

th heritage HERITAGE
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Earth heritage

The geological and landscape conservation magazine



Safeguarding treasures
of a fossil forest



Voyage of geological
discovery

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Spring 2016

UNESCO adds weight
to UK geopark status



Geology underpinning
international trail

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Dog-watch on the Brymbo Fossil Forest excavation and conservation (see page 7).
Photo by Peter Appleton



EDITORIAL

Moving on up...

Despite the best efforts of the geoconservation community, many would argue that our work has been hampered by a lack of 'profile', especially at international level.

We have certainly struggled in comparison with biodiversity, where internationally recognised designations have consistently driven policy and action, embedding biodiversity more strongly in people's minds and political agendas. Recent developments, however, are starting to make people aware that biodiversity is not possible without geodiversity! *Earth Heritage 44* reported on vitally important resolutions by IUCN – the International Union for Conservation of Nature – that make geodiversity and geoheritage integral parts of natural diversity and natural heritage, respectively. In this issue we report that recognition of our subjects gets even stronger: UNESCO – the United Nations Educational, Scientific and Cultural Organisation – has announced that it will champion Global Geoparks at the same level as World Heritage Sites. This elevation brings an essential element of international branding to geoheritage work in the UK. It provides a more powerful platform for us to build on.

Elsewhere in the issue, there are articles aplenty on interesting practical geoconservation and promotion – work we can progress with a new-found confidence borne of the UNESCO status.

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

MANAGING EDITOR
STEWART CAMPBELL,
Natural Resources Wales
0300 065 3914
stewart.campbell@
naturalresourceswales.gov.uk

EDITORS
HANNAH TOWNLEY,
Natural England
0300 060 1610
hannah.townley@naturalengland.org.uk

COLIN MACFADYEN,
Scottish Natural Heritage
0131 316 2616
colin.macfadyen@snh.gov.uk

RAYMOND ROBERTS,
Natural Resources Wales
0300 065 3896
raymond.roberts@
cyfoethnaturiolcymru.gov.uk

DAVID BRIDGLAND,
Geologists' Association
01325 484803
d.r.bridgland@durham.ac.uk

MICK STANLEY,
Geodiversity Consulting
01765 609481
mick.stanley1@btinternet.com

CYNTHIA BUREK,
English Geodiversity Forum
c/o University of Chester
01244 513051
c.burek@chester.ac.uk

PRODUCTION EDITOR
SEABURY SALMON,
Seabury Salmon & Associates
01584 877442
EH@seaburysalmon.com

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Peatlands confirmed as a GCR site

Natural England's Board has approved Bolton Fell and Walton Mosses as an SSSI, with a slightly modified boundary following consultation with landowners and interested parties.



Areas of Bolton Fell and Walton Mosses not cut for peat have been designated as a Geological Conservation Review site for the outstanding paleoenvironmental archive contained in the peat layers.

Photo by Anna Wetherell

This is an expanded SSSI consisting of the previously notified Bolton Fell Moss SSSI and Walton Moss SSSI, but with a significantly larger combined boundary to reflect a greater understanding of the distribution of important peatland habitats in the area, taking the total to just under 1000 ha.

Most people will think of these sites as designated for lowland raised bog and associated habitats. Some of those on Bolton Fell Moss have been significantly damaged by extensive peat milling, which ceased as recently as November 2014.

However, evidence from numerous scientific papers, and in particular research done by Keith Barber leading to the

publication of *Peat Stratigraphy and Climatic Change: a palaeoecological test of the theory of cyclic peat bog regeneration* in 1981, has also been considered. Areas of Bolton Fell and Walton Mosses that have not been cut for peat have been designated as a Geological Conservation Review site for their peat stratigraphy and now form part of the SSSI interest. The citation says "Both Bolton Fell and Walton Moss have provided a wealth of high-resolution palaeoenvironmental records, significantly contributing to our understanding of past ecological and climatic change as well as human impact in the landscape of Northern Britain".

It will be interesting to see how the peat record reflects the future restoration of the damaged areas of this SSSI!

Anna Wetherell, Natural England



The specimen dinosaur foot reassembled after its discovery by Sam Davis.

Photo © Amgueddfa Cymru – National Museum Wales

Sam times it right for dinosaur foot discovery

In June 2014 when Amgueddfa Cymru – National Museum Wales announced the discovery of the new Welsh Jurassic dinosaur at Lavernock, South Wales, no-one expected that any more of the animal would be found. However, a series of fortuitous events has led to the discovery of the animal's foot.

Sam Davis from Bridgend, a student at University of Portsmouth, arrived at the site to undertake field work for his undergraduate palaeontology project. He was there just 10 hours after a new cliff fall and he spotted two rocks containing bones. Unsure of what he had found, Sam emailed photos to his tutor Dr David Martill, who has described the original dinosaur. David examined the bones and concluded they were part of the same animal. Had Sam arrived a day later they would have been destroyed by the tide!

The blocks have been reassembled to reveal the amazingly well preserved long bones of the right foot together with many of its toe bones, still in their original alignment. Sam has donated the find to Amgueddfa Cymru, and it is now on display at National Museum Cardiff with the rest of the skeleton.

Caroline Buttler, Amgueddfa Cymru – National Museum Wales



Laura Hamlet and George Farlow celebrate the extension of the North West Highlands Geopark status at the GGN meeting.
Photo by Laura Hamlet

'Green card' for Scottish geopark

The North West Highlands Geopark has earned a 'green card' four-year extension of membership of the Global Geoparks Network (GGN).

Geopark Chairman, Councillor George Farlow and Information Officer, Dr Laura Hamlet learned the 'green card' news at a GGN meeting in Rokua, Finland. Over the summer, geopark volunteers and staff welcomed GGN inspectors to assess geopark performance against key metrics including promotion of geotourism, community activities, education and conservation. Critically important too was a viable business model ensuring financial stability.

2015 saw the beginning of North West Highlands Geopark's second decade as a member of the GGN, an organisation recognised by the United Nations Educational, Scientific and Cultural Organisation (UNESCO). On 17 November 2015 UNESCO announced a new programme which creates UNESCO Global Geoparks (see page 23).

George Farlow explains: "A higher profile for geoparks globally through this UNESCO designation will undoubtedly be of benefit. To make our organisation sustainable we need income from a wide range of sources including tours, merchandise, sponsorship and funding to supplement grants from central government. Having full UNESCO status will help us secure sufficient sponsorship and funding to continue our programme of tours, activities, educational and conservation projects."

Glen Roy retains its NNR status

Over the summer of 2015, there were moves by Scottish Natural Heritage (SNH) to 'de-declare' the National Nature Reserve (NNR) status of Glen Roy. The NNR is part of an internationally significant late Ice Age landscape containing three shorelines of ice-dammed lakes, known as the 'Parallel Roads'. One of the issues threatening NNR status, which is intended to showcase the very best of Scotland's nature, has been the distinct lack of on-site interpretation of the features within the Glen.



The fan at Brunachan in Glen Roy was formed by deposition of sands and gravels from a powerful stream coming into the glen from a side valley. There is no interpretation of this stunning feature, yet!
Photo © Lochaber Geopark

However, Lochaber Geopark has always treated the Parallel Roads of Glen Roy as one of the jewels in the Geopark crown and the NNR status is important in that respect. The existing interpretation panels, at the single viewpoint, were produced by Lochaber Geopark which has also invested in a GeoTrail guide to Glen Roy leaflet, now in its second print run. A new road sign installed by the Geopark at Roy Bridge on the A86 is designed to attract visitors up the Glen to the 'Ice Age Landscape'. As reported in *issue 44*, the Geopark has also developed a visitor centre and café to serve Glen Roy. The centre is both a venue for

interpretative presentations and a starting point for excursions up the Glen. One recent visitor was Euan McIlwraith of BBC Scotland's *Out of Doors* programme. A self-professed 'geo-sceptic', his first reaction on seeing the Parallel Roads was 'WOW'!

Following meetings between SNH staff and Board members, the NNR status for Glen Roy has been retained, with a review of progress on developing the on-site interpretation aspects of the NNR due in 2017. Lochaber Geopark, with the support of the local community, proposes to lead tourism and interpretation development of the Glen Roy NNR to become a prime visitor attraction to Lochaber. For further information contact Lochaber Geopark at info@lochabergeopark.org.uk or phone 01397 705314.

Jim Blair, Lochaber Geopark

QRA's 'Top 50 sites' triggers tide of enthusiastic nominations

As part of the celebrations of the Quaternary Research Association's 50th birthday, Emrys Phillips proposed documenting the 'Top 50 Quaternary Sites', a shortlist of favourite UK sites as nominated by the Quaternary community.



The montage of favourite sites, used on the cover of the new QRA publication. Further nominations are invited.

Image © QRA

The idea was enthusiastically received by the QRA Executive Committee and there was an overwhelming number of submissions (over 80). It was ultimately decided that they all deserved inclusion in a publication, as it would be near impossible to justify accepting some and not others. They are thus all to be found in the new book, *UK Top Quaternary sites: a compilation to celebrate the QRA's semi-centennial year*. Thanks are extended to all those who took the time and effort to submit their favourite site (or sites!!).

The editors fully recognize that this volume represents a subjective selection of sites, reflecting the interests and passions of the nominators. It should be viewed as a light-hearted celebration of the sites that are considered important by QRA members in 2014. However, the selection provides a 'snapshot' of some of the diverse Quaternary sites in the UK. It will be fascinating, if the exercise is repeated in the QRA's 75th year, to see which sites remain 'key' and which new sites will be added.

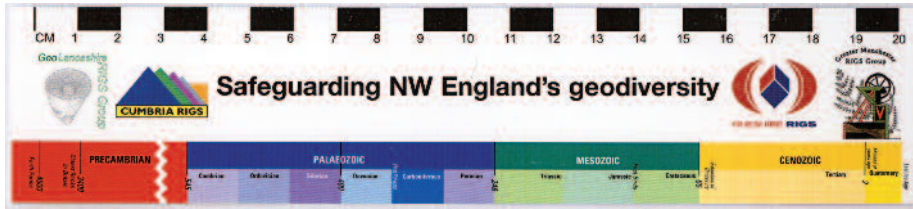
On a more serious note, we would very much like this initiative to be developed further, with more sites added over time, hopefully growing into a valuable and dynamic resource. Submissions would, in the first instance, be uploaded onto the 'Google map' that can be viewed on the website. We anticipate that as batches of new sites are submitted, the volume can be updated periodically.

If *Earth Heritage* readers are inspired (and we very much hope they are) to submit some Quaternary sites, the QRA would love to hear from you. For nomination forms, as well as to view the Google map and download the volume, visit: www.qra.org.uk/outreach/ and click on the 'Top 50 Quaternary Sites' link.

Barbara Silva and Emrys R. Phillips

Scale ruler continues to evolve

A lightweight, laminated, combined geological timescale and ruler pioneered by the North East Wales RIGS group and adopted by the North West Geodiversity Partnership continues to evolve.



