funded by the Arts and Humanities Research Council and was led by Dr João Florêncio (University of Exeter) and Professor Nigel Clark (Lancaster University), in collaboration with the British Geological Survey.

Photos by RockBody Project

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Iggy & Horace

The Iguanadon Restaurant.
Photo by James Price

Worker ants at Emerald Ant (**https://emeraldant.com**) lovingly use engineering, imagination and performance art to illuminate the wonderful world of geology in an outdoor theatre constructed as a life-size dinosaur. Horace the Pliosaur, a 35-foot inhabitant of a Jurassic ocean, lets visitors brush his teeth and crawl inside his belly to meet a mad professor and handle gooey surprises. His younger cousin Iggy (aka the Iguanodon Restaurant) was inspired by an 1853 dinner party held inside the Crystal Palace Iguanodon. Back then the festivities were restricted to gentlemen, but this reincarnation provides the stage for a family-friendly performance filled with colourful characters from science and history. Horace & Iggy are available for appearances at science festivals.

Horace and Joe.
Photo by Emerald Ant

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Knockan Crag

Scotland is rich in human and natural history and at Knockan Crag National Nature Reserve both are on display in abundance, portraying 3,000 million years of geology in action and 150 years of geology as a science. It was here that the Moine Thrust was first identified and our understanding of metamorphic processes, faulting, and geological sequences was developed. Today, the contours of this ancient landscape are celebrated through rock art and poetry scattered along trails that take visitors up close and personal with the Moine Thrust and iconic vistas over Coigach and Assynt.

Sculptures and rock art contribute to the sense of place and they help convey the geological stories in the landscape at Knockan Crag National Nature Reserve.

Photos by Colin Macfadyen

Know of any other great examples? Tell us about them through Facebook or Twitter @Earth Heritage #geoart

Cornish miner stands tall in World Heritage Site

Sarah Manning, Natural England

The United Kingdom is at the forefront of geoconservation and development of best practice. Few regions of the UK boast a more varied geological landscape or a richer geoheritage than Cornwall, where celebrating and protecting that heritage are vital for economic and social development.

Photos by Sarah Manning

I spend much of my free time outdoors, immersed in our varied landscape. I am absorbed by the huge diversity of landforms, enriched by the character and the tangible sense of place that these surroundings give me. I have spent summers on beaches backed by unfeasibly contorted and folded cliffs, puffed my way out of hideously steep valleys to be rewarded with stunning long coastal views, and both enjoyed and escaped the crowds among Dartmoor's granite tors.

This summer I was one of 149,000 people celebrating the 10th anniversary of the Cornish and West Devon Mining UNESCO World Heritage Site (WHS). The largest UNESCO designated site in the UK (covering 19,710 hectares), the Cornish and West Devon Mining WHS harbours unique geology that supports more than 90% of all the mineral species ever identified, not to mention the copper, tin, arsenic, lead, zinc, silver and gold that have contributed to over 4,000 years of Cornish mining history.

Parties celebrate mining and landscape

To remind people about this unique, spectacular landscape and heritage, and to commemorate the pride and local identity within Cornish communities, the WHS threw a series of epic street parties over a two-week period. These were rousing communal sing-songs with newly penned pieces (Hard Rock Cornish Miners anthem!) alongside traditional songs telling the yarns of Cousin Jacks, the colloquial term for Cornish miners.

I joined the party on the thronged high street of Penzance under a perfect blue sky, the sun intensely hot, a gentle breeze keeping colourful flags fluttering. This was day 11 of a 12-day, 130-mile, 22-site celebratory tour of someone quite magical. People of all ages, locals and holiday makers alike (many decked out according to the voluntary 'steam punk' dress code), packed the pavements and street, smiling and chatting, swigging tea and beer. Attention was focused on a large mound on a trailer covered by a vast Cornish black and white St Piran flag. It was the Man Engine. This was not the clever system of moving rods and platforms designed to transport miners up and down (invented in Cornwall in 1842 and known as a man engine), but instead the tallest mechanical puppet ever made in the UK. *continued overleaf*

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Constructed at a former mining location in Cornwall using salvaged metal and other bits and bobs, the Man Engine stands 10 m high, equivalent to two and a half double-decker buses.

The proceedings opened with an MC, who presented the story and importance of the WHS and its geological and cultural history. With anticipation growing, the Cornish flag was pulled away and, led by his entourage of miners, bal-maidens (female mine labourers), and a brass band, we sang hard and watched awestruck as the Man Engine was 'transformed'. Amongst a rush of steam and smoke, in an impressive feat of mechanical puppetry, he rose up from his recline to stand and sing with us, dwarfing the buildings around him. His eyes, mouth and head movements, his swinging arms and the gaily flashing light on his miner's helmet endeared him to the crowd, although in truth he was more sombre than jolly (a testament to the harshness of Cornish mining life?). Due to the incredible numbers of people in Penzance, it was unsafe for him to walk as he had at other locations (*e.g.*, the Geevor Tin Mine, where he purposefully strode across the heathy, wind-pruned site); nonetheless, the crowd was wooed and thrilled. A sea of hands hoisted phones, iPads and cameras to capture the scene. A special Penzance gift was carried down the hill and presented – an appropriately scaled Davy Lamp, hooked over his arm as he reached down (the Davy Lamp was invented by Penzance native Humphry Davy, whose statue still adorns the town). Once the singing, puppeteering and rotation of people shuffling forward to view him at close quarters was over, the crowd gradually drifted, chatting excitedly about the spectacle.

Extended programme of events

The 12-day tour was a resounding success for a project that had mushroomed from the WHS's original commission. Through crowd funding and other money-raising initiatives, the Man Engine was accompanied by an extended programme of heritage events ranging from theatre and film to a European conference, and a school education programme (**http://tinyurl.com/hr2kblp**).

National and regional print and TV coverage provided a reach of 122 million views/reads, which was multiplied yet again by social media spreading the news worldwide. But the Man Engine's journey is far from over. It is hoped that the puppet will go on a world tour, visiting the 40 countries and six continents to which 250,000 Cornish miners were forced to emigrate when their industry declined from 1860.

Recent years have seen the WHS mining landscape well promoted; aside from the Man Engine, the TV series Poldark has boosted local tourism, while the Seasalt clothing company reinforces its Cornish roots through a Cornish tin mines feature and link to the WHS website in its autumn catalogue. Such a variety of media gives the region the best possible chance to conserve its geological and cultural history.

Achieving public support for geoconservation

We need the public both to value and speak up for geoconservation. Achieving this requires the widest possible appreciation of geodiversity and its links to our cultural history and the places we all love to experience. Activities such as the Man Engine tour (and the other events highlighted in this issue of *Earth Heritage*) enable people to 'feel' the connections and stories and to create lasting memories of something communal, experienced with friends and family. Long may the Cornish Man Engine stand tall!

English Coast Path lays geology open to all

Sarah Henton De Angelis, Natural England

It has inspired and it has terrified. It can provide a constant comfort, or can change lives forever. It is a place of sunshine and ice cream, but also a place of wreckers and pirates. In all its guises, the English Coast Path is opening up our geology like never before.

We are an island nation with a proud maritime history. We are also a land of walkers and outdoor enthusiasts. Given these facts, it is surprising that, until now, England has had no continuous coastal path. In England, everyone lives within 75 miles of the sea, and the newly established English Coast Path will ensure our right to access the entire coastline for the first time.

The English Coast Path initiative was enabled by the Marine and Coastal Access Act 2009, which enshrined in UK law a right of public access to the coastal margin (excepting private houses and gardens, and Ministry of Defence land). Critically, and for the first time, the Act accounts for 'roll back', in other words, as erosion causes the coastline to retreat, access rights and the position of the coastal path will move back accordingly.

The new coastal path, which is being developed and constructed by Natural England, will consist of 62 continuous sections. At the time of writing, work is underway on over 60% of the path, with new sections opening all the time. When completed in 2020, the path will be 2,795 miles (4,498 km) long, placing it in the top five long-distance walking paths in the world, and the longest continuous coastal walking route. The route will also link up to the 870-mile Welsh Coast Path, which opened in 2012. Taken together, the length and diversity of this coastal right-of-way are truly unrivalled.

England's coastline has inspired colourful and poetic musings and missives from such varied characters as Julius Caesar, William Shakespeare and Vera Lynn. The English coast boasts dramatic cliffs, gently sloping beaches and much loved seaside towns. This medley of places and landscapes owes much (if not all) to the underlying geology.

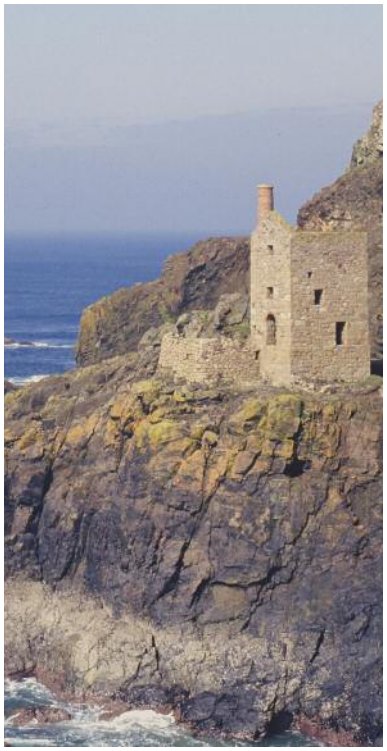
The geological heritage exposed around the English coast is second-to-none, providing a rare opportunity for time travel through the evolution of our planet. Many of our best-loved coastal locations not only owe their existence to geological and geomorphological processes, but are also iconic on a global scale; think the White Cliffs of Dover, Dorset's Jurassic Coast and Land's End. Others are lesser known but are no-less national gems; Samphire Hoe (a new sliver of land formed from chalk marl excavated during the creation of the Channel Tunnel), Another Place (cast iron men of sculptor Antony Gormley's imagination that appear and disappear with the ebb and flow of grey Mersey tides at Crosby), and the Minack Theatre (an open-air venue built into the iconic Cornish granite), are among them.

When the Geological Society compiled a list of the 100 greatest geosites in the UK and Ireland (based on public nominations), 18 were along the English coast. Highlights include the Whin Sill exposures along the Northumberland coast, most dramatically seen at Dunstanburgh Castle and Lindisfarne; the distinctive red and white stripes of the Hunstanton Cliffs (Norfolk), where red chalk is overlain by white chalk; and the rugged cliffs and coves of the Lizard Peninsula (Cornwall), known as the 'graveyard of ships'. *See overleaf*

Rocky outcrops on the Blue Anchor to Lilstock coast in Somerset.

