Earth heritage

The geological and landscape conservation magazine

Putting fossil forest treasures on display

Importance of South Downs geology

ISSUE 46
Autumn 2016

Spreading the word about geodiversity

Welsh geology's global significance

INSIDE

COVER - Scotland's most extensive dinosaur footprint and trackway locality, at Duntulm, northern Skye with its co-discoverers Steve Brusatte and Tom Challands of the University of Edinburgh. This rare find will shed light on a Middle Jurassic ecology that has global significance. Photo by Mark Wilkinson

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EDITORIAL

With enduring pressure on budgets, and with the great unknown of 'Brexit' ahead of us, it is more important than ever for everyone engaged in geoconservation and geodiversity to work together to keep our subjects at the forefront of agendas.

With this in mind, our packed *issue 46* ranges widely over many of the strands of work that make conserving Britain's geodiversity perenially worthwhile. There are articles on the importance of sites for scientific study; practical site management; site interpretation and promotion to the public; the use of geotourism to boost local economies; geology within education; building geoconservation issues into planning; and even a request for ideas on how best to limit damage to sites. The writers of these articles also illustrate the diversity of people and organisations active in our subject – national conservation agencies, geoparks, societies, academics and volunteers.

As ever, we want to hear your views and to learn of new projects. Please contact the most appropriate editor (below). For our next issue, Natural England's editorial board representative will be Sarah Henton De Angelis (Sarah.HentonDeAngelis@naturalengland.org.uk), who replaces Eleanor Brown, herself standing in for regular board member, Hannah Townley, who is on maternity leave.

Stewart Campbell, Managing Editor

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GA conference heads for Jurassic Coast

Broken ammonite among the toppled Portland stone at the base of the Southwell Landslip, near Church Ope Cove, Isle of Portland, Dorset. Photo by Jim Champion CC BA-SA 3.0

The Geologists' Association's 2016 annual conference will be held on the Jurassic Coast, in the Portland Heights Hotel, Isle of Portland on 21-22 October.

Celebrating 15 years since the inscription of the World Heritage Site, the conference will review and explore geological research on the Jurassic Coast. Triassic, Jurassic, Cretaceous, Quaternary and geomorphological interests will all be touched on as the meeting brings together the diverse geology that has created England's only natural World Heritage Site.

The conference will share the innovative approaches to linking geoscience, heritage and people that have been developed by the Jurassic Coast World Heritage Team. This will include the educational, volunteering, interpretation and arts programmes that have brought the communities and visitors of the Jurassic Coast closer to their geological heritage. Conference speakers include Professor Mike Benton (University of Bristol), Dr David Martill (University of Portsmouth), Professor Malcolm Hart (Plymouth University) and Professor Rory Mortimore (Chalkrock). Tim Badman (International Union for the Conservation of Nature) and Professor Denys Brunsden will bring a wider World Heritage perspective.

Field visits will provide the opportunity to see the spectacular Kimmeridgian Etches Collection (**www.theetchescollection.org**) in its new home, The Museum of Jurassic Marine Life, and recently conserved dinosaur footprints on the Isle of Purbeck.

More details are on the GA website **www.geologistsassociation.org.uk/conferences.html** and to make a booking please email: conference@geologistsassociation.org.uk. The conference will be organised and supported by the Geologists' Association, Jurassic Coast World Heritage Team, Natural England and the Dorset Geologists' Association Group. It is sponsored by Elsevier.

The Jurassic Coast is on an equal footing with the Grand Canyon and the Great Barrier Reef as one of 1,031 World Heritage Sites in 163 countries (as of June 2016). The Jurassic Coast was designated a World Heritage Site in 2001 because of its globally important geology, palaeontology and geomorphology. The wide variety of sedimentary rocks exposed in the cliffs between Exmouth, East Devon and Studland Bay, Dorset record 185 million years of environmental change throughout the Mesozoic Era. Fossils from these rocks provide a detailed insight into the evolution of life, and several individual locations along the Jurassic Coast are of global palaeontological importance.

Hutton Roof Crags, one of the sites to be considered at the *Caves and Karst* symposium. Photo by Colin Prosser, Natural England

Cave and karst conservation symposium

The fifth EuroSpeleo Congress, a week-long festival of British caving covering all aspects of caving, took place at the Dalesbridge Centre in the Yorkshire Dales, from 13-20 August 2016.

The Congress, which offered presentations, workshops, training events, field trips and guided cave visits, included the fourth EuroSpeleo Protection Symposium entitled *Caves and Karst – Protection and Conservation under EU Law* **http://tinyurl.com/gl8edte**.

This two-day symposium brought together cavers, cave and karst scientists and conservationists from all over Europe to discuss and explore issues around the development, application, appropriateness and effectiveness of cave and karst conservation legislation. The symposium aimed to share and learn from good practice in cave conservation across Europe. For more about the symposium, contact protection@eurospeleo.org.