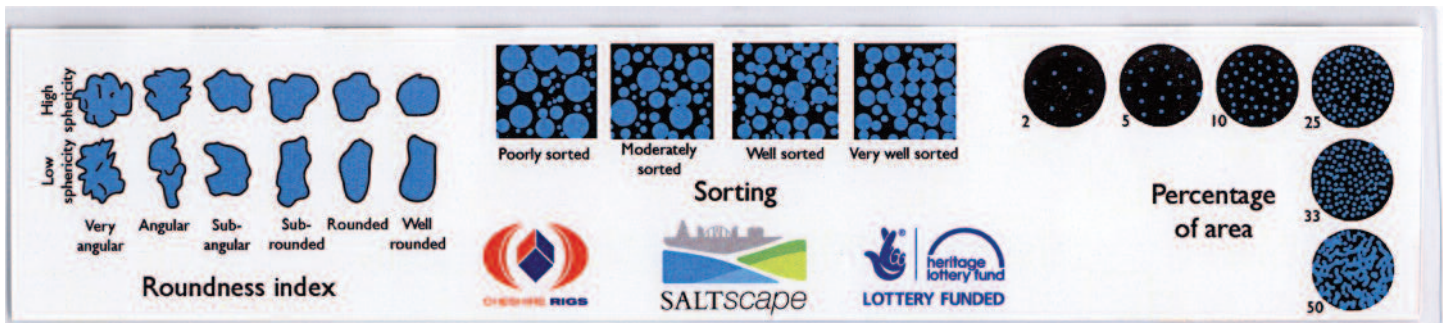
The original rulers carried mm and cm measures and a geological time bar. The latest incarnation, from Cheshire's SaltscapE project, incorporates additional features – a grain shape, percentage and sorting index.



SaltscapE has attracted three-year Heritage Lottery Fund backing and recognises the importance of geodiversity in underpinning culture and biodiversity. The HLF grant has already delivered free lectures and geological walks around the Weaver Valley to explain the underlying 'saltscapE'. Also planned for the next two years are further leaflets (town and cemetery), individual

conferences aimed at professionals and the general public and a geodiversity audit, producing Regionally Important Geodiversity Sites for Cheshire. For further details, contact c.burek@chester.ac.uk or veronicacubitt@hotmail.com or visit www.saltscapE.co.uk

Cynthia Burek



Tour of property's internal geodiversity

A joint project between the Field Studies Council, the University of Chester and the Cheshire RIGS Group has produced a leaflet that takes readers on a geological tour of the interior of the National Trust-owned Malham Tarn House in the Yorkshire Dales National Park. It also recounts the Tarn's geodiversity and serves to highlight the importance of geodiversity in fieldwork education.

The free leaflet is available in print at the property and online as a virtual tour facilitated by the Open University at <http://weblab.open.ac.uk/blogs/malham>

Cynthia Burek

Root and branch reform for Brymbo fossil

**Raymond Roberts (Natural Resources Wales),
Peter Appleton (Brymbo Heritage Group) &
Caroline Buttler (Amgueddfa Cymru – National Museum Wales)**

Recently notified as a SSSI, Brymbo Fossil Forest in north-east Wales has attracted widespread attention since its discovery in 2004. Hundreds of well-preserved fossils have been found and many are already being conserved at Amgueddfa Cymru - National Museum Wales (AC-NMW) in Cardiff. Now, one of the most iconic and visually impressive specimens is undergoing specialist conservation work for an exhibition at Wrexham Museum in January 2016.

All photos by Peter Appleton unless otherwise accredited

The work follows financial support from AC-NMW, Natural Resources Wales (NRW), Wrexham County Borough Council (WCBC) and donation of the specimen itself by Brymbo Developments Limited (BDL).

The scientific value of Brymbo and the contribution the fossil forest can make to geotourism in Wales have already been highlighted in *Earth Heritage* (e.g. issues 26 and 43). But the most recent work at the site epitomises some of the challenges faced in conserving both fragile and very large fossils.

When the fossil forest was discovered during the reclamation of the former Brymbo Steelworks, over 20 large lycophtye (giant clubmoss) stumps were found. Most were concentrated in the core of the fossil forest area. However, some were on the margin of the site where excavations to construct a link road and roundabout were ongoing. Further threats to the fossils exposed by excavation were theft and vandalism. It was at this time that a large fossil trunk and root system was found in life position (as in these photos).

• Continued next page



Above, *Lepidodendron* (trunk) and *Stigmaria* ('rooting') of a giant clubmoss revealed during excavations at the former Brymbo Steelworks in 2005. This is a very rare example where a large proportion of the trunk is still attached to the stigmarian base. Right, close-up of the *Stigmaria* shows branching and markings where rootlets were attached.



PRACTICAL GEOCONSERVATION

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The trunk and its 'rooting' were found in the upper part of the Coal Measure sequence. The trunk, or *Lepidodendron*, is about 1.7 metres tall with a diameter of 0.54 m at the base. The *Stigmaria* spreads out nearly 5 m and with a vertical drop of around 1.5 m. The whole specimen therefore has a height of more than 3m and a spread of 5 m. It is rare to find plant fossils preserved as a whole. Pieces of trunk, branches, leaves, cones and roots are more often than not preserved separately and as a consequence different parts of the same fossil plant species are given different names. Strictly, the name *Lepidodendron*, although often applied to the tree as a whole, relates to fossils of the trunks and branches.

Due to further excavation work and the difficulties of conserving the Brymbo fossil *in situ*, initial plans were to remove it for safekeeping, conservation work and hopefully display at a visitor centre in Brymbo (subject to successful fundraising). Through the support of the developers and the co-ordinated effort of the Brymbo Heritage Group (BHG) and local RIGS group members, in 2008 the fossil was removed and stored in one of the historical buildings being preserved at Brymbo. This was no easy task! The fossil comprised hundreds of individual pieces weighing from a few hundred grams to a few hundred kilograms - some heavy duty machinery was required to move the larger pieces (pictured right).

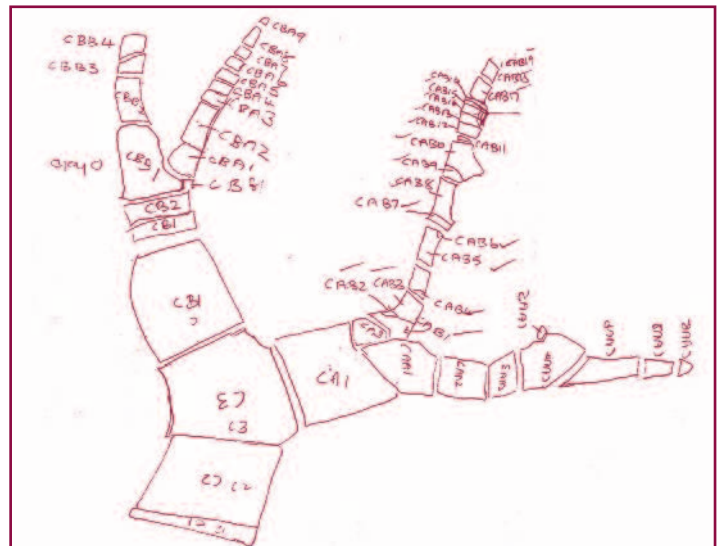
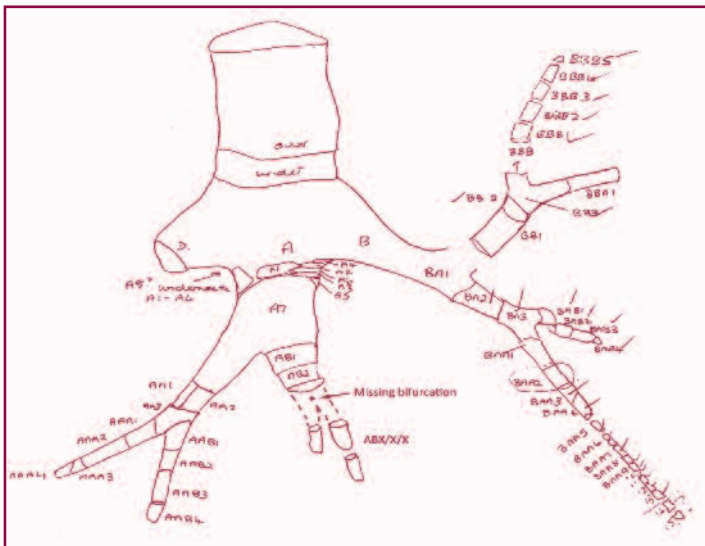
Because the ambition was to try and reconstruct the specimen in growth position, all of the fossil fragments needed careful labelling and recording (below).

The giant specimen subsequently sat in a former machine shop, amongst hundreds of other plant fossils found on the site, until summer 2015. The cold and damp conditions in the machine shop were far from ideal and there were further problems with vandalism and theft at the site. In particular, arsonists set fire to one of the containers storing some of the fossils.

• Continued next page

Right, in 2008 it was decided to remove the specimen from the site to allow further work on site development and to enable the fossil to be kept in a more secure location away from vandals and the weather. Removal of the large trunk sections required heavy-lifting machinery kindly provided by Brymbo Developments Limited.

Below, marking and recording the relative location of the many fossil fragments proved essential for the fossil to be reconstructed and mounted in growth position.



PRACTICAL GEOCONSERVATION

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As well as cataloguing the rarer and more fragile fossils and moving them to the National Museum in Cardiff for conservation work, BHG and others involved with the fossil forest used the intervening years for fundraising and developing feasibility plans for the site.

Co-ordinated effort

Since the discovery of the fossil forest, the story of Brymbo has been one of co-ordinated effort, and the rescue and conservation of this spectacular fossil was no different. With the generous donation of the specimen by BDL, financial support from AC-NMW, WCBC and NRW, and volunteer effort by the BHG, it was agreed to donate the specimen to AC-NMW.

Nigel Larkin of Natural History Conservation carried out the conservation work and fabricated a bespoke stand to display the fossil. Due to the size and estimated weight of the specimen (0.81 tonnes for the trunk alone!) it was decided that both the specimen and the stand should be modular, so individual sections could be shown in smaller exhibition spaces. Casts will be made of the two upper parts of the trunk, with the actual finds being displayed on the floor. Manoeuvring the original pieces at height could have been dangerous and there was an additional concern that the weight of the upper pieces could have crushed the one below. The lighter casts eliminated the risks.

When the specimen was originally moved from the ground in 2008, Sheila Jarvis made detailed notes and Peter Appleton took photographs which were invaluable to volunteers and BDL as they packed the pieces for transport in September 2015. The data were again indispensable in reconstructing the fossil and mounting it on the stand.

The first exhibition is due to start in Wrexham Museum on 30 January, 2016. There are few places where such a complete specimen of this iconic Carboniferous plant can be seen with the trunk and root together! One day, hopefully, it will form the centrepiece of an exhibition in the redeveloped Brymbo Fossil Forest and Steelworks Heritage Centre – to be appreciated by former local steelworkers and visitors alike.



The *Stigmaria* on display at the Museum Am Schölerberg in Osnabrück, Germany, provides an example of how spectacular the finished Brymbo specimen will look. The Brymbo specimen will benefit from nearly 2 m of trunk! Photo by Stewart Campbell



Once removed from the ground the *Stigmaria* (above) and trunk sections (below) were stored on the floor of the former machine shop - part of a complex of historical buildings being conserved as part of the former Brymbo Steelworks.