Photos by Peter Wakely / Natural England

Derelict buildings stand sentinel at the old Botallack Mine, Cornwall.



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Whether born from the enthusiasm of youth or from a lifetime spent along the margins of the sea, the coastline is for many a place of discovery. Few could argue with the joys of an afternoon spent exploring the foreshore – that magical place exposed only at low tide, where the same spot is never the same twice, and where all manner of wondrous things can be discovered, from geological formations and fossils from another era, to living flora and fauna. And it is not just the visible geology that has been the subject of human discovery. The rocks below our coastline play host to a profusion of man-made marvels, including the mighty Channel Tunnel, which brings land under water, and state-of-the art laboratories where research is revealing the very origins of the universe.

The English Coast Path promises to be a national treasure that we can all enjoy. So whether you are searching for the entrance to Jean-Benoit Aubéry's hiding place or watching for bluebirds above the White Cliffs of Dover, don those walking boots and hit the trail!

For more information, please visit: **www.gov.uk/englandcoastpath**

Walkers head towards Scolt Island, north Norfolk. Photo by Allan Drewitt, Natural England

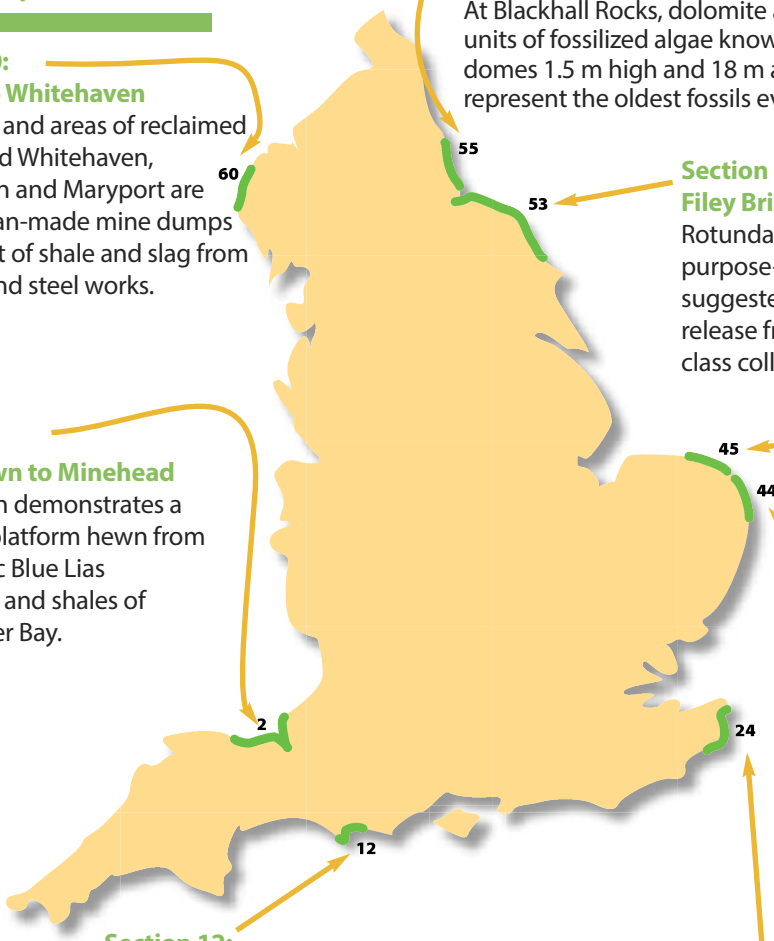
Coastal path brings geological features out of the shadows

Sections in green are already open to the public

Section 55: North Gare to South Bents
At Blackhall Rocks, dolomite and conglomerate strata are overlain by laminate units of fossilized algae known as stromatolite, some of which form spectacular domes 1.5 m high and 18 m across (elsewhere in the world stromatolites represent the oldest fossils ever identified – up to 3.7 billion years old).

Section 60: Allonby to Whitehaven
Some cliffs and areas of reclaimed land around Whitehaven, Workington and Maryport are actually man-made mine dumps that consist of shale and slag from collieries and steel works.

Section 53: Filey Brigg to Newport Bridge
Rotunda Museum, Scarborough, is one of the oldest purpose-built museums in the UK. The design was suggested by William Smith, the father of geology, after his release from debtors' prison. The museum houses a world-class collection of Jurassic geology.



Section 2: Brean Down to Minehead
This section demonstrates a wave-cut platform hewn from the Jurassic Blue Lias limestones and shales of Bridgewater Bay.

Section 45: Sea Palling to Weybourne
Cliffs at West Runton mark the resting place of the West Runton elephant- the world's most complete mammoth skeleton, and the focus of a recent art installation project (*see page 20*).

Section 44: Hopton on Sea to Sea Palling
This section reveals unusual dune systems (including Winterton Ness) where sand migration is often in the opposite direction to longshore drift.

Section 12: Rufus Castle to Lulworth Cove
Durdle Dor – an iconic limestone arch along the Jurassic Coast ('Durdle' is derived from 'thirl', which means bore or drill in Old English).

Section 24: Folkestone to Ramsgate
Rare (for the UK) loess deposits (*i.e.* windblown silt) occur at Pegwell Bay (best exposed behind the old hovercraft port).

The Whin Sill, here at Housesteads Crags, is a spectacular and world-famous feature of Northumberland geology and the inspiration behind the project. Photo by Northumberland National Park Authority

Park discovery centre is close to opening

Sarah Glynn, Sill Manager, Northumberland National Park

Northumberland National Park Authority's flagship project to create *The Sill: National Landscape Discovery Centre* **on the edge of Hadrian's Wall World Heritage Site is progressing at full speed to welcome the public in summer 2017.**

The state-of-the-art, all-weather facility, which takes its name from The Whin Sill, a world-famous feature of Northumberland geology, is designed to engage people of all ages and backgrounds with the landscape and unique geology of the county.

Being built at a cost of £14.8 m, including £7.8 m from the Heritage Lottery Fund (HLF), *The Sill* is a project of national and international importance that will fill an identified gap in the visitor, training and education sectors for landscape interpretation. It will provide a centre for education and a gateway for visitors to explore the wider county and other protected landscapes including the North Pennines and the Northumberland Coast Areas of Outstanding Natural Beauty.

The design of the building characterises the distinctiveness of Northumberland National Park by reflecting the landscape in its design and palette of materials, with the roof built to create a fantastic public viewing area of the Whin Sill at its highest point.

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This rocky outcrop is part of a huge sheet of rock which starts at the Farne Islands and runs along the Roman Wall and then under the Pennines. In the southern half of Northumberland National Park this tough dolerite stone contrasts with the surrounding lower ridges and crags of Carboniferous sandstone and limestone and after millions of years of erosion the Whin Sill is now partly exposed at the surface, forming spectacular cliffs and escarpments.

The Whin Sill was formed over 295 million years ago when stretching of Earth's crust caused molten rock, or magma, at over 1,000°C to rise up from deep within the planet. It didn't reach the surface but was injected between layers of limestone, shale and sandstone. The magma cooled and solidified underground to form the Whin Sill – a vast sheet of rock up to 70 m thick, which lies beneath much of North-East England. The Whin Sill complex is usually divided into three components: Holy Island Sill, Alnwick Sill and the Hadrian's Wall-Pennines Sill, which were created by separate magma flows but at about the same time.

The name Whin Sill was first used by local quarrymen. To them 'whin' was a hard dark rock, and 'sill' was a term for a flat-lying layer of rock. Geologists who studied the Whin Sill in the 19th Century recognised its molten origins and the term 'sill' was adopted for all similar bodies of igneous rock. The Whin Sill is thus the original sill of geological science and is well known to geologists worldwide.

Once in a lifetime opportunity

The Sill is a once in a lifetime opportunity to turn a national spotlight on the vital importance of landscape to health and wellbeing. It will stimulate and nurture the next generation of landscape enthusiasts, open up access to the countryside for everyone and ensure that these last wild places - and the communities within them - continue to thrive.

An architect's vision of *The Sill: National Landscape Discovery Centre*

Image by Northumberland National Park Authority

However, *The Sill* also promises to be far more than a visitor destination. It is a gateway from which extensive learning and research activities will be provided and it will become a leading education facility for landscape, conservation, countryside management, leisure and tourism skills. Its comprehensive activity programme will inspire people to celebrate, value and conserve Northumberland's unique natural and cultural features.
The centre is set to attract over 100,000 visitors per year and will give significant support to the rural economy by providing opportunities for new employment, skills development and training, along with a year-round activity, education and events programme.

Northumberland resident and renowned geologist Ian Jackson, former Head of Operations and Director of Information at British Geological Survey, explains: "There can't be many geologists who, as students or professionals, haven't stood on and marvelled at the raw and rugged landscape created by an intrusion that gave its name to all other sills worldwide."

"Here, perhaps as well as anywhere else in these islands, the relationship between landscape and the underlying geology is clear for all to see. As the rock that defined the edge of an empire in AD 122, it and the Roman remains that run along its course now draw millions of visitors every year. Where better to build a facility designed to inspire and engage people with their landscapes?"

Victorian geological curio being restored

Daniel Atherton, Biddulph Grange Garden, National Trust

Earth Heritage 46 **described how Hugh Miller's spirit was being maintained through the written word at his former home in Cromarty, Scotland. Miller's influence spread throughout Britain, particularly after the publication of his book** *Testament of the Rocks* **in 1857. A tangible reminder of this, the unique Geological Gallery at the National Trust's Biddulph Grange Garden, Staffordshire, is now under restoration.**

The Gallery long represented an oddity, but after much research it can now be attributed as being directly influenced by Miller, in particular his theory of *Genesis and Geology Compared*. The restoration is in year four of a five-year plan.

James Bateman built Biddulph Grange around 1840, developing it into a garden of gardens that displayed a wide variety of plant specimens collected from all over the world and planted in innovative and thematic set pieces. Educated at Oxford, Bateman had the opportunity to engage with geology during his academic career, but botany was his only interest and his specialist orchid collection led to his acceptance into the Royal Society.

Geological interest was instead motivated by theological concerns and Bateman first engaged with the subject in a public lecture at Hanley Town Hall (Stoke-on-Trent) in December 1857 entitled *The Mosaic Vision of Creation: Or Genesis and Geology Compared*. The lecture drew heavily on the work of Hugh Miller and sought to establish how the newly discovered fossil record could be reconciled with the creation story in the Bible's book of Genesis. His lecture was accompanied by six diagrams drawn for Bateman by Benjamin Waterhouse Hawkins. Sadly these images are now lost, but they are said to have shown 'ideal representations of the six days or epochs of creation'. Bateman repeated his lecture a number of times in north Staffordshire, but no mention of a construction representing the theory was made. Despite this lack of evidence, by 1862 such a construction was complete and acting as a new and exceptional entrance to the garden.

The Biddulph Grange Gallery is seen here after its re-opening in September 2016.

All photos by National Trust

Biddulph Grange Garden is an ongoing National Trust conservation project; the garden in its entirety is remodelled to represent it at its peak and as described by Edward Kemp in 1862. This invaluable archival source describes the gallery shortly before it was opened to the public as a hallway upwards of 100 feet long. "Singularly illustrative of the great geological facts of the globe… The whole is distributed into 'days' supposed to correspond with the six (so called) days of the Mosaic cosmogony". Entering via steep stone steps, the Victorian visitor was presented with a long hallway. On the north wall a series of fossils was displayed, contextualised by the then familiar religious reference of 'days' and supported by a strip of strata in which the adjacent fossils could be found. Facing this diorama were geological maps and sections in large oak frames, along with tables of minerals and seating 'for the accommodation of those who wish to make the matter of study'. ***continued overleaf***

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The Geological Gallery was a physical representation of Hugh Miller's theories. It demonstrated Bateman's liberal approach to the problems created by new scientific discoveries. However, the short-lived popularity of such theories was reflected in the gallery's history as it soon disappeared from prominence in descriptions of the garden, and was last mentioned shortly after Bateman left Biddulph in 1877. The following century of the gallery's life was anonymous, used as a storage room and even a mortuary when the Grange became an orthopaedic hospital.

Only in the 1970s was its importance recognised. Dr John Stanley, then of Keele University, found it in a dilapidated state with the majority of its fossils and strata missing. The few remaining fossils were removed and taken to Keele University for conservation and storage until the National Trust began the restoration in 2012.

This *Chirotherium* footprint has been restored.

Identifying missing specimens

With the help and concerted research of Keele's Professor Hugh Torrens and Dr Ian Stimpson in identifying the gallery's missing specimens, its history and the story of its creation is now better understood. Exciting results also followed the investigation of the original collection. The surviving fossils came from the later end of frieze, beginning with a *Chirotherium* footprint positioned with Day IV representing the period in which mammals became established on land. The majority of the original specimens were positioned in Day V, displayed to represent an abundance of swimming and flying creatures. A large ichthyosaur skull and a complete juvenile ichthyosaur have proven to be excellent, iconic specimens in the collection. Furthermore, a large slab originally thought to contain fish, has since been identified as Solnhofen limestone containing the remnants of a pterosaur. Further investigation into provenance is ongoing, but this discovery strengthens the notion that Bateman was using his connections, particularly such friends as Sir Richard Owen, to get hold of specimens at the cutting edge of geological discoveries.

The restoration of the Geological Gallery is expected to continue throughout 2017 as the hallway is slowly returned to its former self. Replica fossils are being created and the installation process will take place over several phases beginning with Day I and progressing along the gallery, installing the missing sections of geological strata at the same pace.

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The ichthyosaur before conservation (above) and after conservation (below) – top is the original (now conserved) specimen, below is the cast.

Challenges behind the Biddulph restoration

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A view from the conservator – **Nigel Larkin,** freelance palaeontological conservator and curator

Working on this project is a unique experience. Some of the specimens, such as the large fossil turtle, were very possibly handled by Sir Richard Owen and the gallery was opened during an era of fervent theological and scientific enquiry, most notably expressed in *On the Origin of Species* **by Charles Darwin. So this unique gallery has a very specific place in history.**

Of the 70 fossil specimens that were originally on the wall, 10 remain. Some of these simply needed careful cleaning, others required extensive conservation. They are in the process of being carefully moulded so that high-quality casts can be made and painted ready for display. The real specimens are too important to go on the gallery wall where environmental conditions are not ideal. These fossils are stored in the Biddulph Grange Garden archive (it is hoped they may be able to be displayed in appropriate conditions in the future).

One of the most interesting aspects of the project is trying to identify the specimens and work out where they were originally found (and therefore how old they are) as no such records exist.

The large anonymous ichthyosaur skull is currently in the process of being conserved and prepared but analysis has revealed this to be a *Temnodontosaurus* skull. The similarly anonymous small ichthyosaur skeleton was identified as a juvenile *Ichthyosaurus breviceps* by ichthyosaur specialist Dean Lomax. This species is only known from Lyme Regis so the fossil is almost certainly from Sinemurian deposits of the Lower Jurassic in the vicinity of Lyme Regis and would be between about 199 and 190 million years old. The large fossil turtle has been CT scanned to see if any more bones can be discerned inside the nodule. Samples of matrix from several of the specimens have been sent for microfossil analysis. If successful, this will help to date them and suggest their possible provenance.

One of the most difficult tasks is to deduce what originally filled the remaining 60 holes in the wall and find suitable substitutes to fit the spaces. We know what was likely to have filled each space (*e.g.*, 'primitive' invertebrates in Day 1 through to mammals in Day 6) but we have to find suitable specimens to fill the relevant space that are robust enough to be moulded – but they also have to be from sites that would have been known to Bateman and his associates around the time the gallery was constructed.

This was the gallery in 2015. One of the most difficult tasks is deducing what specimens filled the holes in the gallery walls.

Throwing new light on London's rare Chalk exposure

Diana Clements, London Geodiversity Partnership

In response to the rather alarming article in *Earth Heritage 45* **by Jonathan D. Paul, University of Cambridge:** *Managing London's finest Chalk exposure – Riddlesdown Quarry***, the London Geodiversity Partnership (LGP) decided to make Riddlesdown the focus of its geoconservation day for 2016.**

In 2009 LGP recommended the quarry for RIGS (Regionally Important Geological Site) status as it is by far and away the best chalk quarry within Greater London and arguably the best quarry altogether. The pit is a Site of Special Scientific Interest (SSSI) for its biology and we would like it upgraded to a SSSI for the geology too.

In 2010 it was heartening to see how the Geoconservation Plan, drawn up by chalk expert Rory Mortimore for the City of London Corporation, had been put in place. Access had been cleared to the important faces he had identified and rudimentary wooden steps created up the spoil heap for examination of the north cliff face. A flock of resident goats was employed to help keep the vegetation down. I organised a trip for the Geologists' Association (GA), led by Rory, in November 2010 to coincide with the publication of his detailed description of the quarry in the new GA London Guide. We were all delighted about the work that had been achieved by the rangers and volunteer groups.

Six years later I was shocked to see how much the vegetation had progressed on all the faces. The goats had been retired and occasional visits from sheep had failed to do the job adequately. We all know that birch grows very rapidly and once it takes hold can mask the lower slopes. The steps were all but destroyed by rock falls. I had last visited the quarry in 2013, when the steps up the cliff face were still usable and other faces, although less accessible than previously, were still visible.

Hard hats, gloves, loppers and saws

Matt Johnson, a ranger with the City of London Corporation, had been out with us on previous visits both with the GA and the Open University Geological Society (OUGS) and gladly accepted the offer of a geoconservation day organised by LGP together with the London branch of the OUGS. The face chosen was the south face described by Jonathan Paul as 'one of the few remaining complete exposures of the Lewes Nodular Chalk Formation in the North Downs'. It was a logical place to start. In advance, Matt had prepared a base for a big bonfire and arrived with a van-load of hard hats, gloves, loppers, saws and other equipment; also a very welcome box of tea-making equipment.

One of the sweeteners to entice LOUGS members to participate in our geoconservation days is to begin by looking at and explaining the geology. On this occasion we invited Liam Gallagher, another chalk expert, to talk to us. Before we set to work we stood in the centre of the quarry while he explained the importance of what we were looking at, pointing out the features we could see at a distance. Some of us then scrambled through the undergrowth to examine the face we were about to clear. Finally, when we had finished, he could more readily demonstrate the face's stratigraphy and structure to the entire group. Liam provided a comprehensive handout which will be an excellent reference.

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The quarry's showpiece south face is inspected during the Geologists' Association visit in November 2010, led by Rory Mortimore.

Photos by Diana Clements

Members of the London branch of the Open University Geological Society making good use of the newly constructed steps up the spoil heap to examine the north face cliff in April 2010.

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The main vegetation for us to clear was birch trees. Liam and Matt joined the team of 'heavies' to saw them down while others of us dragged the felled trees to the bonfire or lopped smaller vegetation. We were all surprised how much we managed to clear.

We hope to return in the autumn of 2017 to tackle another face in earnest. In the meantime Matt had other volunteer groups lined up who cleared more of the scrub away from the face. We would dearly like to see a return of the goats to help keep this face open.

Many thanks to Matt and Liam for a very satisfying day's work and to volunteers from LGP, LOUGS and the few from other London geology groups for all their hard work. We need to keep our best quarry available for visitors.

Geoconservation scrub clearance on the lowest south face by members of the London Geodiversity Partnership and the London Branch of the Open University Geological Society. Below, the team lines up against the south face after clearance.

For more photographs of the geoconservation day, see the LGP Flickr site: **www.flickr.com/photos/londongeopartnership/albums** and for more details on the site, the main LGP website, **www.londongeopartnership.org.uk/londonguide.html**

Full details of the geology described by Rory Mortimore are available to purchase (£2) as a digital download from the GA website, **www.geologistsassociation.org.uk/londondownload.html**
GA Guide 68 Geology of London, compiled by Diana Clements, Itinerary 9.