Above, the fossil was stored in the machine shop from 2008 until summer 2015 and could be viewed from a gallery above. There were many visitors, often during popular open days. The restoration project drew a lot of political support from local Welsh Assembly Members and MPs and the fossil was hailed as the star attraction! Photo © Caroline Buttler, AC-NMW

Managing London's finest Chalk exposure – Riddlesdown Quarry

Jonathan D. Paul, University of Cambridge

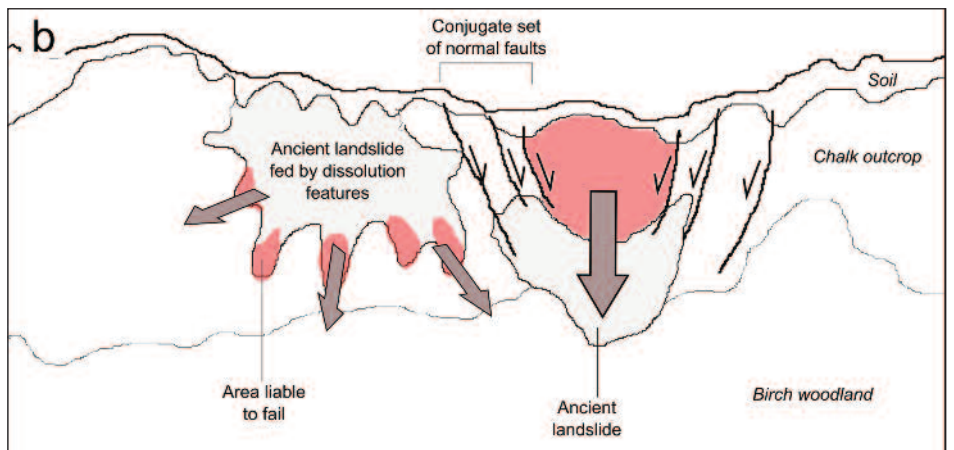
The disused Riddlesdown chalk quarry, near Croydon, contains the most complete, fully accessible outcrop of Upper Cretaceous chalk in the London area, if not the UK as a whole. Currently managed by the City of London Corporation, the quarry is an excellent example of geoconservation, yet its future remains uncertain. Three options are available: more intensive management as a tourist attraction; upholding the *status quo*; and a process of 'managed decline' (i.e. abandonment).

The name Riddlesdown was first recorded in the 14th Century, originating from the Old English words *rid* (clearing), *leah* (woodland), and *down* (hill). Starting around this time, local inhabitants simply helped themselves to the chalk in the hillside; formal quarrying for lime began in the 1820s and continued until 1967. The only major interruption came during the Second World War, when a gigantic barbed wire fence ringed the quarry, and watchtowers closely monitored the activity of the German prisoners of war who worked there.

Nowadays, only the fence remains: the quarry has been closed to the public since it was acquired by the City of London Corporation in 1996. The City has appointed a team of dedicated rangers who oversee a programme of active conservation: Riddlesdown is fortunate to have avoided being appropriated for landfill or redevelopment, as with most other quarries in the London area. A flock of goats has proven invaluable in removing scrub from the cliff faces, while a flight of steps has been installed to give access up the main face.

Designated a biological Site of Special Scientific Interest (SSSI) in 1975, the area is not only a valuable wildlife habitat but also a unique geological locality recognised as a Regionally Important Geological Site (RIGS) by the Greater London Authority. The numerous chalk-loving plants that have colonised the warm, sheltered, south-facing slopes have in turn attracted other wildlife, such as lizards, glow-worms, and bats. There are also several species of rare butterfly, as well as numerous birds of prey that nest here, including kestrels, sparrowhawks, and peregrine falcons.

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The north-east face of the quarry has 20-30 metres of chalk cropping out (a). The annotation (b) shows the same outcrop. Brown area = pipes with Clay-with-flint infills. Note two ancient landslides (grey), and areas that are presently liable to slip (red). The block on the right-hand side is bounded by two conjugate sets of normal faults, which have acted to shear large blocks away from the cliff face.

All images by Jonathan Paul

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Few remaining complete exposures

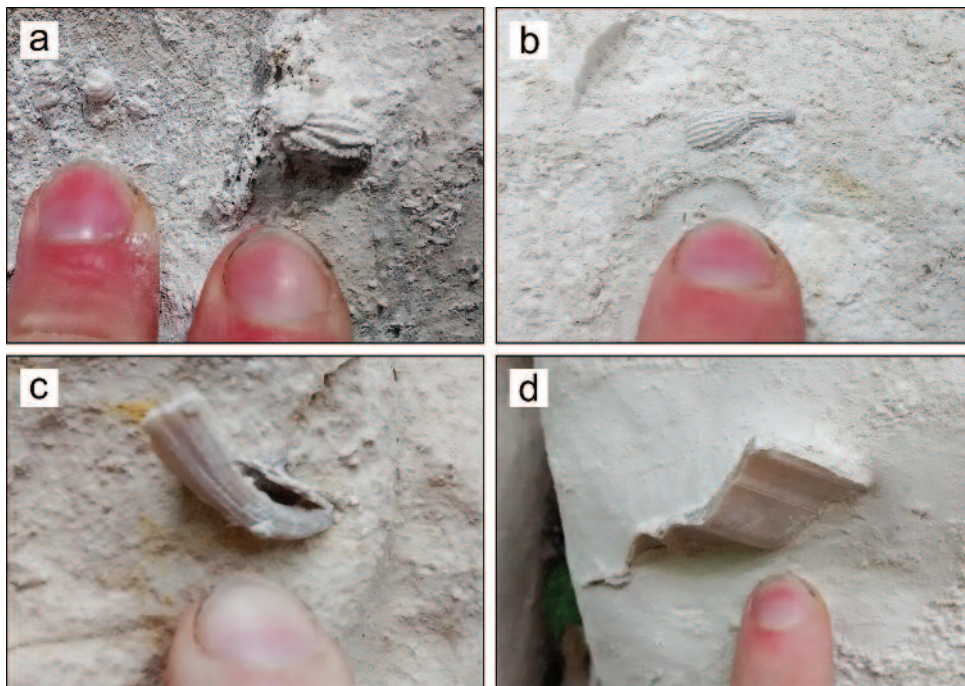
Geologically, Riddlesdown contains one of the few remaining complete exposures of the Lewes Nodular Chalk Formation in the North Downs. These rocks were deposited during Turonian and Coniacian times in the Cretaceous Period, roughly 90 million years ago, and allow direct observations of fracturing and flints that otherwise would have required sourcing from sparse borehole records. These observations, together with those of karst formation and weathering depth during Quaternary times, are invaluable for engineers working in these chalk formations deep under central London.

However, a conversation with Matt Johnson, the Chief Ranger responsible for the quarry, reveals that the City's conservation programmes may not be sustainable in the present straitened financial times. Budgets have been slashed; manpower and resources reduced. A field trip to the quarry in July 2015 revealed a reversion to the forces of Mother Nature. Many important geological sections are now barely accessible: a prominent normal fault in the south-east corner is almost completely overgrown, while the steps up along the main face – installed barely five years ago – have been abandoned to successive rock falls and scrub invasion.

City's dilemma

The City currently faces a dilemma: what to do with the quarry? There are three potential future scenarios. First, subject to a comprehensive scheme of re-fencing and fire clearance, Riddlesdown could potentially be opened up as a tourist attraction, though there are significant hurdles to be surmounted. Compared to certain other quarries that have been reimagined as music festival or shopping locations, access is relatively poor, and the cliff faces dangerous: conjugate sets of normal faults have developed, making landslides common. Secondly, the quarry could continue to be managed as a geological and ecological haven, while the final (and most cost-effective) option involves what Johnson ruefully refers to as "managed decline" – or complete abandonment.

Although pressure from geologists and naturalists will never measure up to hard financial realities, the City is leaning towards the middle option of maintaining a *status quo* of active conservation, subject to additional volunteers and donations. Plant life is carefully monitored for rapidly spreading invasive species, while laborious scrub clearance operations are directed around geologically important areas of the quarry. Johnson hopes to re-install the flight of steps 'in the next few years', which will allow close inspection of the entire main face. Riddlesdown contains the finest complete succession of Upper Cretaceous chalk in the London area, and has been an excellent example of habitat conservation. With careful planning and sound geological advice, this sensitive approach to quarry management should continue well into the future.



Fossils of the Lewes Nodular Chalk Formation:

- (a) Left = tiny gastropod (sea snail); right = echinoderm (sea urchin)
- (b) Fragment of an ancient echinoid
- (c) Bivalve shell
- (d) Large fossil clam: this species would have measured 10–15 cm long.

FURTHER READING

The Geology of London (2010),
Geologists' Association Guide No. 68

Monument or scientific resource: the Agassiz Rock dilemma

Colin MacFadyen, Scottish Natural Heritage

Agassiz Rock, an enormously significant locality which demonstrates the erosive action of ice in Scotland, is facing inexorable destruction, in part by humans. The conservation community now faces the challenging question of whether to try to save the last vestiges of the geological evidence on show, or let the site become a mere monument to Louis Agassiz's historic discovery.

Set near the bottom of a river valley to the south of Blackford Hill and three kilometres south of Edinburgh city centre, Agassiz Rock is one of the localities where, in 1840, Swiss geologist Louis Agassiz identified a prime example of the erosive action of ice in Scotland.

It was to conserve the rock that in 1908 Edinburgh Geological Society negotiated with Edinburgh Town Council to install a protective railing and erect a memorial plaque to mark its significance. In 1953, Agassiz Rock was afforded statutory protection as a Site of Special Scientific Interest. However, the fence became degraded and was eventually removed; the plaque disappeared. A replacement plaque unveiled in the early 1990s, by the then Chairman of Scottish Natural Heritage, Magnus Magnusson, has also been lost to vandalism and theft.

SSSI designation has not protected the rock from natural erosion. Frost-shattering has fragmented the rock and severely degraded the polished surfaces illustrating scratches interpreted by Louis Agassiz as glacial striations. The loss of the fence has exposed the face to the detrimental impacts of rock climbers and bonfires set at its foot. This ongoing deterioration was exacerbated considerably in July 2015 when three wheelie bins and their contents fuelled a blaze that has severely affected a large area of the rock face (*pictured*). At first it was thought that gentle non-abrasive cleaning could restore the soot-blackened glacial feature. But the damage lies deeper; on gentle tapping, areas of the blackened polished rock with striations appear to be on the point of spalling from the face. The intensity of the flames and the baking heat have affected the structural integrity of the already structurally vulnerable face, accelerating its deterioration. Edinburgh Council rangers have worked with the police to trace the perpetrators, but to date nothing has come of enquiries.



Agassiz Rock in the valley to the south of Blackford Hill, Edinburgh. The most important part of the face, illustrating scratches that Louis Agassiz interpreted as glacial striations, has been blackened by a blaze fuelled by what appears to have been three wheelie bins and their contents.

Photos by Colin MacFadyen/Scottish Natural Heritage

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A temporary fence has been installed at the face. While this is principally to protect the public from the potentially hazardous fall of overhanging blocks, the fence has a geological benefit too, helping to safeguard it from those wishing to climb the rock and set bonfires. It is hoped that the fence will become a permanent feature. If the Edwardian fence had been maintained and replaced when required, we would not be faced with today's sorry situation.

What approach should be taken now regarding the conservation of Agassiz Rock?

Initially the remaining evidence could be 3D laser scanned and imaged for posterity with perhaps sections of striation-bearing rock face removed to safe storage. Then with the erection of a permanent fence, the soot could be left to weather away naturally and over decades the remaining features left to become degraded to the point that the evidence of glacial erosion, identified by Agassiz, is no longer visible. In that scenario the rock simply becomes a memorial to a scientific discovery.

Alternatively, the face could be cleaned and with the careful application of rock stabilisation techniques on a micro-scale, involving bolting loose blocks and grouting of joints and other discontinuities, the last vestiges of evidence for the passage of ice on-site could be preserved, perhaps for centuries. The restoration route is hypothetical given the expense and is not without its risks. But should it at least be investigated? Or is it sufficient to leave as is and have future guide books note 'Agassiz was here'? Opinions welcome.

Close-up of some of the scratches on polished surfaces interpreted by Louis Agassiz as being 'the work of ice'. Patches of this fire-damaged polished surface sound hollow when tapped, indicating that they are likely to spall in the near future.



The significance of the Agassiz Rock

Louis Agassiz attended a British Association meeting in Glasgow in 1840 to present a paper which argued that northern Europe, Asia and America had at one time been covered in ice. Following the meeting he toured Scotland, accompanied by William Buckland, to investigate the field evidence. On 27 October, on examining scratches on the now eponymous Agassiz Rock, Agassiz is reputed to have exclaimed 'That is the work of the ice'. The striations and other features indicate that ice moved eastwards across the area; Blackford Hill forming a crag and tail structure akin to Edinburgh Castle Rock.