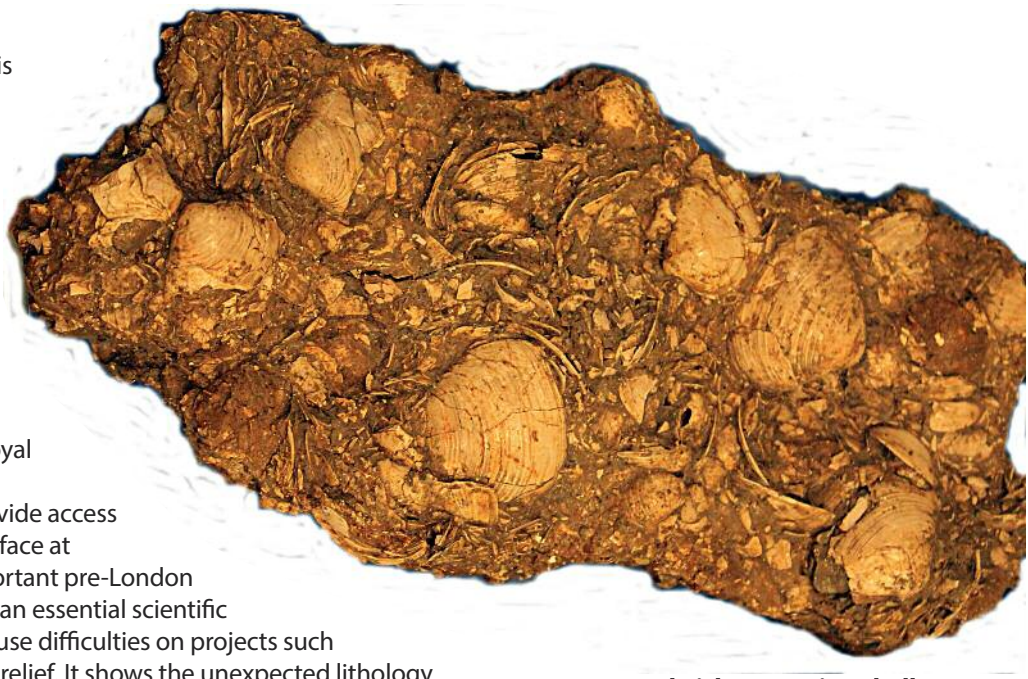
Opening access to pit's geological past

Laurie Baker, London Geodiversity Partnership

Gilbert's Pit at Charlton in south-east London was designated a Site of Special Scientific Interest (SSSI) as long ago as 1953 because it provides one of the most complete sections of late Palaeocene and early Eocene deposits. It provides a sequence from the Thanet Formation to the Blackheath pebble beds of the Harwich Formation. The year 2016 has seen the culmination of a long-held desire to provide greater accessibility to view and examine the Lambeth Group beds that are tunnelled through by much of London's new infrastructure.

This quarry was one of a number of pits in this part of London worked for sand, gravel and chalk. The pit was worked primarily for the fine-grained Thanet sand used for moulding at nearby Woolwich Arsenal foundries and for local amber-coloured and green-bottle glass manufacture. The pits were worked from the early 18th Century to just before the Second World War. Gilbert's Pit ceased working in 1938.

The London Geodiversity Partnership (LGP) has been working for some years with the Royal Borough of Greenwich, Natural England and Geotechnical Consulting Group (GCG) to provide access to the geological interest near the top of the face at Gilbert's Pit. This face provides the most important pre-London Clay Palaeogene site in the London area. It is an essential scientific place for engineers to view strata that will cause difficulties on projects such as Crossrail and the Thames tunnel for sewer relief. It shows the unexpected lithology that can be encountered when building in London.



Woolwich Formation shells found at Gilbert's Pit

Photo by Laurie Baker

Best route for stepped pathway

On the higher part of this face is the Woolwich Formation, which has been designated as the type section. It shows the varied lithologies that make it difficult to engineer. The fossils found here indicate that it was deposited in estuaries and lagoons.

The SSSI was in an unfavourable condition, and was deteriorating due to erosion, growth of trees, nettles and brambles, and build up of scree at the base. After years of meetings, the LGP and London branch of the Open University Geological Society held a geoconservation day in 2013 to strip away undergrowth and some of the smaller trees to see the best route to install a stepped pathway.

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In 2014, Capita produced a geotechnical report on how access could be provided and a second volunteers' geoconservation day in 2015 enabled a local company to quote to provide access. Natural England provided substantial finance through its Conservation and Enhancement Scheme and the Royal Borough was able to match fund. Complete Ecology was engaged to carry out the works and, in April 2016, the aim of providing access for students, geologists and engineers was finally achieved when steps were completed. Councillor John Fahy formally cut the ribbon to launch the steps, supported by representatives of LGP and Natural England and with local press present.

Councillor Fahy cuts the ribbon on the new step.

More than 30 people came to a summer open day to be shown around by Jackie Skipper from GCG. The Geologists' Association also had one of its trips as part of the Festival of Geology in November 2016.

The LGP will provide interpretation panels that are available on our website (**www.londongeopartnership.org.uk**) and to visiting parties. The Royal Borough will renovate the existing board and a new permanent interpretation board has been designed by the LGP.

The remaining tasks include stabilising the Blackheath pebble beds at the top of the faces to reduce the amount of scree build up at the bottom and managing the rampant vegetation.

Anyone can gain access through the Park Rangers at the Royal Borough of Greenwich, parks@royalgreenwich.gov.uk or telephone 020 8856 0100

Below, the exposure viewed from the top landing.

Further reading

An introduction to the geology of this pit and of south-east London is best found as Itinerary 6 to Charlton, Plumstead and Abbey Wood in *Geologists' Association Guide No. 68, The Geology of London*, edited by Diana Clements. Online copies of individual itineraries can be purchased from the GA website, **www.geologistsassociation.org.uk**.

Jackie Skipper from the Geotechnical Consulting Group discusses the face with budding engineers.

Photos by Greenwich Borough Council and London Geodiversity Partnership

To restore, or not...

Colin MacFadyen, Scottish Natural Heritage

Irresponsible core sampling has created a legacy of defaced rock outcrops across the UK and is a problem internationally. The development of a methodology for core hole restoration within classic sites has great merit. However at one of the most iconic geological localities in Scotland, Edinburgh's Salisbury Crags, the debate centres on whether a set of unsightly core holes should be restored or left as they are since, ironically, they now have educational and cultural significance.

Earth Heritage has run several articles over the years about irresponsible core sampling (*see issues 17, 27, 28, 36*). This is an important method of sampling rock for geoscience research. However, where done irresponsibly, it can deface outcrops for all to see and core sampling in hard rock has an impact that persists on a geological timescale. In some instances, particularly in classic sites, irresponsible coring becomes reckless damage and a criminal offence.

As a geological sampling technique, coring became widespread in the 1970s and 1980s. However, the activity defaced outcrops in well-known research localities and ruined their photographic value. In response, the Geologists' Association in 1989 was the first body to publish best-practice guidance, a coring Code of Conduct, to encourage responsible behaviour.

Scottish Natural Heritage (SNH) produced its own Core Code in 2011 in response to calls from researchers dismayed that coring was not only ruining outcrops for photographic illustration but at worst was damaging features of limited extent, including fold cores and shear zones, to the point of their removal. 'Rashes of ugly holes' were also reported to SNH by members of the public who found their countryside experience blighted by holes in trackside and remote outcrops.

Although UK researchers may be more aware of the need to core responsibly, geoscientists from overseas can be oblivious to site designations and codes of conduct, as evidenced by an episode in the Garvellach islands (*see right*). To help raise the issue internationally, Dr Rob Butler at Aberdeen University has instigated the Rock Damage Scotland Facebook page (**https://www.facebook.com/rockdamagescotland**), where visitors are invited to add images of irresponsible coring. This will hopefully reach a wider audience.

Whilst awareness raising and the promotion of best practice continue, there has been discussion in Scotland on restoring the appearance of damaged hard-rock exposures,

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Worst case known

The worst case of coring known to SNH is on the Garvellachs Site of Special Scientific Interest. Internationally important exposures in the Dalradian Supergroup that provide evidence relevant to the Snowball Earth theory, have suffered irresponsible coring, damaging the geotouristic value of the site. Damage has continued despite boat operators offering codes of best practice to researchers visiting the site.

It is understood that these are only 11 holes out of 100, drilled by geoscientists based overseas. Permission was not sought to remove the cores so therefore could constitute theft. If consent had been sought, the drilling would have been permitted with the proviso that it was undertaken responsibly so as not to ruin the outcrop for other users.

One would hope that researchers in the UK are adhering to best-practice guidance given that it has been around for 30 years. However, in at least two cases in Scotland the damage has been inflicted by overseas-based research groups with links to UK researchers.

Photo by Hazel White/SNH

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particularly within classic sites. Information concerning attempted restoration is largely anecdotal. Currently the method to restore exposures in hard-rock lithologies involves filling the hole with small chips of the drilled lithology mixed with resin and then plugging the end of the hole. For preference, the plug should be either the weathered end of the original core, broken off the extracted sample. If that is not possible, a plug can be created by coring a loose chunk of the rock type lying nearby, provided it has a similarly weathered face. That way, the substitute matches the originally cored face as nearly as possible. However, good evidence of either method is lacking and if there is a desire to ameliorate the appearance of core holes, research is required.

But whether restoration is needed at all is the question under consideration by the Scottish Geodiversity Forum regarding Scotland's most iconic example of irresponsible core sampling – in an exposure of the teschenite sill intrusion forming Salisbury Crags in Edinburgh's Holyrood Park. The cored rock exposure is beside a path used by hundreds of thousands of people a year on the climb up to Arthur's Seat. Seven holes, drilled presumably for palaeomagnetic research in the 1980s, are evident to all. Constituting an eyesore in a rural-type setting, there have been calls to infill the holes, and to use them as a test-bed for the restoration methodology outlined above.

But Forum discussions have also considered that the holes should be left in all their incongruity because they actually draw attention to the rock. They have become a locality in their own right in the educational and geotourism excursion routes taken in the Park. By demonstrating the ongoing importance of the rock and Salisbury Crags to science, the holes provide another layer in the history of scientific development, given that the key rock exposure made famous internationally by James Hutton in his *Theory of the Earth* (Hutton's Section) is only a few metres away. In essence the holes have become part of the cultural and educational fabric of Holyrood Park.

If research is to be undertaken to establish the preferred methodology for restoring core holes drilled in hard rock, then the eight holes at Salisbury Crags may not be the most appropriate test site.

Please get in touch with the author (colin.macfadyen@snh.gov.uk**) and the Scottish Geodiversity Forum to have your say in the discussion.**

An ineffectual effort to restore core holes drilled in a Palaeogene ring dyke at Mingary Pier in Ardnamurchan SSSI. They were drilled by researchers from overseas under the auspices of a UK-based researcher. Lumps of grey Jurassic limestone have been used partially to fill the sample holes in brown-weathering black dolerite. These have then been capped by what appears to be a mix of shell sand and household silicone sealant. The 'restoration' effort was cosmetic and did not last a winter.

Further reading

MacFadyen, C. 2010. *The vandalising effects of irresponsible core sampling: a call for a new code of conduct*. Geology Today, Volume 26, Number 4, July/August.

The Scottish Core Code: **http://tinyurl.com/kyerp96**

The prominent set of seven holes (ringed) beside the path that leads tourists to the main ascent route for Arthur's Seat, Holyrood Park, Edinburgh. Drilled in the 1980s, and only metres from the internationally important Hutton's Section, the holes can be viewed either as an eyesore or a demonstration of the ongoing role and value of Salisbury Crags to geoscience. In reality they represent a mixture and therefore probably merit retention.

Fossil Grove: Room for cautious optimism

Alan Owen, University of Glasgow & Geological Society of Glasgow

The famous Fossil Grove in Glasgow's Victoria Park is again a cause of concern. The *in situ* stumps of 11 fossil trees are some of the earliest examples of geoconservation, especially one involving the preservation of a geological site within a building.

The trees were discovered in 1887 and the highly foresightful local authority deemed that they should be preserved. They were carefully excavated and the building displaying them was opened in 1890. Fossil Grove was designated a Site of Special Scientific Interest (SSSI) in 1954 and became a Regionally Important Geological Site (RIGS) in 2007. It is internationally important in providing a rare glimpse into a Lower Carboniferous forest and for 126 years it has played a very popular role in displaying aspects of geology to the wider public. The past decade has been a rollercoaster of pessimism and optimism about the future of this important and, especially to many Glaswegians, much loved site.

All photos by Colin MacFadyen/SNH unless otherwise credited

Dark areas on the floor are water stains, including water that has condensed and dripped from metal infrastructure.

The story so far

Concerns about public access to Fossil Grove were first raised with Glasgow City Council in 2007 following rumours of closure when it became the responsibility of the Council's Land and Environmental Services department (LES) rather than the museums service, which had been incorporated in the new Culture & Sport Glasgow (*see Earth Heritage 29*).

As a result of discussions between interested bodies (Strathclyde RIGS Group, the Geological Society of Glasgow, Scottish Natural Heritage [SNH] and the museums service and LES), seasonal opening of Fossil Grove was secured, pressing maintenance matters were dealt with and, eventually, the dormant Fossil Grove Trust was revived in 2010.

The Trust began addressing the future development of Fossil Grove and, along with Glasgow City Council, by 2014 had arrived at proposals which were intended to lead to a bid for Heritage Lottery funding to replace the present, deteriorating, building with a new structure. This would ensure the conservation of the site and provide a greatly enhanced visitor and educational experience (*see Earth Heritage 42*). Unfortunately, progress on the bid stalled because no organisation was prepared to take on the eventual management of Fossil Grove, with all its financial implications.

One of the fossil tree stumps with ponding of water (dark areas) and showing the effects of successive wetting and drying (white patches of efflorescent salts on the lower part of the roots).

Since then, staffing and opportunities for visitor access have been progressively reduced; lighting and other internal features have degenerated; and the condition of the building and its surroundings have worsened, resulting in a serious threat to the fossils. The findings of an interim assessment by SNH as part of their programme of Site Condition Monitoring of SSSI in December 2015 were that the fossils were deteriorating and that the site may be in unfavourable condition.

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Sadly, until very recently the condition of the site continued to decline. This is despite a formal petition being made by Strathclyde Geoconservation Group to Glasgow City Council early in 2016. This attracted press and internet coverage and led to a recommendation from the petitions committee that LES should continue to work with stakeholders 'to safeguard the site in the short term and to explore long-term solutions'.

A party from Strathclyde Geoconservation Group worked to clear debris beside the building that had probably contributed to the ingress of water, and alarm bells on the state of Fossil Grove were rung in the local community. The geological world was also alerted by articles in the Palaeontological Association and Geological Society of Glasgow newsletters. Feedback from visitors was commonly that they were impressed by the fossils but saddened by the building.

The south side of the Fossil Grove building showing the accumulation of soil and plant debris against the wall. Left to accumulate for years, this material has probably aided ingress of water through the building into the grove.

Not all doom and gloom

Positive developments over the past year are bearing fruit. The Fossil Grove Trust has been revitalised and is much more proactive in dealing with the Council to seek a long-term plan for the grove. A Fossil Grove Advisory Group has been established to help provide scientific, conservation and curatorial advice to the Trust. The Council has recently undertaken some remedial work to the the building. This included thoroughly clearing debris from the side to help reduce water ingress. As with other relatively straightforward actions such as attention to the gutters, this will need to be done as part of regular maintenance.

Improvements to the drainage are planned following a CCTV survey and there are plans afoot to monitor and regulate the temperature and humidity of the building. Detailed assessment of the efflorescence on the surface of the fossil trees will inform future conservation. All these actions are urgent and essential to the preservation of the fossil trees.

As for the longer term, the Fossil Grove Trust is exploring possible business models to ensure a sustainable future for the site, including taking it out of the control of the Council.

Fossil Grove may well exemplify the wider problem of SSSI having low priority to cash-strapped local authorities. In many ways this is understandable – council budgets are limited and cases can be made for many things to be given priority. Nonetheless, there are statutory responsibilities for the care and maintenance of these scientifically important sites. Fossil Grove is something to be cherished both from a geological and geoconservation point of view and as part of Glasgow's cultural heritage. It has enormous potential as somewhere to promote an understanding of geoscience to the wider public, nationally and as an international visitor destination. Maybe, just maybe, there are signs that this potential may eventually be realised. There may be light through the [fossil] trees. *Watch this space!*

The south wall of Fossil Grove during the clear-up of soil and leaf mould by Strathclyde Geoconservation Group. The build-up of material against the wall was a probable cause of the ingress of water into the building. Photo by Margaret Greene, Strathclyde Geoconservation Group

Treading carefully among periglacial landforms

Vanessa Brazier, Scottish Natural Heritage

Photos by Vanessa Brazier/SNH unless otherwise credited

Ben Wyvis is one of the easier-to-climb higher mountains in Britain. Here on the high mountain ridges are periglacial landforms, most formed toward the end of the last glaciation, blanketed by fragile and rare arctic and alpine vegetation. The intimate mix of landforms and habitats offers significant conservation challenges, given that the mountain attracts thousands of visitors a year.

Ben Wyvis holds about eight kilometres of ridges above 900 m, and the main summit of Glas Leathad Mòr reaches 1,046 m OD. The mountain rises steeply above the Cromarty Firth (30 km north-west of Inverness), but is isolated from the neighbouring North West Highland mountains, making it exposed and marginally drier than its western neighbours.

The footpath crosses the steep slopes of An Cabar, which has weathered soils and active terracettes. In places there is a risk that heavy use could result in braiding of the footpath, where people want to avoid eroded sections. Widespread trampling exposes the soil, risking runoff erosion. Photo by Lorne Gill/SNH

Ben Wyvis has several international and national conservation designations for its wildlife, plants and geomorphology, and is one of Scotland's 47 National Nature Reserves (NNRs). There are management challenges to conserving its thin, erosion-prone soils and associated fragile vegetation on high ground, while also encouraging visitors.

Experiencing an Arctic landscape

Ben Wyvis is a great place to experience something close to an Arctic landscape, and see a whole range of mountain-top periglacial landforms. Most are relict and found in abundance on the crests and flanks of the broad high ridges. Many of these remarkable landforms started forming thousands of years ago, as the mountain summits re-surfaced from the thinning ice sheet into the bitterly cold air (but long after the last British Ice Sheet reached its maximum extent 27,000 years ago). The processes that formed the larger-scale landforms like solifluction lobes date from seasonal thaws of the active layer of permafrost ground. Severe cold-climate conditions ended at the start of the Holocene, about 11,700 years ago, but in winter frost processes continue to be important in the development of small-scale active landforms such as terracettes on many higher British mountains. These landforms grow and migrate due to frost heave of regolith (loose material) on steep slopes, combined with the binding effect of wind stressed vegetation cover.

Non-sorted vegetated stripes next to the track on An Cabar are relict landforms formed by mass movement and frost heave during severely cold climatic conditions.

Landform-dependent fragile habitats

Ben Wyvis has the largest area in the UK of non-sorted vegetated circles and stripes, where you can also see vegetated hummocks (*photo right*), solifluction sheets (*top photo, page 43*), ploughing boulders (*top photo, page 44*), active terracettes and late-lying snow patches. Here plant communities, habitats and soils are inexorably linked to subtle changes in micro topography, shelter, and drainage provided by these landforms. Some of the larger landforms, like solifluction lobes, vegetated stripes and terracettes, are visible on Google Maps, partly distinguished by changes in the plant communities they support. The underlying geology, comprising Moine schists and gneisses, weathers into a silt-rich frost-susceptible regolith.

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The steep path up the west-facing An Cabar crosses actively forming terracettes. When avoiding sections of eroded path, people prefer to walk downhill across this soft ground, further breaking up the binding vegetation cover. Once the cover is removed the terracettes break down and are washed out by surface runoff during snowmelt or storms.

Walkers are encouraged to keep to the stony centre of the trampled route up Glas Leathad Mòr (left of photo). Large relict solifluction lobes can be seen on the right (east) side of the hill. Solifluction is the movement of soil and regolith during the short summer thaw over permanently frozen ground. These landforms last moved while the climate of Scotland was severely cold, more than 10,000 years ago.

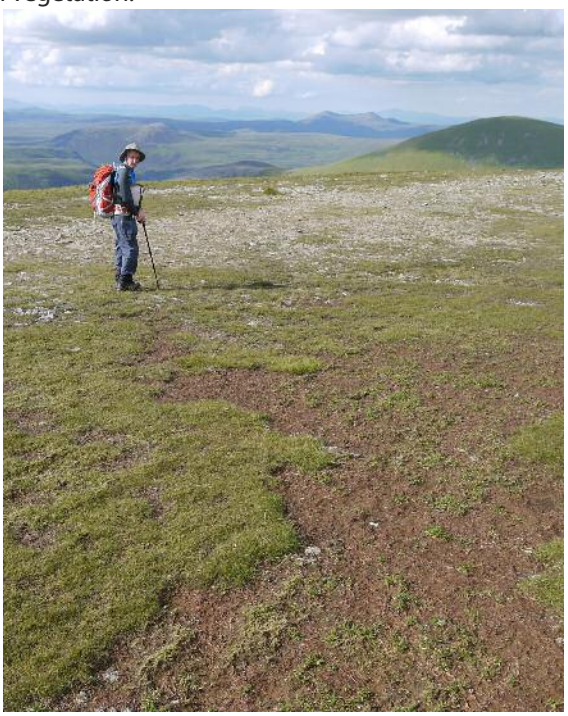
Vegetated stripes are now cloaked in thin peaty soils and support mosses and heath plants. Frost heave and changes in micro hydrology are thought to have been important in the formation of hummocks, and on slopes these hummocks stretched to form stripes, probably through mass-movement processes.