The striations occur along the lower part of the rock associated with an overhang and shallow cave beneath. Other interpretations such as erosion by glacial meltwater have been used to explain the scratches. Regardless of the precise origins of the scratches, the site became a landmark in the understanding of Scottish glacial geology, important in the early development of glacial theory in Scotland. In addition to its scientific and historical significance, Agassiz Rock is one of the first Quaternary sites to have needed practical measures to conserve the feature of interest. As such it is an important landmark in geological conservation.

Fund that seeks to support the unusual

Christopher Green, Geologists' Association

The vulnerability of geological heritage and the importance of geology for the welfare of people and the wider environment are often poorly understood outside the geological community. Geologists are increasingly aware of this challenge and the declared aims of the Geologists' Association – to promote interest in geology at all levels of knowledge and to promote awareness of our geological heritage – reflect this concern.

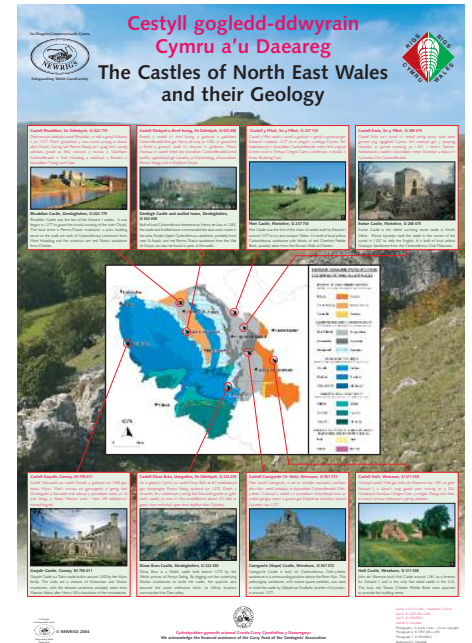
The Curry Fund has an impressive record of support for initiatives that encourage the public to discover the fascination and importance of geology. Support is strong for innovative schemes that attract no other obvious sources of funding. For instance, *Steaming through the Past* is a leaflet guide to geology that can be seen from the train as it passes through a spectacular part of North Wales. Then there are publications drawing attention to geology in churchyards and cemeteries and to the geological origins of building stones in towns and cities – Peterborough, Warwick, Newcastle under Lyme, Bath and Bristol.

The Curry Fund has also funded production of promotional material and displays that enable geologists to explain their science in festivals, geology weeks, rock and fossil road shows and 'Geofun' days. These are all events that bring geology into the community and welcome people, young and old, to find out about geology and its place in our everyday lives. The Curry Fund has also supported local geology groups organising practical demonstrations of geological resources, such as 'lime-burns' – the burning of limestone to produce the 'lime' that goes into lime plaster and lime mortars used in the building industry. Then there has been support for the National Stone Centre, which offers courses in traditional stone crafts and runs an educational programme on Earth Science topics.

The creation of the international network of Global Geoparks (see page 23) and the designation of the Jurassic Coast, the Giant's Causeway and the Cornwall and West Devon Mining Landscape as World Heritage Sites, are instrumental in raising awareness of geology. The Fund has helped to promote several geoparks, with support for the Knockan Crag Visitor Centre in the North West Highlands, leaflets for the North Pennine AONB, display panels for Kents Cavern in the English Riviera, and in Northern Ireland, a booklet for the Marble Arch Caves in County Fermanagh. The Fund has also supported several Jurassic Coast initiatives.

Exciting an interest among children and young people is probably the best way to make sure that the importance and fascination of geology become more widely understood. Projects aimed at young people have secured strong Curry Fund support. These include the GA's own Rockwatch Club and the provision of resources to enhance the teaching of geology in schools.

There's no shortage of enthusiastic geologists with plenty of ideas about promoting geology to the public – from street theatre to interactive woolly mammoths. The Curry Fund helps turn these wonderful ideas into practical outcomes. In addition, the Fund has a record of supporting more traditional projects, for example leaflet guides and waymarks for geological trails, and new display facilities in museums.



A poster highlighting the stones of Welsh castles drew Curry Fund support



Iain Stewart and Elizabeth Devon opening Box Rocks Circus, where the Curry Fund supported the fossil rubbing block in the foreground



The *Steaming through the past* leaflet offers a new dimension to train travel through the Dee Valley and Llangollen

Wall together now... geological heritage on show at Wildlife Trust

Brian Ellis, Warwickshire Geological Conservation Group

Warwickshire has a very diverse bedrock geology with representative strata from Neoproterozoic through to Middle Jurassic (except Silurian). The oldest rocks occur in the north-east of the county, in the Nuneaton area, and they get increasingly younger towards the south. Spread over the current topography is an intermittent cover of Pleistocene and Holocene deposits – till, sand, gravel and alluvium.

The county covers some 2000 km² and widely distributed over that area are just over 100 Local Geological Sites that have been identified by the Warwickshire Geological Conservation Group (WGCG). It is difficult to present the public with a coherent overview of Warwickshire's geodiversity from this scatter of sites.

However, the WGCG has worked with Warwickshire Wildlife Trust (WWT) at its headquarters at Brandon Marsh, Coventry, to create a wall illustrating the county's geology, running beside the main path into the nature reserve.

The wall incorporates examples of most types of bedrock, collected from across the county. We were only unable to source Arden Sandstone, a significant local building stone. Coal is unsuitable for wall building and black paviers were used instead. Similarly, the Carboniferous, Permian and Triassic clays and mudstones were substituted with bricks made from those rocks in the former Warwickshire brick industry.

Fundamental decision

A fundamental decision was to build the wall to illustrate the general geological structure of the county from north to south, showing how the rocks relate to each other. However, accurate representation of the dips and thickness of beds were sacrificed for the structural integrity of the wall.

Several factors come in to play when deciding on the focus of interpretation of the wall. Two ideas captured the imaginations of passers-by we talked to while the wall was being built.

One was the enormous time span covered by the rocks in and on top of the wall – 650 million years. Most were aware that geology involves long time spans but were surprised that it applied so near to home in Warwickshire, rather than to far-away places. But even more captivating was the idea that in those 650 million years, the land that became Warwickshire had moved from well south of the equator to its present position at 50° north. The idea that the land grew bit by added bit over that time was itself novel to many. This interest was encouraging, as these concepts, involving space and time, were ones that we had identified as being significant elements of any interpretation.

• *Continued next page*



Part of a fossil tree trunk used in the wall to represent the Carboniferous
Photo by Brian Ellis

GEOLOGICAL OUTREACH



The whole wall shows the oldest rocks on the left and the youngest on the right, all with a covering layer of sand and gravel. The table below further explains the rock formations. Photo by Lucy Hartley; annotation Ben Steer

• From preceding page

The wall itself is a visually stimulating feature. The contrasts in the colours and textures of the rocks are very obvious – the greys of the oldest rocks at the left-hand, northern end of the wall; the reds of the terrestrial sandstones in the middle; and the paler colours of the marine sediments at the right-hand, southern end. These contrasts give the opportunity to describe and interpret the environmental conditions under which the different rocks were produced. The idea can be pursued at different levels of detail according to the audience. The wall also incorporates some fossils, to illustrate the changing environmental conditions.

An equally important consideration in the interpretation is that people will recognise the significance of changing geology – Warwickshire's geodiversity – through familiar locations, landscapes, activities and features. Direct links to geology can be illustrated by examples such as Hartshill Church (Hartshill Sandstone), Mancetter Quarry aggregate crushing plant (Ordovician diorite), the recently closed Daw Mill Colliery (Coal Measures), Corley Rocks (Carboniferous Sandstone), Kenilworth Castle (Kenilworth Sandstone), Westgate and Eastgate, Warwick (Bromsgrove Sandstone), cottages in Ufton village (White Lias), CEMEX - Rugby cement works (Blue Lias), Burton Dassett Hills Country Park or Edge Hill (capped by Hornton Stone) and the Blythe Valley quarries (Glacial Sands and Gravels).

Further reading

An account of building the wall is in *Down to Earth* 92, August 2015, pp 14-15.

Warwickshire in the Southern Hemisphere Neoproterozoic – Cambrian - Ordovician

- Caldecote Volcanics – erupted on a volcanic micro-continent, Avalonia
- Hartshill Sandstone – deposited in the long-disappeared Iapetus Ocean
- Diorite – igneous rock intruded during mountain building

Warwickshire near the Equator Carboniferous

- Coal Measures – coal* from decaying plants in tropical swamps
- Sandstones – deposited in sandbanks and sand bars in river channels
- Mudstone* – deposited in low-lying, still-water conditions

Warwickshire in the Desert Permian – Triassic

- Kenilworth Sandstone (red) – deposited in intermittent river channels
- Bromsgrove Sandstone (buff) – from river channels and floodplain
- Mercia Mudstone* – windblown sands in temporary desert lakes

Warwickshire under the Sea Late Triassic – Lower and Middle Jurassic

- White Lias – limestone deposited in warm, shallow, clear sea
- Blue Lias – offshore mud and lime deposits in shallow sea
- Hornton Stone – iron-rich gritty limestone deposited in shallow water
- Oolitic limestone – shallow-water oolitic rock with little iron

Warwickshire under the Ice Pleistocene

- Clays – ground up rock from under the ice
- Sands and gravels – deposits from streams when the ice melted

Rocks marked * are represented in the wall by black paviers (coal) or bricks, including from named brick makers – Websters of Coventry, Kenilworth Cherry Orchard Brickworks and Leamington Bricks.

New voyage forms a Testimony of the Rocks

Elizabeth Pickett, geological illustrator and interpreter

In summer 2015 a group of geologists, artists, ecologists, musicians and storytellers, aged 18 to 70-plus, embarked on a voyage of geological discovery around the Argyll islands on *Leader*, a Brixham sailing trawler. Our journey followed on from one last year, when *Leader* and her crew recreated part of Hugh Miller's 1844 cruise of the *Betsey* around the Inner Hebrides. This year, an important part of the voyage was a visit to Luing to celebrate the launch of the new Atlantic Islands Centre.

Our voyage was named *Testimony of the Rocks*, in honour of Hugh Miller's final book. Miller was fascinated by the natural world, writing, "Nature is a vast tablet, inscribed with signs, each of which has its own significance and becomes poetry in the mind when read". He also wrote of his great interest in the close association of human history with geological science. So, with these themes and Miller's inquiring spirit in mind, we set out to explore the beautiful Argyll islands and their interwoven stories of geology, landscape, natural history and people.

20 June – Magmatic Mull

We meet *Leader* and our fellow voyagers at the North Pier in Oban. Our first destination, where we anchor for the night, is Loch Spelve, held in the curve of the ring-intrusions of Mull's ancient volcano, and with the Great Glen Fault passing deep below. The dark igneous rocks that mass above us and disappear into cloud are transformed into arcs of pink, red and green on the beautiful geological map of Mull.



We discuss charts and forecasts with our skipper Lara, and out of this emerges a more detailed plan for our voyage. We are to head south from Mull, bound for islands of far older quartzite and slate. These metamorphic rocks are part of the 'Dalradian', a group of rocks 750 to 550 million years old and named after the ancient Scots kingdom of Dalriada.

21 June – Rocks of Dalriada

Islands slide past as we head south into the Sound of Luing. The sea is silk-smooth and we glimpse porpoises. At Kinuachdrachd Pier on Jura we learn more about Dalradian rocks and the geological events they record. Originally sediments and lavas in long-vanished seas, they were later metamorphosed during Caledonian mountain-building to become slate, quartzite, marble and schist.