On other mountains in Scotland, exposed ground can support active ephemeral stone-stripe formation, where frost heave sorts stones into stripes of different sizes. However, excavation of the vegetated, elongated ridge-like stripes of Ben Wyvis has not shown sorting of sediment and their origins remain a bit of an enigma. Large patches of vegetated stripes (*as bottom photo, page 42*) can be found on the gentle slopes above 900 m. Ben Wyvis is remarkable for its sheer abundance of intact vegetated hummocks and stripes.

Use and challenges of overuse

This high land supports rare Arctic and montane habitats and species, notably breeding dotterel. The mountain is also home to red deer, mountain hare, red grouse, golden plover and ptarmigan. In summer the slopes are a vibrant green, supporting a rich variety of Alpine and boreal heaths and grasslands, including the largest area of woolly moss heath in the UK (*Racomitrium lanugosum*). Alpine heaths and mosses are especially fragile during dry or very cold conditions, where they break into dust when trampled. The soil is easily exposed if the shallow-rooted vegetation dies back, leaving a thin humic layer that can be eroded easily. If all the soil is eroded, and only stony ground remains, it is very difficult to re-establish vegetation.

Contrasting stresses on the summit ridge, stony ground exposed by trampling, and soil erosion from localised overgrazing (foreground).



Work has been done to reduce trampling pressure on the plateau. Since the footpath was built from the car park to An Cabar in the early 2000s, visitor numbers have nearly doubled, to over 7,000 a year. While these numbers are low compared with lowland NNRs like Tenstmuir (25,000 visitors per year), the mountain cannot support greater numbers without management. The constructed path becomes a general route after An Cabar; from there, walkers heading for the highest point, two kilometres away, take several lines with erosion stretching as wide as 30 m in places. Walkers are encouraged to keep to a central part of the route, and some experimental work using biodegradable geotextile with mosses and heath plants has shown promise in restoring vegetation cover even where soil degradation has advanced. Visitor interviews and observation on multiple days during successive summers show that most have read the information board about habitat restoration, and have taken the central route to the summit.

Elsewhere on the summit ridge there are patches of bare ground showing exposed roots and torn vegetation, most likely caused by grazing. Sheep have been removed from the NNR, but deer are harder to control, and they may have taken over former sheep grazings.

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Not all bare ground is un-natural. Ben Wyvis is often snow covered. This protects vulnerable vegetation but where high winds scour it off the ridge where most people walk, vegetation is prone to desiccation. Snow accumulates where wind speeds decrease, particularly on the eastern slopes among the large relict solifluction lobes and in the eastern corries. Late-lying snow patches provide habitat for rare snow-adapted plants. In the corries, melting snow leaves an apron of new sediment and bare ground, which is more vulnerable to trampling by deer while snow melts. Past attempts to develop this mountain for skiing would have led to far greater loss of habitat and landforms.

Fortunately most of the Ben Wyvis's high ridges are relatively infrequently visited. Most people aim only for the highest summit, staying on the main ridge between An Cabar and the summit of Glas Leathad Mòr. Just a few hundred metres from this route, along the ridges above the eastern corries, vegetation is visibly more intact, with many great examples of landforms from a much colder environment. Here you will see hummocks, stripes and solifluction lobes, and even ploughing boulders on the steeper west-facing slopes. Ben Wyvis is worth a visit, but please tread carefully among its periglacial landforms and associated fragile plants and rare ground-nesting birds!

Further information

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Scattered ploughing boulders have moved down the steeply soliflucted flank of the summit ridge. They are thought to move where lenses of ice melt underneath them, literally ploughing down slope in the soft thawed saturated ground, leaving behind a distinctive hollow.

Visitor information and good path surfaces have encouraged more people to reach the higher ground of An Cabar (pointed peak) and the ridges of Ben Wyvis NNR. Photo by Lorne Gill/SNH

Earth heritage EXTRA 4

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What lies beneath: new SSSI flags up subterranean geoheritage

Sarah Henton De Angelis, Natural England

On the surface, an unassuming patch of urban Britain in north Bristol seems an unlikely place for the UK's newest Site of Special Scientific Interest (SSSI). However, hidden just metres below ground level is a great cavern that has, in equal measure, both terrified and delighted the people of Bristol for hundreds of years.

Measuring approximately 60 m deep and 60 m across, Pen Park Hole boasts unique geology and biology, along with a rich history of exploration marked by at least one – and perhaps two – dramatic deaths. It is the site of the world's first published cave survey; the subject of purported goblin sightings; and has stimulated a healthy dose of modern day community activism.

It is for its significant geological and biological features that the site has been notified. First and foremost, Pen Park Hole represents the UK's best known hydrothermal cave. Most limestone caves form through rainwater infiltration; however, an extensive covering of 'dog-tooth' calcite crystals and dispersed galena (lead sulphide) deposits suggest that Pen Park Hole was formed through thermal groundwater forcing its way upwards. This influx of warm fluids (much like those seen in Bath today) led to the dissolution and remineralisation of the Clifton Down Limestone, a Lower Carboniferous carbonate deposit formed in a warm shallow sea 327-359 million years ago.

The main chamber of Pen Park Hole SSSI. The lake is no longer hydrothermally active. Photo by Steve Sharp

The cave is made even rarer by its noteworthy age, ~200 million years (Early Jurassic), something that few other cavities around the world can boast. Its dendritic structure was controlled by a steeply inclined fault running through the limestone. The base of the cave is filled by a lake (although the waters are no longer hydrothermally active) with a water level that has varied by more than 27 m since records began. The reason for such extreme fluctuations remains unknown, providing a tantalising example of the secrets yet to be revealed.

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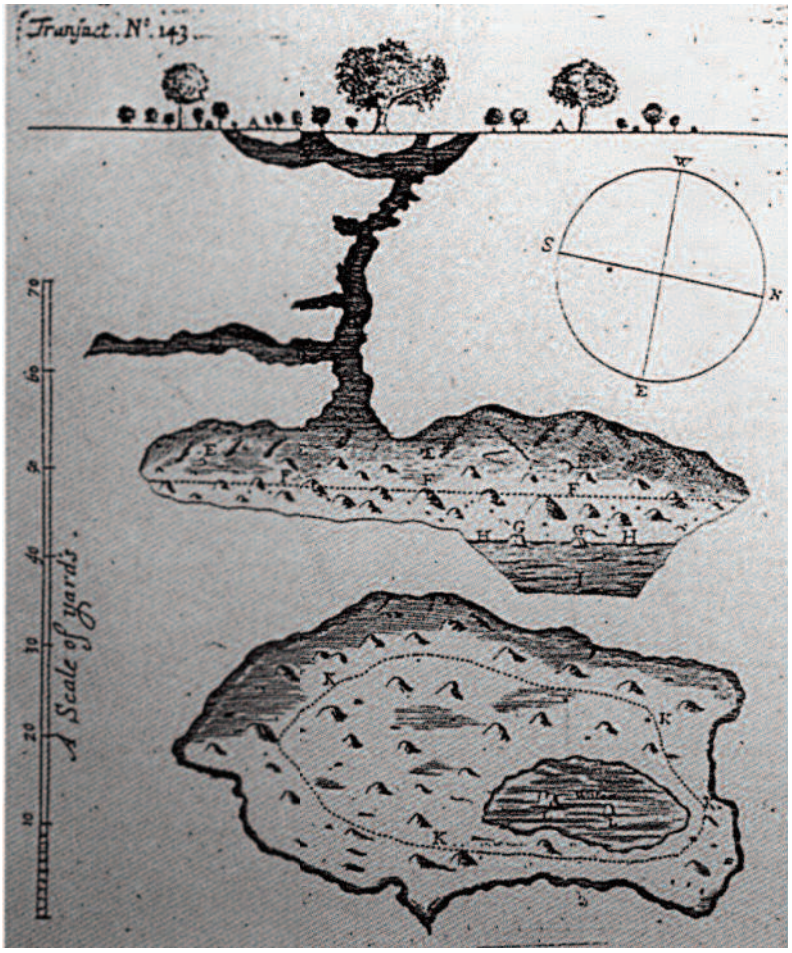
Pen Park Hole also supports an important community of invertebrate and crustacean species, including the only known example of cave-dwelling *Niphargus kochianus* (a form of shrimp), a species more commonly found in seeps and springs of chalk aquifers. This unique ecosystem makes the site critical for studies of cave biology.

In addition to its fascinating and scientifically important natural features, Pen Park Hole also boasts a varied and colourful human history. The discovery of the site can be dated to 1669 when a retired sea captain, Samuel Sturmy, made the first known foray into the cave, which he (mistakenly) believed to be a Roman lead mine.

The notoriety of Pen Park Hole was sealed just days later when the intrepid explorer succumbed to a fever attributed to his time in the cave. Sturmey's exploration entered into local legend, even inspiring a Tolkein-esque work of poetry (author unknown!) unlikely to have allayed the fears of the local population:

> *"On, and still on this path they follow*
> *Through many a chasm and gorge and hollow;*
> *Until from a passage narrow and small*
> *They enter what looks like a monster hall;*
> *And then as a sudden turn they take,*
> *They see before them a spacious lake -*
> *There are knackers, and gnomes, and frightful shapes*
> *From which no trespasser ever escapes."*

Over a decade passed before the next exploration of the site. Again, the man for the job was a mariner, Captain Greenville Collins, who along with the crew of his coastal survey ship inspected Pen Park Hole in 1682. The resulting document, part of which is pictured right, represents the earliest known published cave survey in the world.



Pen Park Hole, as sketched in 1682 by Capt. Greenville Collins, is the earliest known published cave survey.
Image courtesy of Graham Mullan

Following the Collins survey, the cave fades from the history books until 1775 when it was again associated with a tragedy. In March of that year, the hapless Reverend Thomas Newman fell to his death when the tree root he was using for support gave way as he lowered his plumb line into the cave entrance. Ironically, just hours before his death the Reverend had preached Psalm 88 to a Clifton congregation, including the lines

> *"and my life draweth nigh unto the grave.*
> *I am counted with them that go down into the pit…*
> *Thou hast laid me in the lowest pit, in darkness, in the deeps."*

Reverend Newman's body was finally recovered 17 days later. His dramatic demise prompted renewed interest in Pen Park Hole and the cave has been thoroughly explored in the years since.

The myth of the Roman lead mine persisted for most of that time, and in 1807 the site was condescendingly described by Thomas Dudley Fosbrooke as "the immense remains of an ancient lead mine – what women would call an ugly, deep, dangerous, hole". However, it was only with the expanded geological knowledge and technological developments of the last century that the true majesty of Pen Park Hole became apparent. Surveys between the late 1950s and today have revealed more detail about this unique location, and the astounding features for which the site has been notified.