To the sound of a cuckoo we explore a shoreline of Jura Slate. The coast is bright with the pinks of thrift, ragged robin and foxgloves and the yellow of bird's-foot trefoil and tormentil. The geological map of Jura is mainly yellow too – representing a great thickness of Jura Quartzite.



• Continued next page

GEOLOGICAL OUTREACH

• From preceding page

22 June – Metalimestone and music

On the west coast of Shuna, the geological maps spread on the shingle make the island stand out with its stripe of bright blue. This is the Degnish Limestone and we examine a nearby outcrop. Intriguing textures provide clues to its origins in a warm shallow sea and later alteration to become the cleaved metalimestone, or marble, we see today.

Orchids thrive in this lime-rich spot. Islanders used the limestone too – there's a ruined limekiln nearby. Walking across the island we peer through rhododendrons at the crumbling concrete castle of Shuna House, and admire swirling patterns in sea-worn Craignish Phyllite. In evening sunlight in Arduaine there's singing and guitar music on deck.

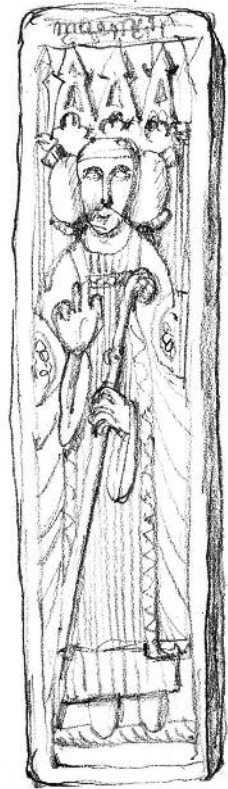


23 June – Through the Corryreckan

We take a window of opportunity and motor through the Gulf of Corryreckan towards Colonsay and Oronsay. The sea is calm but seething patches of water hint at the whirlpool that churns when the tide rips through. On either side are vivid green hillsides of layered rocks. The Paps of Jura, blue-purple and sun-tinged, rise to the south.

Landing on Oronsay we head inland from a white beach to explore the ruins of the 14th Century priory. Corncrakes rasp and medieval priors stare out from carved grave-slabs. We find one of the Mesolithic shell middens for which Oronsay is famous. Packed limpet shells tell of people's lives 6,000 years ago, as close in time to the end of the last glaciation as to today. The turquoise waters tempt some of us in for a breathtaking swim!

• Continued next page



Grave-slab at the priory on Oronsay.



Looking at geological maps on the white sands of Oronsay

GEOLOGICAL OUTREACH

• From preceding page

24 June – Rock of the saints

The thin rugged spine of the Garvellachs is our much-anticipated destination today. We arrive at Eileach an Naoimh and step ashore by a sea-washed outcrop of Port Askaig Tillite. We learn of the ancient glaciation, around 650 million years ago, that formed this famous rock, and contemplate 'Snowball Earth'.

These small islands seem remote now, but were once an important centre of early Christianity. St Brendan founded a monastery here in AD 542 and St Columba reputedly visited the islands. We explore the monastery ruins, the grave of Eithne (St Columba's mother), and two amazing beehive cells. A stump of lichen-crusting rock is known as 'Columba's pulpit'. A spring near our landing is still called the Holy Stream.

25 June – Slate island songs

Luing welcomes us for the final part of our voyage. We walk round Cuan Point, past red cattle and over drifts of grey slate. It has a rippled sheen and is flecked with gold pyrite cubes. To our left rear cliffs of Easdale Slate, sculpted by past quarrying. We are faced by a great wall of rock, a dyke, which chops through the slate and heads out into the green sea like a dark path.

In the evening we join a ceilidh in the new Atlantic Islands Centre, which celebrates the natural and cultural heritage of the Argyll islands. Our leaders, Joyce Gilbert and Simon Cuthbert, speak about the voyage and we enjoy songs, poems, music and stories from islanders and Leader crew. It is a special end to a memorable journey.

26 June – Journey's end

We head back to Oban past the dark cliffs of Seil and Easdale, veiled in rain and mist. Islands merge into a watercolour of slate, sea and sky. Back on the North Pier we say our goodbyes. We have had an inspiring week. We have read some of the signs inscribed on Hugh Miller's vast tablet of nature, and on this journey these certainly became "poetry in the mind" for all of us.

But this isn't the end of the project. Future initiatives are being discussed. Watch this space!

More information

The 2014 voyage was run by the Royal Scottish Geographical Society, the Friends of Hugh Miller and the Scottish Geodiversity Forum.

See: <https://cruiseofthebetsey.wordpress.com> and a film by Fergus Cruickshank at <https://vimeo.com/129989765>

See also *Earth Heritage* 43:

<http://www.earthheritage.org.uk/ehpdf/eh43F.pdf>

The 2015 voyage was run by the Scottish Geodiversity Forum, the Isle of Luing Community Trust and the Friends of Hugh Miller. Young Earth scientists Dyfan Roberts, Andrew Law and Jack Gillespie were sponsored by Glasgow and Edinburgh geological societies. See Emma MacLachlan's film:

<https://vimeo.com/132918394> and *Hugh's News* 26 in:

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



All illustrations and photographs by Elizabeth Pickett

Passing through the Gulf of Corryvreckan

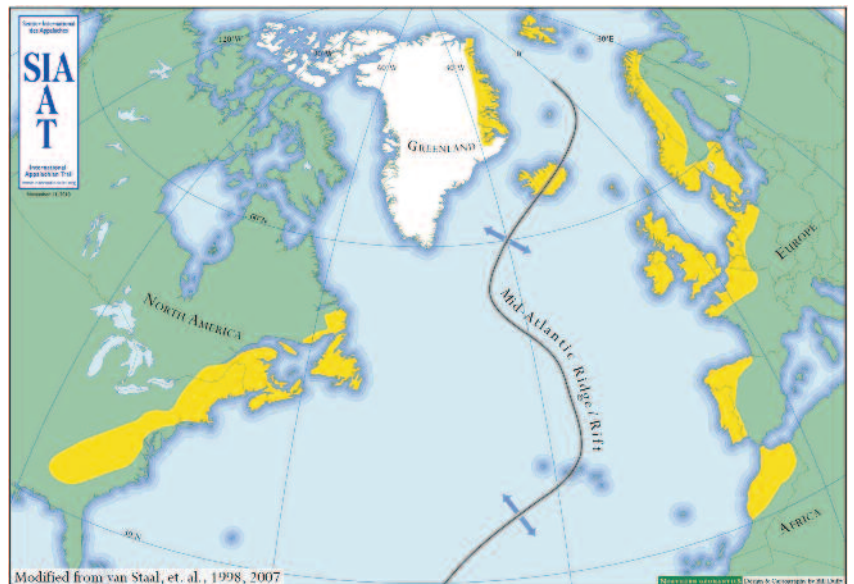


International Appalachian Trail bridges Atlantic divide

Hugh F. Barron, British Geological Survey and IAT Scotland
Robert G. Marvinney, Maine Geological Survey and IAT Maine, USA
Paul Wylezol, IAT Newfoundland and Labrador, Canada

Caledonia and Appalachia – neighbours on ancient continents, together in continental collisions that created great mountain ranges, separated by the opening of the Atlantic Ocean, brought back together by the International Appalachian Trail – a shared geological and cultural heritage

Throughout human history, geodiversity has determined the location of settlements, trade routes, and human migratory paths, inextricably linking our culture to the geological foundations of our landscapes. The International Appalachian Trail (IAT) celebrates our common geoheritage by establishing a long-distance walking trail that extends beyond borders and jurisdictions to all regions once connected by the 'Appalachian – Caledonian' mountain range, formed more than 300 million years ago on the super-continent Pangaea. In addition to connecting people and place, the aim of the IAT is to promote natural and cultural heritage, environmental stewardship, health and fitness, fellowship and understanding, cross-border co-operation, and rural economic development through ecotourism and geotourism.



North Atlantic Appalachian – Caledonian domains (in yellow) span 11 countries.

The IAT is the longest network of walking trails in the world with an estimated 12,000 miles of trail along the ancient Appalachian – Caledonian terranes in 11 countries around the North Atlantic. These include the USA, Canada, Greenland, Iceland, Norway, United Kingdom (including Scotland, England, Wales and Northern Ireland), Isle of Man (British Crown dependency), Ireland, France, Spain, Portugal and Morocco.

The project began in 1994 when visionary Maine conservationist Richard 'Dick' Anderson had the inspired idea to create a hiking trail that followed the Appalachian Mountains, beyond borders, from Maine's Katahdin to Mont Carleton in New Brunswick and then on to Mount Jacques Cartier in Quebec's Gaspé Peninsula. With the support of like-minded conservationists such as Don Hudson of the Chewonki Foundation and Walter Anderson of the Maine Geological Survey, the idea was soon adopted by former Maine Governor Joseph E. Brennan and interested parties in New Brunswick and Quebec, followed by others in Newfoundland, Nova Scotia and Prince Edward Island.

• *Continued on next page*



Maine conservationist Dick Anderson (right) had the idea of stretching the trail beyond borders. He is with Maine Governor Joe Brennan. Photo © IAT

GEOTOURISM & ECONOMIC OPPORTUNITIES

• From preceding page

In June 2009, the British Geological Survey in Edinburgh invited IAT representatives from Maine and Newfoundland and Labrador to visit the British Isles to explore interest in extending the IAT to the Caledonian terrains of Scotland, Ireland, Northern Ireland and Wales. This visit led to Scotland becoming the first European Chapter of the IAT, with the 96-mile West Highland Way, one of Scotland's official long-distance routes, becoming the first IAT Scotland route officially welcomed during the grand opening of the Appalachian Trail Museum in Pine Grove State Park, Pennsylvania on June 5, 2010. The following year the Firth o Clyde Rotary Trail and the Cape Wrath Trail joined the IAT Scotland family to complete an adventurous 470-mile route between the Mull of Galloway and Cape Wrath in north-west Sutherland.



The West Highland Way is officially welcomed during the grand opening of the Appalachian Trail Museum in Pine Grove State Park, Pennsylvania in June, 2010. Photo © IAT

The first IAT Chapter outside North America was formed in Greenland in April 2010, with a route in the Nuussuaq Peninsula of Western Greenland. The IAT now also includes representative trails across Ireland and Britain, from Slieve League to the Ulster Way, English and Welsh National Trails, the Wales Coast Path and Isle of Man's Raad ny Foillan. There are also IAT-designated trails in Scandinavia, Iceland, Spain, Portugal and most recently Morocco. IAT Scotland and IAT England are now working on linking trails across the border – this may include linking the Firth o Clyde Rotary Trail to the Southern Upland Way, St Cuthbert's Way and the Pennine Way.



IAT delegates from Europe and North America symbolically bridge the North Atlantic Rift in the Pingvellir National Park, Iceland in June 2012. Photo by Hugh Barron

Outside North America

Reykjavik, Iceland was the location of the IAT's first annual meeting outside North America, in 2012. In 2013, the IAT annual meeting was held in the Loch Lomond and The Trossachs National Park. En route to this meeting a small North American IAT delegation visited Dunbar to pay tribute to that great Scottish American conservationist John Muir, and to Siccar Point to pay homage to James Hutton, the founder of modern geological science. The 2014 IAT annual meeting was held in Plymouth, Devon, where keynote speaker Iain Stewart presented '50 Shades of Grey', or how to inspire the lay public with geology. The nearby South West Coast Path National Trail and IAT England route passes through the English Riviera Geopark and highlights the growing opportunities for co-operation on geotourism development between geoparks and IAT trails.

In Scotland, the West Highland Way and Cape Wrath Trail pass through the North West Highlands Geopark and Lochaber aspiring Geopark. In northern England, the Pennine Way traverses the North Pennines Geopark and, in Wales, the Wales Coast Path allows access to 90% of Anglesey's geological highlights in GeoMôn Anglesey Geopark. Elsewhere in Europe, IAT Portugal route Grande Roto Do Muradal-Pangeia lies within the Naturtejo Geopark.