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The most recent instalment in the human history of Pen Park Hole began in 2013, with a planning application to build a housing estate and supermarket on disused land above the site. Horrified by both the potential damage to the cave, and the possible threats to people and infrastructure above (in some areas the cave roof is just 1.7 m below street level), local residents and Bristol North West MP Charlotte Leslie launched a campaign to secure statutory protection. In March 2014, the housing planning application was rejected and the land was awarded Open Space Protection by Bristol City Council. The underlying cave was officially notified by Natural England as an SSSI on 5 August 2016.

Pen Park Hole has been an important site for hundreds of years and finally, with the new measures in place, it will remain protected for future generations to study and enjoy.

Right: Surveying Pen Park Hole in 1956 or 1957.
Photo by Phil Davies MCRA, Mendip Cave Registry & Archive

Below: An extensive covering of 'dog-tooth' calcite crystals suggests that Pen Park Hole was formed through thermal groundwater forcing its way upwards. Photo by Chris Westcott, Natural England

Earth heritage EXTRA 5

December 2016

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

Exploring geological language in the Welsh landscape

Elinor Gwynn, Language Heritage Officer, National Trust Cymru

Following *Earth Heritage* items by Mick Stanley and Colin MacFadyen on Namescapes (*issue 39*), this article tracks the way geology and geomorphology have influenced place names in Wales. Elinor was crowned at the National Eisteddfod in August 2016 for her collection of poems themed on *Llwybrau* (paths).

How do you begin to explore the geological landscape lexis of Wales? The scope of the topic is vast, the journey complex. If place names themselves ARE our history, as Anthony Lias states in his book *Place Names of the Welsh Borderlands*, then surely geology has provided the backdrop against, and the stage on which centuries of history have been played out. It is the defining force that has shaped our nation, its history, language and culture.

Wales has several layers of linguistic contact, as explained in the *Dictionary of Place Names of Wales*. Successive and overlapping periods in our history – Celtic and Brittonic, the Roman occupation, Anglo-Saxon settlement, Scandinavian invasions, Anglo-Norman conquests and English immigration, have all left their toponymic footprints. It's worth bearing these influences in mind when attempting to interpret place names in the landscape.

The language of our landscape illustrates both continuity and change in our history and culture. Names can be read in different ways; at their simplest they provide a descriptive, and often poetic portrait of the country. But those words, printed on maps and etched into memories, have shadows behind them – of past lives and livelihoods, of changing settlement patterns and shifting cultures, of socio-political struggles, and of economic fortunes and failures.

They also hint at the rich tapestry of habitats that has frayed and unravelled across our landscapes; leaving only bare threads hooked tentatively onto a 21st Century canvas by evocative combinations of vowels and consonants.

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**Pen y Fan (the mountain summit), Brecon Beacons, Powys
Photo by Joe Cornish, National Trust**

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The topography of Wales

A quick browse of any OS Explorer map for Wales leaves no doubt about the landscape character that typifies this country. Alternatively you might just read the second verse of the Welsh National Anthem:

Hen Gymru fynyddig, paradwys y bardd,
pob dyffryn, pob clogwyn, i'm golwg sydd hardd;
Trwy deimlad gwladgarol, mor swynol yw si
ei nentydd, afonydd, i mi.

Old land of mountains, the paradise of bards,
each cliff and each valley a loveliness guards;
Through love of my country, so charmed will be
its streams, and its rivers, to me.

Wales, with a landmass of just over two million hectares, is predominantly mountainous. And if topographic names 'reflect a direct human response to the environment, promoted by a simple human need to feel at home', it's no wonder that we have a wealth of Welsh names for mountains, hills, slopes and gradients – as well as for rivers, valleys and wetlands.

In common with Gaelic, and possibly with other Celtic languages, Welsh names for landscape features often include words for parts of the body. In *Gaelic and Norse in the Landscape*, Roddy McLean illustrates this tendency in the Gaelic language with the example of *fe'ith* (a vein or sinew) to describe a bog channel or stream and even to refer to bogs themselves. Examples of Welsh words used to describe topographical features include *trwyn* (nose), *braich* (arm), *cefn* (back), *talcen* (often shortened to *tal* – forehead), *pen* (head), *ceg* (mouth), *genau* (jaws), *llygad* (eye), *troed* (foot), *boch* (cheek), *cesail* (armpit) and even *cest* (paunch).

Welsh topographical names also commonly include references to domestic items associated with everyday rural life – such as *mainc* (bench), *barclod* (apron), *bwrdd* (table), *crib* (comb), *dysgl* (bowl), *cawg* (basin), *cribwr* (wool comber), *cadair* (chair or seat), *crochan* (cauldron), *drws* (door), *ystyllen* (plank), *rhiniog* (threshold), *cyllell* (knife), *nodwydd* (needle).

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Llech cyllyll (slab of knives), Porthclais, Pembrokeshire

Trwyn Hwrddyn (ram's nose), St David's Head, Pembrokeshire

Moel y Gest (the bare, paunch-shaped hill), Porthmadog,

This word-cloud illustrates the rich Welsh vocabulary for slopes, hills and mountain.

Trum y Ddysgl (bowl-shaped hill/ridge), Dyffryn Nantlle, Gwynedd

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Sometimes these topographical words are used in a very general sense; for example *Rallt* (slope). But mostly they include additional elements that tell us some something else about the landscape – its appearance, its habitats, its cultural associations and its use. Examples include *Moel Mawn* (bare peat hill) at Llanddewi Brefi and *Trwyn Penwaig* (promontory of the herrings) at Amlwch.

Welsh names for rivers and lakes are often very descriptive and portray their appearance, sound and physical characteristics in relatively straightforward ways. Examples include *Afon Llafar* (the babbling river), *Afon Prysor* (the river with thickets), *Afon Ystwyth* (the lithe river), *Afon Alun* (the wandering river), *Afon Tawe* (the flowing river), *Afon Clywedog* (the wild river) and *Gloywlyn* (the lake of bright water).

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Afon Yswyth (the lithe river), Ceredigion, aerial photograph © Crown Copyright and database right 2016. Ordnance Survey licence number 100019741

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The use of animal names, though more uncommon, may also illustrate the character of a watercourse. For example, the *Afon Elan* in mid-Wales is derived from elain or fawn, referring probably to its light, tumbling flow. The names *Twrch* (in Carmarthenshire) and *Banw* (in Montgomeryshire) were given to rivers that seemed to burrow or root through the land like pigs. Welsh names of rivers and lakes sometimes relate to their uses by humans, such as *Pysgodlyn* (a fishing lake).

Work undertaken by Cymdeithas Edward Llwyd to map the distribution of historic place names that refer to specific plants, such as alder (*gwern*) and beech (*ffawydd*), has added a further layer of information to our cultural interpretation of our natural heritage, providing an interesting correlation between language, biodiversity and Wales' topography and soil types.

Place names in Wales including the element *Wern* (which may refer specifically to the presence of alder trees or describe, more generally, boggy places with trees). Data taken from Ordnance Survey Digital Gazeteer. Reproduced by permission of Llên Natur

Rocky references

References to rocks and stones, in a general sense, are common throughout the Welsh landscape. Words such as *maen*, *meini*, *carreg*, *cerrig*, *carnedd*, *llech*, *llechen*, *llechog*, *llychau*, *gro* and *graean* are found in names of houses such as *Tŷ Maen* and in settlements such as *Tre Maen*, *Bontfaen*, *Gronant* and *Llechryd*. They also feature in names for topographical features, for example *Cerrig yr Hafan*, *Cerrig Mawr* and *Craig y Llech*. They also appear frequently as elements in names of rivers and streams, such as *Nant y gro* (gravel stream) and *Afon Gorlech* (river of gritstone).

Sometimes names refer to very specific stones or rocks. For example, *Benllech* on Anglesey specifically means the capstone. The element 'llech' is found in both *cromlech* (curved stone) and in *penllech* (capstone). Benllech had a distinctively large capstone which gave its name to a mill (*Melyn y Penllegh*, 1453), a fulling mill (*Pandu'r Benllech,* 1718/19) and a croft (*Thythyn y Benllech*, 1691) which gave the 8th Century village its name of *(Y) Benllech*.

In some places, names provide clues to specific rock types and sometimes hint at past industries connected with Wales' geology. Inland of Benllech on Anglesey, a smallholding named *Galchfaen* confirms that we're in limestone country. A little farther north towards Amlwch, and with Parys Mountain rising colourfully on the skyline, might the tiny settlement of *Penygraigwen* (the end of the white rock) signify the place where the rich band of limestone to the south had petered out? Or is it, more simply (if interpreted equally correctly as the summit of the white rock), a description of the hillock of weathered Coedana granite on which the small cluster of houses and farms sits?

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Moel Penllechog (the bare summit at the end of the slate/slab rocks) towers above Tan y Graig (the house beneath the rock), near Trefor, Gwynedd.

A large capstone still survives in the cromlech at Benllech, Anglesey.

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Rhuddlan Castle, Denbighshire

The name *Rhuddlan* refers to the red banks of the River Clwyd as it flows through red sandstone country. The same element *Rhudd* (red, from the old Celtic *roudo-s*) is also found in the name of the nearby town of Ruthin, where it is linked to *hin*, meaning the edge of the river Clwyd or the sandstone rock of the castle.

The importance of mining and quarrying in Wales is illustrated in place names such as *Bwlch y Maen* (gap of stones), *Y Chwareli* (the quarries), *Mwynglawdd Cwm Orog* (Cwm Orog mine), *Craig y Mwn* (ore rock), *Pwll y Mwn* (ore pool), *Penmaenmawr* (headland of large stones), *Rhyd y Mwyn* (ford of the ore). Names such as *Pentre Gwaith* and *Henwaith* on Parys Mountain also hark back to the days of active quarrying; *Y Gwaith* (the Work(s)) was common in Welsh for quarries and mines. The name *Brymbo*, derived from *bryn* and *baw* (meaning mud, or dirt hill), reflects perfectly the conditions created by the extensive coal and iron works in the area.