• Continued on next page

North American IAT representatives descending Ben Nevis via the Carn Mòr Dearg arête at the northern end of the West Highland Way, one of three IAT Scotland trails. Photo by Hugh Barron



• *From preceding page*

Canada links geology to natural, built and cultural heritage

In Canada, IAT Newfoundland and Labrador (IATNL) is planning to establish the Cabox Geopark in Western Newfoundland, spanning the Bay of Islands Ophiolites from Lewis Hills to Tablelands in Gros Morne National Park, which also hosts the Global Stratotype for the Cambrian–Ordovician boundary at Green Point. With the Cabox Aspiring Geopark, IATNL is a partner in the EU Interreg VB Northern Periphery Programme's 'Drifting Apart' project which aims to 'unearth and strengthen the understanding, appreciation and enjoyment of the fascinating and interconnected geological heritage of the Northern Periphery region, and its many links to natural, built and cultural heritage'.

The project will support the development of new and aspiring Global Geoparks (*see following article*), promote innovative products and services to encourage social and economic prosperity across the Northern Periphery Region and continue to strengthen the network of Northern Periphery Global Geoparks.

Other partners in the project include the Geological Survey of Northern Ireland, the Geological Survey of Ireland, the North West Highlands Geopark, Lochaber Geopark, Geopark Shetland, and other geoparks and aspiring geoparks and national parks in Ireland, Canada, Iceland, Norway and Russia.

The geodiversity of the IAT trails offers a journey through time, insight into Earth's geological history, and an understanding of past and present social and economic development.

The IAT also offers great opportunities to develop new economic opportunities, enhance culture and sense of pride in place, and conserve historical links between Appalachian and Caledonian terranes on either side of the North Atlantic. Earth scientists can use the IAT to provide an excellent opportunity to participate in this unique recreational/educational project and to engage the public in a discussion of the geological foundations of modern society.

The Atlantic Ocean may have been dividing us for eons, but the International Appalachian Trail is well on its way to bringing us back together! For more information on the IAT, go to www.iat-sia.org.

Published with the permission of the Executive Director, British Geological Survey.



Peridotite and gabbro landscape of the Bay of Islands ophiolite complex, IATNL Blow-Me-Down Mountain Trail, Western Newfoundland
Photo by Hugh Barron

Katahdin (1,606 m), an exhumed Acadian granite pluton in the Baxter State Park, Maine, is the location of the southern terminus of the IAT in North America. Photo by Bill Duffy



UNESCO branding boosts status of UK geoparks

The UK's seven Global Geoparks have received a massive lift with the announcement by UNESCO – the United Nations Educational, Scientific and Cultural Organisation – that it is recognising them as UNESCO Global Geoparks.

This is the first new UNESCO listing programme in over 40 years and ranks Global Geoparks alongside UNESCO's World Heritage Sites. Under the new programme, the status of Global Geoparks, which previously operated with the informal support of UNESCO, will be formally recognised. The move provides a platform for the UK's seven Global Geoparks to develop further their potential for geotourism and input to local economies. UNESCO Global Geoparks are locally led partnerships that support sustainable economic development, primarily through geotourism and ecotourism.

The UK Government, which helped lead work for the UNESCO designation, welcomed the news through the Parliamentary Under-Secretary of State for Environment and Rural Affairs, Rory Stewart, who said: "It gives us a great international profile. Connecting our geological heritage and literally our bedrock with our community and economy is a very exciting opportunity. The work Geoparks do locally, and their new UNESCO status, could inspire people for years to come."

The Natural Sciences Director of the UK National Commission for UNESCO, Dr Beth Taylor, said: "The UK's seven UNESCO Global Geoparks are a national treasure, not just in terms of their geological interest but the enthusiasm and dedication of their local champions who work so hard to maintain them and to make the most of the educational and economic opportunities they offer. They are a great illustration of local communities working very effectively in some of the most remote and beautiful areas of the UK. But I appreciate that they are also a bit of a national secret, not widely recognised by visitors or even by many of those who live within their boundaries. I hope that the UNESCO brand will give our Global Geoparks the same recognition factor as World Heritage Sites – a visible guarantee of their international significance and an assurance that they are great places to visit and explore."

357,000 people live within a UK geopark boundary, and the geoparks receive over 17.5 million visitors each year. Chair of UK Global Geoparks Forum, Mel Border, said: "We are feeling very proud of this formal UNESCO recognition and look forward to making the most of the opportunities it presents".

Visitors experience an adventure in Kents Cavern, part of the English Riviera UNESCO Global Geopark. The most important find from the caves, a human jawbone, dated at approximately 41,000 years old, is the oldest modern human fossil in north-west Europe.



UK's magnificent seven – and what makes them so special



ENGLISH RIVIERA

South Devon's geology has created a stunning coastline, linking the rich diversity of the landscape with its wildlife, people and culture.
www.englishrivierageopark.org.uk

Kayakers explore the marine Devonian limestone coastline and iconic natural arch of the English Riviera Geopark.

Photo by English Riviera Tourism Company

UK's magnificent seven

All photos on this page by
Stewart Campbell



FFOREST FAWR

(Welsh for the 'Great Forest') – comprises the uplands of the western Brecon Beacons National Park. It is a landscape sculpted by ice then transformed by humans.

www.fforestfawrgeopark.org.uk

Fforest Fawr Geopark contains some of Wales' finest glacial scenery. A spectacular array of Younger Dryas moraines and rockslides occurs within Craig Cerrigleisiad, seen here against the ice-gouged backdrop of Corn Du and Pen y Fan, the highest peaks of the Brecon Beacons.



GEOPARK SHETLAND

contains the highest sheer cliffs in Britain and the best 'hands on' exposure of the Great Glen Fault.

www.shetlandamenity.org/geopark-shetland

Shetland's islands provide fantastic opportunities to study a three billion-year geological history. The recently redeveloped Sumburgh Lighthouse, on the southern tip of mainland Shetland, showcases some of the finest geology and wildlife.



GEOMÔN

Anglesey's Geopark is one of the UK's most geologically diverse areas. Its geological treasures extend back around 1.8 billion years and include Precambrian pillow lavas and mélangé, some of the oldest fossils in England and Wales and important Ice Age deposits and landforms.

<http://geomon.co.uk>

Anglesey's coast and coastal footpath provide unrivalled access to a multitude of rock formations. Here, on Llanddwyn Island at the south-west tip of Anglesey, Precambrian mélangé is cut by a Palaeozoic dolerite dyke.

UK's magnificent seven



NORTH PENNINES

This landscape has been 500 million years in the making and reveals a story of tropical seas, vast deltas and deserts, huge ice sheets and continents on the move, alongside a world-class mineral and mining heritage.

www.northpennines.org.uk

High Cup Nick is one of northern England's geological treasures. This classic U-shaped valley bears testimony to the intense glaciation of the region, and the spectacular grey-blue dolerite crags of the Whin Sill (foreground) clearly show the importance of geological structure in landscape development.

Photo by Steve Westwood/Natural England

MARBLE ARCH CAVES

Ranging from rugged uplands, lakes and forests through to gently rolling drumlins of Counties Fermanagh and Cavan, the landscapes here represent a complex Earth history dating back 895 million years.

www.marblearchcavesgeopark.com

Visitors enjoy the world-famous Marble Arch Caves and can look forward to new attractions such as Cavan Burren Park.

Photo by Robbie Shone



NORTH WEST HIGHLANDS

This Scottish geopark has the oldest rocks in the UK. The Lewisian gneiss is over three billion years old. One of the park's boundaries follows the Moine Thrust, the internationally significant structure that helped 19th Century geologists determine how the world's great mountain ranges were formed.

www.nwhgeopark.com

The dramatic peaks which form Quinag are typical of the mountains in Assynt. It was voted the UK's favourite landscape in a poll organised by the Geological Society of London in 2015.

Photo © North West Highlands Geopark

Shaping a geological trail in the Clyde and Avon valleys

**Katie Whitbread, BGS Scotland
Kirsten Robb and Sarah O’Sullivan,
Clyde and Avon Valley Landscape Partnership**

A new geological trail is being developed in central Scotland, just 30 minutes from the city of Glasgow, by the British Geological Survey and the Heritage Lottery Fund supported by the Clyde and Avon Valley Landscape Partnership (CAVLP).

The *Shaping our Landscape* trail will reveal the dramatic history of the changing landscape of the Clyde and Avon valleys by linking a network of geological sites with a range of online and on-site information resources.

The fertile arable and pasture land of the Clyde and Avon valleys, and the abundance of coal, stone and sand and gravel that are the legacy of the geological past, have long provided the region’s communities with a wealth of natural resources. Farming, coal mining and quarrying have supported local lives and people have left their mark on the land. Through the geological trail, people will be able to explore the fundamental links between past and present landscapes.

The Clyde and Avon valleys are a testimony to the power of rivers to shape our environment over timescales from millennia to decades. Many of the rocks of the Clyde Valley area are the ‘fossil’ remains of ancient rivers that once coursed across the landscape. Around 400 million years ago, in the Lower Devonian, braided rivers carried vast quantities of sand, forming the purple sandstone rocks characteristic of the Upper Clyde Valley. Later, in Carboniferous times, the region was occupied by meandering streams migrating across broad swampy floodplains.

The sandstones left by the Carboniferous rivers form the excellent building stones once quarried for the construction of Hamilton Palace, the former seat of the Dukes of Hamilton, of which only the grand hunting lodge of Chatelherault now remains. Coals formed from the organic remains of the floodplain swamps have been mined extensively in the Clyde and Avon valleys, fuelling the industrial development of nearby Glasgow.

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**Chatelherault was built in 1732 as the hunting lodge and summer house for the Duke of Hamilton in the grounds of the now demolished Hamilton Palace. Designed by the famous Scottish architect William Adam, local sandstone was used in its construction. A former 20th Century sand and gravel quarry, now parkland, sits to the right of the image.
Katie Whitbread © BGS/NERC**



• *From preceding page*

In more recent times, the erosive power of rivers has shaped the landscape. The Upper Clyde Valley is characterised by its many dramatic gorges and waterfalls that were carved by rivers following the retreat of large glaciers that blanketed Scotland 20,000 years ago. Ice flowed east across central Scotland from the Southern Uplands and western Highlands into the Firth of Forth. Sediment deposited by the ice infilled the pre-existing valleys of the River Clyde and its tributaries. As the glaciers retreated to the west, meltwater ponded up at the ice margins, eventually breaching the ice-dam to cause a torrent that carved a new channel into the hard Devonian sandstone – forming the Falls of Clyde. New gorges were also cut into rock along the many tributary streams, creating the network of young valleys of the Upper Clyde.



The falls of Corra Linn, part of the World Heritage Site of New Lanark, is a 27 metre-high waterfall in Devonian sandstone, on the Falls of Clyde. Generally considered to be the finest and most spectacular of the Clyde's three great waterfalls, it has been painted by a number of artists including J.M.W. Turner. Katie Whitbread © BGS/NERC

The power of the rivers remains important today. Hydroelectric power stations at Bonnington and Stonebyres were constructed in the mid-1920s to harness the natural power of the River Clyde – the electricity from these stations is enough to power over 17,000 homes.

As well as forming picturesque landscapes that have inspired poets and artists, the gorges have long been exploited as defensive sites such as at Craignethan Castle, perched on the rim of the Lower Nethan Gorge. Today, these gorges provide havens in which ancient woodland habitats still flourish and are protected as the Clyde Valley Woodlands National Nature Reserve.

The first phase of the *Shaping Our Landscape* project, a geological audit to identify the key sites that reveal the dramatic history of the landscape, is under way. Local residents have been contributing their knowledge of features in the area, revealing some surprising hidden gems, including networks of underground 'stoop and room' caverns worked into Carboniferous sandstone, and the enigmatic 'erratic' block named Samson's Slingstone. A second phase of the project, beginning in 2016, will develop the information resources exploring the history behind the shaping of the land.

The *Shaping Our Landscape* Geological Trail is one of over 70 projects being delivered under CAVLP between 2011 and 2018. The CAVLP projects, focussed on the Clyde and Avon Valleys Area of Great Landscape Value, aim to help communities celebrate and connect with the region's environment and history via exploration, volunteering and training. Visit www.clydeandavonvalley.org.

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Samson's Slingstone is an enigmatic block of sandstone, four metres in diameter, perched on the edge of the gorge at Fiddler's Burn. The stone may have been deposited in its precarious location by floods of glacial meltwater during deglaciation of the region around 15,000 years ago.

Katie Whitbread © BGS/NERC



Travel choices add adventure for stone forest geopark visitors

Hu Zhenbo, Lanzhou University, China
David Bridgland, Geologists' Association

Jingtai Yellow River Stone Forest National Geopark in Lanzhou Province, China, is one of the third batch of national geoparks approved by the Ministry of Land and Resources of the People's Republic of China, established in 2007.

The geopark covers 50 km² on the south side of the Yellow River, some 160 km downstream from Lanzhou city. Its geoheritage interests are largely geomorphological, although the bedrock in which the landforms are sculpted plays a prominent role. This is Late Cenozoic fluvial sandstone and conglomerate, many tens of metres thick, which was emplaced in a subsiding fault-bounded basin before incision of the landscape by the Yellow River began, with this 'basin inversion' probably occurring in the late Early Pleistocene. The Yellow River has formed a curving cliff in the edge of the basin-fill sediments, its course following the northern bounding fault. An impressive meandering gorge, Yinma Great Gorge has been formed where a left-bank tributary has kept pace with the incision by the Yellow River, but it is the myriad tributaries of this gorge, highly sinuous and steeply incised, that define the pinnacles (hoodoos) of the 'stone forest'.



Cable-car ascent to plateau viewpoint in the Jingtai Yellow River Stone Forest National Geopark is an adventure (above), as is the road to the Yellow River (below). All photos by David Bridgland

Multi-hairpin descent

Access to this locality from Lanzhou requires a drive of ~70 km eastwards to Baiyin, and a similar distance north to the entrance gate of the Geopark. Only those living and working within its boundaries are allowed to take vehicles into the park. For visitors, various modes of transport are available and required. First a bus takes them down a terrifying multi-hairpin road that descends from the entrance complex on the plateau (from where the Yellow River can be seen looping through the park against a backdrop of dramatic sandstone cliffs with pointed peaks) into Longwan village, on the floodplain between the river and cliffs in lush farmland.

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GEOTOURISM & ECONOMIC OPPORTUNITIES

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Farmers grow multiple crops as well as keeping donkeys (>300) and horses for transporting tourists. From a bus station, an electric 'toast-rack' microbus conveys visitors into the heart of the village.

After this there are choices. Those wishing to visit the 'stone forest' must travel to a jetty about 1 km downstream, to the mouth of Yinma Great Gorge. This journey can be done on the river by large boat, small speedboat or precarious-looking rafts floated on inflated animal skins. Alternatively the journey can be made along farmland tracks by donkey cart, car or on horseback.



Travel choices on the ascent

Once there, visitors must travel ~4 km up the gorge to see the stone forest. Again numerous travel choices are available, including walking. For those in a hurry there are minibuses but most choose donkey carts. At the head of the gorge a cable car (separate fee) provides access to look-out points (with refreshments and toilets) above the Yellow River and the stone forest. It is also possible to hire self-drive go-carts to drive farther up the dry river bed, upstream of the gorge.

While the geopark's explanatory information in English is somewhat meagre, there is basic detail that may well be adequate for the predominantly touristic clientele. At the focal point, just inland from the jetty and at the mouth of Yinma Great Gorge, more interpretation board space is devoted to information about the numerous movies filmed at the location than to its geoconservation importance. Nevertheless, anything that raises interest in the area's geology and its geoconservation is to be warmly welcomed.



The river journey can be made on precarious rafts (top) while electric minibuses and donkey carts are also on the travel agenda for visitors.

Most information boards carry little English.

All photos by David Bridgland



Geoconservation in the *Proceedings of the Geologists' Association*

**Colin Prosser,
Natural England and Editor, *PGA***

For a science- or policy-based discipline to grow its profile, credibility and influence, it is vital to have a platform where new ideas can be aired and challenged, issues can be analysed and new approaches and good practice can be shared.

Peer-review publications constitute one such platform. Despite a 65-year history of geodiversity and geoconservation in the UK, and rapidly increasing activity in many countries over the last 20 years, until recently there has been no real outlet for peer-reviewed geodiversity and geoconservation papers. As a consequence, few have been produced. Happily this is now changing.

The founding of the journal *Geoheritage* <http://tinyurl.com/oorb843> in 2009 to promote geodiversity and geoconservation across Europe has been a great success, with approximately 130 papers published in its first six years. The papers have been sourced from across the world, and often grouped as thematic issues.

The decision by the Editorial Board of the *Proceedings of the Geologists' Association (PGA)*, also in 2009, to encourage the submission of papers on geoconservation, was equally important, but for different reasons. The *PGA* geoconservation papers, other than those in special issues, appear alongside more general geology papers, so presenting geoconservation as part of the full span of geoscience. The hope is that *PGA* readers interested in other aspects of geology may now be drawn into reading about geoconservation too.

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Hope's Nose Marine Devonian GCR site, which exposes Middle Devonian limestones and Lower Devonian slaty mudstones, is one of the sites described in a special issue of the *PGA*. Photo by Hannah Townley



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The *PGA* has helped to advance geoconservation in two main ways: Firstly, it has taken on publication of the definitive Geological Conservation Review site evaluations (formerly published in volumes by the Nature Conservancy Council, Chapman & Hall and the Joint Nature Conservation Committee). So far it has produced special issues on *The Marine Devonian of Great Britain*, *The non-marine Lower Cretaceous Wealden strata of southern England* and *The Dalradian rocks of Scotland*. In doing so, it has placed the scientific evidence-base that underpins many Sites of Special Scientific Interest into both the public domain and the scientific literature worldwide.

Further GCR special issues are being prepared, for example on the *Quaternary of southern England* and the *Mineralogy of Scotland*, and should result in hundreds of new site evaluations being made widely available.

Secondly, the scope of the journal has been widened explicitly to encourage the submission of papers on geoconservation. This has resulted in a major upsurge in the publication of geoconservation papers and interest in doing so from across the world. Although the *PGA*, established in 1859, has always published field meeting accounts and extremely useful papers on sites which are now Sites of Special Scientific Interest, the paper by Duff in 1979 on *The conservation of geological localities* appears to be the only conservation-focussed paper produced in its first 120 years. Between 1980 and 2008, in terms of geoconservation, only a handful of short notes, a couple of book reviews and a paper by Murray Gray in 2008 were published in the *PGA*.

Most-cited papers are on geoconservation

It has been a completely different story, however, since 2009, with over 30 geoconservation papers published, including a special issue, *Geoconservation for science and society* (2013). Although UK focussed, these papers have also included submissions from Spain, Portugal, Norway, Russia, Australia and Hong Kong, bringing new experience to the *PGA* and taking the *PGA* to new audiences.

In addition to creating an opportunity for peer-reviewed geoconservation papers to be published and the geoconservation community to develop its profile, credibility, evidence base and participation levels, has the *PGA*'s editorial policy attracted interest to the journal and to the geoconservation papers it has published? A quick glance at the *PGA* website <http://tinyurl.com/z9rnlkf> suggests it has. At the time of writing, the three most cited papers in the journal are all geoconservation papers, five others are in the top 25 and a steady supply of new submissions continues to arrive.

Thanks to the efforts of the *PGA* and *Geoheritage*, peer-reviewed publication is now an established building block in the development of geoconservation. Through detailing their academic research, analysis and experience on the ground, the community of geoconservation scientists and practitioners can generate new momentum for the discipline, advance thinking about it, raise its profile and draw in new people and new funding. **More geoconservation papers please!**

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

New online diploma in Geology of Yorkshire & Northern England

Are you interested to learn more about Earth history and the geology of Northern England whilst studying for a qualification? If so, read on!

This month, September 2015, the University of York, a Russell Group university, launches a part-time, two-year online Postgraduate Diploma, *The Geology of Yorkshire and Northern England*. The programme is aimed at anyone with an active interest in geology who is looking to gain new skills, whilst developing their geological analysis abilities and science communication skills.



The distance-learning course is taught completely online, so offering the flexibility to suit individual lifestyles and work/home commitments. Online interaction with both the tutor and fellow learners is actively encouraged and the course is fully supported throughout. An introductory residential week in York at the beginning of the course will provide students with the opportunity to meet fellow learners and staff, and to gain an overview of the course and the online learning environment. The course will also include field excursions and days in the classroom, providing students with the chance to examine the geology of Yorkshire and Northern England up close.

The geology of Yorkshire and Northern England holds an exceptional variety of landscapes and classic geological sites. The course deals with more than 500 million years of geological history – a story that describes the closure of ancient oceans, catastrophic volcanoes, Himalayan-scale mountain ranges, tropical seas, deserts and ice ages. Through this regional geological understanding, students will be introduced to the tools required to interpret larger-scale Earth processes and structures. They will also be able to assess Yorkshire and Northern England's importance to current controversies in Earth sciences, from fracking to climate change, and understand the region's role in the history of geology.

Find out more at <https://www.york.ac.uk/lifelonglearning/geology> or contact Lifelong Learning on 01904 328482. The programme begins in late September, and applications are being taken now. Only limited IT skills are required – all you require is a PC or Mac with broadband internet connection.

Above, the intriguing Millstone Grit of Brimham Rocks, North Yorkshire is one of the subjects of the diploma.

Image: <https://pixabay.com/en/nature-shapes-england-brimham-rocks-316746/>

Below, gently folded beds of the Redcar Mudstone Formation (Lower Jurassic), Robin Hood's Bay, are also within the course remit.

Image: Liam Herringshaw



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

Geoconservation's worldwide growth

Colin Prosser, Natural England

Approximately 80 delegates from 24 countries gathered in Reykjavik, Iceland, from 8-12 September 2015 for the 8th International ProGEO Symposium, *Geoconservation strategies in a changing world*.

A cloudy, wet and windy pre-symposium excursion to the newly established Reykjanes Geopark, accepted into the Global Geopark Network just the previous week, provided the first taste of both Iceland's fantastic geology and its changeable weather. Highlights included lava flows, feeder dykes, pillow lavas, and the chance to step across a short bridge from the North American Plate to the Eurasian Plate. The symposium started with an address from Ólafur Ragnar Grímsson, President of Iceland; how many geoconservation meetings have been opened by a national President I wonder? Business moved swiftly into four sessions:

- How to secure the integrity of geosites under threat?
- How to incorporate geological heritage into Environmental Impact Assessment (EIA)?
- What is sustainable use of a geosite?
- Is mining and quarrying compatible with geoconservation?