Origins of the word Brymbo, the former industrial works near Wrexham, reflect the dirty conditions of the area's extensive coal and iron workings. Photo by Brymbo Heritage Group

Llithfaen, near Trefor in Gwynedd, illustrates the difficulty of interpreting place names. The Welsh word *ithfaen* means granite and at first glance the name of this tiny village, perched high above the north Wales coastline, seems straightforward. But it continues to challenge toponymic experts. The first element (*llith* – meaning decoy or lure) has been recorded since 1160 and could be associated with the traditional belief that the rocky cliffs of *Yr Eifl* have the power to affect mariners' compasses, in which case the name Llithfaen may mean lodestone. But Llithfaen as a name wasn't recorded until 1858. Could the Irish adjective *liath*, meaning grey, have been part of a name-phrase to describe the grey granite of the hills hereabouts? The famous quarrying village of Nant Gwrtheyrn, now a centre for Welsh learning below the village of Llithfaen, was called *Nantyllithvaen* in 1612. Granite was certainly widely quarried in the area but the word *ithfaen* itself wasn't independently recorded until 1850. The name of the village remains a mystery.

Even over the border, Welsh names still persist in the landscape, reflecting the more widespread use of the language, in some form, as far as the Firth of Forth up until the about 9th-10th centuries. *Cefn Gwynlle* (the ridge of the white stone) on the Stiperstones, in south-west Shropshire, still testifies to the presence of the lead and barite *white rock-veins* exploited by 19th Century miners.

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Nant Gwrtheyrn, below the village of Llithfaen, now houses a centre for Welsh learning.

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Challenges of interpretation

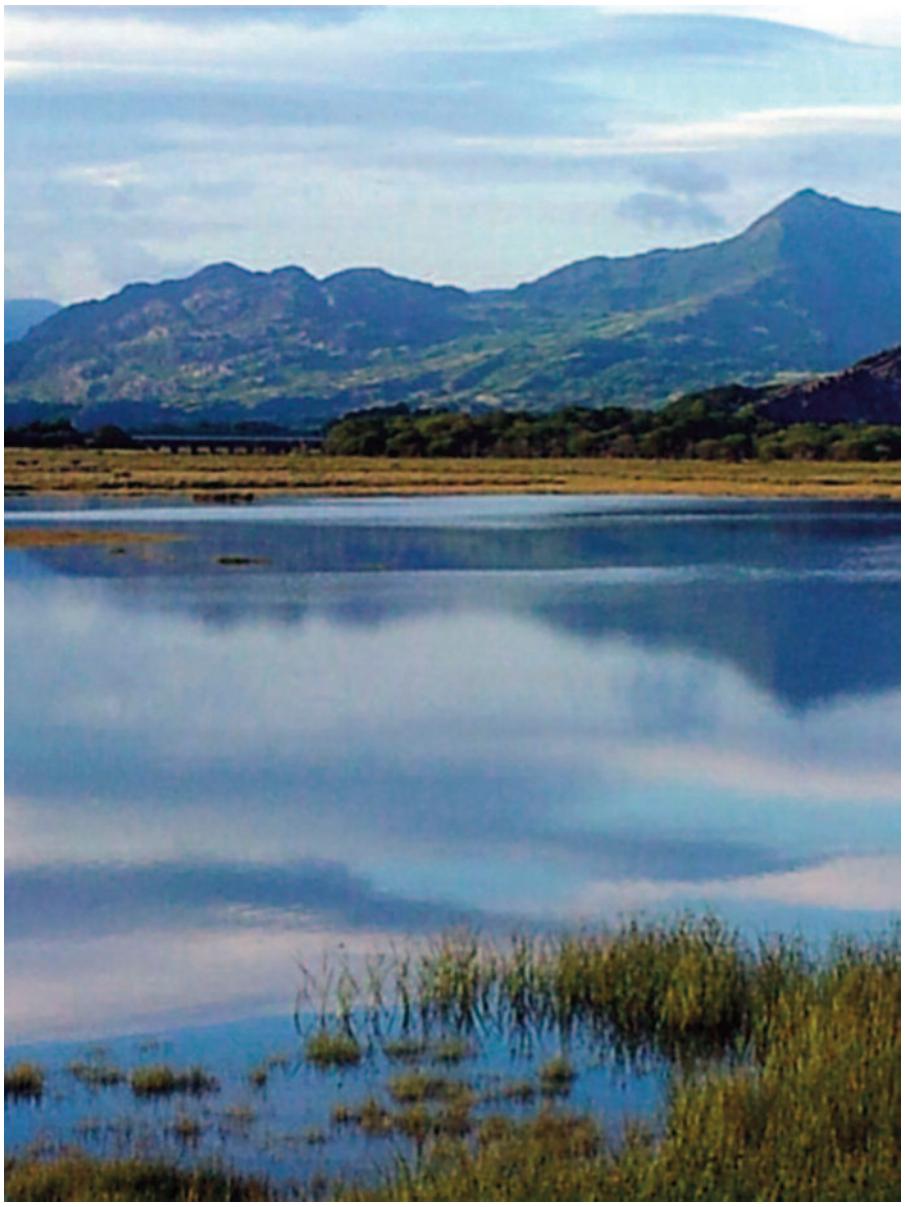
The waves of people that came into Wales over the centuries were influenced by the way existing languages were used in the landscape. In turn they influenced those languages – sometimes appropriating and adapting existing words and place names, and sometimes coining new ones. Interpreting landscape language can therefore be extremely challenging. Any piece of the Welsh landscape can contain a mix of Welsh words and names that have weathered the long centuries of change, along with a few Old English and Middle English names, occasional Norse and Norman French names, as well as blended versions of all of these – and a more recent Cymricisation of some elements.

In some cases the interpretation can be straightforward. For example, the name of the town *Flint* is a Middle English word meaning hard rock and it has survived more or less unchanged both in the contemporary English form and the Welsh name, *Y Fflint*.

The very Welsh-sounding *Wepre*, in Flintshire, is however an Old English name meaning silted land and one can probably guess at the meaning of *Mos* in nearby *Mostyn*; it is Old English for fen or swamp, a habitat which would once have characterised the low-lying land along the Dee Estuary.

At the other end of Wales, *Newgale* in Pembrokeshire is a combination of Old English *Niwe* (new) and Old Norse *geil* meaning ravine or narrow lane. The modern Welsh form *Niwgwl* is a Cymricisation. Old Norse words and place names are frequently found along the Welsh coast, often ending in –ey (e.g. Bardsey, Ramsey) and testify to past Viking raids and invasions.

But old Celtic and Welsh names still abound in these coastal areas, and include words such as *parrog* (stony beach), *pil* (creek), *traeth* (beach) and *ynys* (island). The latter two are particularly interesting as they can also be found some distance inland: *traeth* indicating lands at the uppermost reach of the tide (*e.g. Traeth Mawr*, a large area within reach of the tide, inland of Porthmadog, which forms part of the Glaslyn Estuary) and *ynys*, signifying a piece of raised land in the middle of wetlands (*e.g. Ynys-hir*, a long piece of raised land, in the middle of the coastal wetlands of Cors Fochno, Ceredigion, and *Ynys Ddu* in Monmouthshire, a small model village built by F.H. Moggridge on the west bank of the Siryhwyi river, and *Ynysgynwraidd*, a small hillock on which Skenfrith Castle and settlement were built in the middle of a low-lying area of wetland).



Traeth Mawr, Glaslyn Estuary, Porthmadog, Gwynedd

In some cases, Welsh words have survived into contemporary English over the border; for example the word *Crūc* (from the Celtic *crouc*, meaning hill or mound) passed unchanged into Old English and is seen in elements such as in Creech Barrow, Shropshire.

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Sometimes, names for places are so completely different in Welsh and English that it is almost impossible to find a common thread, let alone find a topographical and geological connection. Take the town of Mold, for example – *Yr Wyddgrug* in Welsh. The English form is derived from the Norman French *Mont* and *hault* (from the 12th Century Latin *mons/montis* and *altus* – high mountain). It refers to Bailey's Hill, a mound or hill (*crug* in Welsh) on which the Normans built a castle in the 14th Century. The element *gŵydd* here most probably signifies prominent – therefore bringing the Welsh name (first recorded as *Yr Wyddgrug* in the 15th Century and as *Wythgric* in 1612) close in meaning to the very different sounding English name Mold. It illustrates not only their similarity but the relevance of both names to the local geology and topography .

The Tryweryn Valley (above) and (below) protestors against the drowning of the valley and the village of Capel Celyn. Photos by Daily Post

The social and political associations of some of our topographical names are fascinating. Consider the name *Tryweryn*, meaning a section of river that was extremely liable to flood (*gweryn*); it was almost a premonition of the fate that befell the Tryweryn valley, and the village of Capel Celyn, when both were drowned in 1965 to create a reservoir of fresh water for Liverpool, catalysing a period of political tension in Wales.

Digging back even farther, seeds of unrest were also sown in 1295 on Anglesey when Edward 1 built the town of *Beaumaris* (*beau marais* – Norman French for beautiful marsh) intending to invest only the English and Norman-French residents with civic rights. Native Welsh residents of Beaumaris were largely disqualified from holding any civic office, carrying any weapon, and holding assemblies. Neither were they allowed to purchase houses or land within the borough. Many of the native Welsh people were deliberately relocated to the other side of Anglesey, to the village of Newborough which is close to *Malltraeth* (the element *mall* meaning rotten, putrid, unwholesome, unhealthy – and *traeth* meaning beach).

The elegant seafront houses of Beaumaris make a strikingly colourful sight.

Celebrating language heritage

The importance of language heritage as a distinctive, valued element of our landscapes is gaining recognition in Wales. Recent years have seen, for example, energetic lobbying to broaden the scope of the Historic Environment Bill in order to encompass historic place names, new awareness-raising initiatives led by *Mynyddoedd Pawb* (translated as Everyone's Mountains, **twitter.com/mynyddoeddpawb**), support for recording and interpretation activity by the newly formed Welsh Place Name Society (**www.cymdeithasenwaulleoeddcymru.org**), and individual practical projects that bring these intangible elements of our landscape to life. One example is the section of wall recently constructed by Snowdonia National Park staff to illustrate local names used for physiographic features in the adjacent Mawddach river channel.

These activities, and many others, are important in helping us understand how the language of our physical landscapes can inform our sense of history and cultural identity. They also have a significant role in contemporary landscape or ecosystem management approaches, by offering more diverse ways in which people can become involved with our natural environment and landscapes.

The recently constructed wall at *Pwll Penmaen* (the pool at the far end of the rock) illustrates local names for channel features along the Mawddach and Wnion rivers, Gwynedd. Photo by Rhys Gwynn

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Globe, by sculptor Joe Smith, is one of the artworks at Knockan Crag National Nature Reserve set in the Northwest Highlands Geopark. This fine piece of rock art, as well as fragments of poetry set in stone, provide different ways of looking at this special place.

Photo by Lorne Gill, Scottish Natural Heritage

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