Spread over two days, 26 presentations and verbal introductions to a further 25 posters provided a fascinating insight to the themes. They illustrated the innovative, diverse and interesting activities now taking place as geoconservation continues to expand globally. The range of topics covered was extraordinary and included approaches to site selection and management, national geodiversity charters, a review of the journal *Geoheritage*, geotourism and management of excessive tourism, use of social media, EIA, the recognition of geoheritage within IUCN, multimedia technology, 3D and augmented reality, collecting policy, community engagement, interpretation strategies, potential Geoparks, inventories and collaboration with mining and quarrying companies.
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Pillow lavas and overlying volcanoclastic deposits are exposed in a quarry at Stapafell in the new Reykjanes Global Geopark. Photo by Colin Prosser

November date to explore landscape's tourism potential

A day of sharing knowledge, skills and experience of tourism activities utilising Scotland's landscape is being staged at Battlebury Conference Centre, near Perth, on 25 November.

The *Sharing Good Practice* event is for anyone who encourages the use and enjoyment of the landscape by visitors, and anyone who delivers tourism services, including Blue Badge guides, bus and tour operators, wilderness-ecotourism experience providers, rangers, visitor centre, tourism business and property managers, and those offering outdoor pursuits.

Presentations, case studies and interactive workshops will explore what's currently on offer and how the sector might use Scotland's world-class geodiversity to develop tourism and expand visitor numbers.

The day is organised by Scottish Natural Heritage in partnership with Visit Scotland, Scottish Tourist Guides Association and the Scottish Geodiversity Forum. Booking in advance is essential. Participation, including lunch and refreshments, costs £40, or £20 for students, volunteers and senior citizens. Booking forms and payment details are at <http://tinyurl.com/p3r4shy>



Photo by Scottish Natural Heritage

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A keynote address highlighted the outstanding natural beauty of the highlands of Iceland, and their geological and ecological importance as well as the growing challenges they are likely to face, including increasing tourism and exploitation of geothermal power.

The post-symposium field excursion visited the Volcanic Zone of Southern Iceland, taking in the rift zone and site of the former open-air Icelandic assembly in the Þingvellir National Park, the hot springs of Geysir, a chance to swim in the warm springs at Flúðir, and some incredibly spectacular volcanic scenery which included spatter cones, vast areas of black tephra and the large rhyolitic flow at Landmannalaugar. The return journey included time in the Katla Geopark, enjoying from a distance the Mýrdalsjökull glacier, Katla and the infamous ash-generating Eyjafjallajökull volcano, as well as a trip down the beautiful Skafta river to stop at Vik, for a briefing on future plans for the Katla Geopark and some well-earned soup.



Þingvellir National Park is a World Heritage Site and includes the site of the open-air assembly for Iceland (930-1798). This view shows the NE-SW elongated graben marking the continuation of the Mid-Atlantic Ridge across Iceland.

The field excursions certainly showed off the geological wonders of Iceland, a place where tourism, based largely on geology and active geological processes, is now the dominant force in the economy. The challenge now is to grow this geotourism industry without damaging the unspoilt natural beauty which visitors come to see. The symposium sessions showcased the expanding and exciting range of geoconservation research and practical activity taking place, suggesting a growing and healthy discipline. From a personal perspective, I was struck by how rapidly geoconservation is expanding as a discipline and how difficult it is to keep up with it all; perhaps it has already spilt into a number of different but related disciplines? The progress in getting geoconservation recognised at IUCN, particularly in IUCN-protected areas, and the opportunities that this might bring, were important points to emerge during the symposium. Significant too, was the presence of active and well informed delegates from Brazil, Iran and the USA, which raised the question as to whether ProGEO, founded as a European association, now needs to consider going global?

The volcanic cone at Landmannalaugar forms a dramatic backdrop to the Icelandic Highlands.
Photos by Colin Prosser

The symposium was extremely well organised and everyone that attended seemed to come away truly inspired by what they had heard, by the geology, geological processes and landscapes they had seen, and by the geoconservation and geotourism challenges that lie ahead. The symposium was a great reminder of how spectacular our geoheritage can be and of the conservation and promotion work still needed. Oh, and did I mention the wonderful display of the Aurora Borealis enjoyed by those that attended the post-symposium excursion? That wasn't bad either!



A symposium declaration, **Declaration of Reykjavik**, produced by Iceland delegates, is available as a photograph on the ProGEO Facebook page <https://www.facebook.com/progeo.geoheritage>

Taking the wraps off Ripon's restored cathedral geoheritage



Mick Stanley, Geodiversity Consulting

Ripon Cathedral is a dominating presence within the Yorkshire city. Maintaining the cathedral's imposing looks while replacing the ageing fabric of the north transept of the building has depended heavily on sourcing suitable replacement stone. But where did the original come from? Detective work was necessary.

When the scaffolding and covers on the north side of Ripon Cathedral come down – probably late October 2015 – they will reveal a considerable amount of stone replacement, repointing and three new gargoyles inserted high on the north face of the choir. Initial cleaning, pointing and cutting out of defective stonework started in March 2015.

The Cathedral's earliest visible architecture is the 12th Century North transept, clerestory and arcading. This is the outstanding example of Northern England's early Gothic style, and is the most heavily French-influenced building constructed in England in the last quarter of the 12th Century. Its significance is on a par with the east arm of Canterbury Cathedral.

Many important buildings have an archive of fabric rolls providing historians with details of construction. As extensive as Ripon's archive is, the fabric rolls revealed little available detail dating from before 1354, and it was those earlier 200 years that would have told us about the construction, so detective work was necessary to try to retain integrity in today's maintenance work.

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The north transept portal is constructed mainly of 12th C blocks of gritstone. The lighter-coloured blocks were replacements made by Gilbert Scott.

All photos by Mick Stanley

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General observation revealed that the earliest 12th C Romanesque transitional and 13th C Early English architecture, which Ripon is best known for, uses mainly coarse-grained, pebbly, current-bedded, multi-coloured sandstone of Namurian (Millstone Grit Sandstone) age. This is the same local material used by the monks to build Fountains Abbey three miles to the south. This is seen on the right, with Gilbert Scott's Hackfall sandstone on the left of the image.

Since 1280, following the collapse of the choir, Permian Magnesian Limestone from Quarry Moor, a mile to the south of the city, has been extensively used for repairs, new build and to expand and fortify the Cathedral with parapets with arrow loops, to defend against the marauding Scottish army of Robert the Bruce in 1318 and 1322. Buttressing for the failed East end, the new Lady Chapel on the South, and the extra massive piers for the central tower, and new North and South nave aisles also used Magnesian Limestone. It is unmistakable with its wavy-lined algal mat structure (old blocks seen here) in comparison to the later Magnesian Limestone used in the 19th and 20th centuries, from Monkton Moor, five miles to the south, which is more homogeneous and does not exhibit the algal structure.

Tradition has it that the tower collapse in 1450 was caused by an earthquake, but none are documented in Britain between 1382 and 1480. It is more likely that poor foundations were the cause, and observers will see the massive pier on the south side of the nave where it meets the south transept taking a lot of the extra weight deemed necessary to prevent another collapse.



The three buff-coloured blocks on the left side are of Gilbert Scott's Hackfall sandstone.

Old blocks of Magnesian Limestone show distinctive wavy-lined algal mat structures.

Only one column, the north-west of the four supporting the central tower, is of Millstone Grit. The other three, providing most of that extra mass, comprise Magnesian Limestone from Quarry Moor. The central tower spire collapsed in 1660, damaging the 1484 quire stalls, and the west end spires were taken down as a precaution in 1664.

Magnesian Limestone from Smaws Quarry, Bramham Moor, now sadly filled with domestic waste, was used in Bloor's 1830s work as recorded in the building stone 'bible', the report of the Commissioners on the rebuilding of the Houses of Parliament. The Commissioners appointed to visit the quarries included William Smith, 'The father of English Geology' and Henry De la Beche, the first Director of the Geological Survey. Their report records Ripon as "lower part, east end, south east angles (Norman), of coarse sandstone of the vicinity, in good condition... the west front, the transepts, and tower (of 12th and 13th centuries) of coarse sandstone of the vicinity, in fair condition... the aisles of the nave, the clerestory, and the choir (quire) of the 14th and 15th centuries, of coarse sandstone and Magnesian Limestone intermixed, not in good condition... the lower parts of the building generally, but particularly the west front, which are coarse sandstone, are very much decomposed."

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Of the four columns supporting the cathedral's central tower, only the north-west one, seen here on the left, is of Millstone Grit.

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George Gilbert Scott's extensive restoration of the 1860s took note of the report and replaced most of the stones in poor condition with a buff sandstone from Hackfall, a Grade 1 listed landscape garden designed by William Aislabie around 1750 and owned by a descendant, the Marquis of Ripon, in the Victorian period. He also helped sponsor the Scott restoration, and must have allowed stone to be taken from the rim of the Ure gorge where the garden is located, near to Grewelthorpe. When continental Europe became unavailable to British aristocrats for their 'grand tours' during the Napoleonic Wars, Hackfall became a substitute with artists such as Dall, Devey and Turner recording the views. Robert Adam was employed to design a ruined folly which today is managed by the Landmark Trust as a holiday cottage with the second best view in Yorkshire (the best view is from Sutton Bank).

The 20th Century witnessed more replacement stone for the original work that was by then 900 years old. However, it was not in sympathy with the two main building stones as, in the 1960s, a Cathedral architect added the very exotic Jurassic oolite from Clipsham to rebuild two pinnacles on the exterior of the north quire aisle, one is seen here on the left of the image with algal-mat Magnesian Limestone on the right.

This history was the background to the current stone replacement programme, and there was detailed discussion with Oliver Caroe, Ripon Cathedral architect (also the Surveyor of the Fabric of St Paul's Cathedral – 'the other place', as it's known at Ripon!). It was agreed that stone samples should be sent to the British Geological Survey's stone expert, Dr Stephen Parry, who produced large thin sections of stone types – two samples from 12th C stonework that was to be replaced and one sample of Scott's replacement stone. Under a microscope, the coarser sandstone of 12th C was seen to be similar to Namurian Lower Plompton Grit. The finer sandstone was Triassic and both were sourced from within three miles of Ripon. Scott's stone was a medium- to fine-grained, current-bedded sandstone from Hackfall, and was confirmed by a visit to the landscape garden and a scramble for samples of stone on the gorge rim. Stephen Parry suggested that stone from Killinghall Quarry, 10 miles south of the city, would be an ideal match for the Lower Plompton Grit as the quarry was in the same geological horizon (bed). Samples were obtained, and it is now being used for replacement.

The replacement for Scott's finer-grained sandstone was sourced from Calvert's of Leyburn and is Namurian Lower Follifoot Grit, from Grey Yaud Quarry, Leyburn and is known as Witton Fell sandstone. Quarry Moor where the Magnesian Limestone came from is now a SSSI owned by Ripon City Council and managed by a committee of councillors, practitioners and residents. It is the only site in Britain where Permian-age shoreline beds can be seen and the site also has 2% of the available Magnesian Limestone grassland in Britain.



The wall to the right is constructed of local Magnesian Limestone. The pinnacle on the left is made from Jurassic Clipsham Oolite.



Lower Plompton Grit of Namurian Age, from Killinghall Quarry, lies on pallets, ready to be fixed in place.



An exposure of Permian Limestone at Quarry Moor SSSI contains algal mat beds.



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REMARKABLE NEW DINOSAUR FOSSIL SITE ON ISLE OF SKYE

A coastal outcrop in northern Skye preserves numerous trackways of sauropod dinosaurs, in multiple stratigraphic layers, exposed upon bedding planes of Middle Jurassic lagoonal deposits. This is the largest known *in situ* dinosaur track locality in Scotland and the first record of sauropod tracks in the country. It documents the body size and locomotion of generations of sauropods during an interval in the Jurassic from which limited dinosaur fossils are found. It is therefore of international significance. Already within a Geological Conservation Review site, nationally important for Middle Jurassic stratigraphy, on the margin of an existing Site of Special Scientific Interest (SSSI), it is envisaged that the site will soon have full statutory protection.

Photo by Colin MacFadyen/Scottish Natural Heritage