Fossil shark find commemorated near discovery site

***Akmonistion*, the Bearsden Shark, with its unusual structure rising up from behind its head. Photo by J.K. Ingham**

**"O what a whack of a black of a sleek sweet cheeky tail in its big blue den
Of water! There were no bears then!" from *The Bearsden Shark* by Edwin Morgan (2010)**

330 million years in the making, and to become one of the best-known fossil sharks from Scotland, the Bearsden Shark was found by fossil collector, preparator and dealer, Stan Wood when he worked for the Hunterian at the University of Glasgow.

In 1981, Stan Wood, then of Baljaffray, Bearsden, on the north-western outskirts of Glasgow, was given some fossiliferous shales by local children. He recognised that these shales could throw light on the early development of vertebrate terrestrialisation, as well as holding a selection of beautifully preserved fossils. The fossils are so well preserved that not only are the sharks' last meals identifiable, but so are blood vessels and muscles in phosphatic mineralisation. So began, with the participation of The Hunterian, a small-scale excavation on the banks of the Manse Burn near Bearsden. By 1982, hundreds of fossil fish, many new to science, along with sharks and shrimps had been collected by Stan and his team. Amongst the discoveries was the Bearsden Shark. Stan spent many months carefully preparing the 70 cm-long shark from the encapsulating shales until the complete articulated shark was fully exposed.

When it was first examined, it was thought to be a complete example of *Cladodus* or *Stethacanthus*, but a later study by Mike Coates and Sandra Sequeira identified it as a new species, which they named *Akmonistion*. The name describes the strange, anvil-like structure immediately behind its head (akmon is anvil and istion is sail in Greek).

In December 2015, after much work by a local community group intent on celebrating the significant discovery made on its doorstep, a plaque was unveiled near to where the shark was found. The local 'shark group' accessed funding and help from a number of sources including Tarmac, which operates the nearby Douglasmuir Quarry. Help was also provided by Scottish Natural Heritage, East Dunbartonshire Council and Ranger Service and the Hunterian Museum. The plaque is on top of a small cairn by a bridge with railings that have the name Bearsden Shark bent into the baluster.

– Neil Clark, Curator of Palaeontology, Hunterian Museum

**Unveiling the plaque to the Bearsden Shark. From left, Amanda Stewart and Nan Lawless (shark group), Dr Neil Clark (Curator of Palaeontology at The Hunterian), Andrew Kent (designer from Bedrock Design Glasgow), Neil Buchanan (shark group), Stephen Cowan (Tarmac), Debbie Macrae (shark group) and East Dunbartonshire Provost Una Walker. Missing from the photo was East Dunbartonshire and Mugdock Country Park Ranger Alan McBride, also a shark group member.
Photo by Debbie Macrae**

Colin Prosser of Natural England is the new President of the Geologists' Association. Photo by Natural England

New President will re-emphasise GA's strong links with geoconservation

The election of Natural England's Colin Prosser as President of the Geologists' Association (GA) provides a wonderful opportunity to emphasise and reinforce the links between the GA and geoconservation.

The GA has had a longstanding involvement in geoconservation through the work of its local groups and affiliated societies, grants such as the Curry Fund, involvement in the editorial board of *Earth Heritage*, making representation on conservation matters through local groups and GA Council, and increasingly through publishing papers on geoconservation in the *Proceedings of the Geologists' Association* (*PGA*). In fact, geoconservation papers, including descriptions of Geological Conservation Review sites, are amongst the most cited papers in the *PGA*.

Colin hopes to use his term as President to emphasise the importance of geoconservation to geological science and education and highlight the role that the GA plays in conserving, managing, interpreting and promoting geological sites for the benefit of all.

This year already looks exciting. A GA field trip to Dudley to visit the Wren's Nest National Nature Reserve on its 60th birthday and to learn about the Black Country UNESCO Global Geopark bid has taken place. A GA presence is also arranged at the UNESCO Global Geoparks conference in the English Riviera UNESCO Global Geopark, Torquay, in September 2016. Last but not least for 2016, the GA Annual Conference, *The Jurassic Coast – Geoscience and education*, is scheduled for 21–22 October on the Isle of Portland (*see page 3*). It's also a good bet that geoconservation will feature in the annual presidential address in May 2017!

The GA is a major user of geological sites and has a vital role to play in making sure that the best such sites remain available for future generations to visit. The election of the first GA President employed in the conservation sector provides an opportunity to demonstrate the GA's pedigree, influence and importance in geoconservation in the UK.

– David Bridgland, Geologists' Association

View east along the line of Strontian Mines SSSI. This is the type locality for Strontianite from which the element strontium was first isolated. Photo by Colin MacFadyen Scottish Natural Heritage

Scientific justification for conserving top mineral localities nears publication

Scotland has 645 different types of mineral and 13% of the 5,000 mineral species currently known worldwide. Many of these occur in Scotland's network of mineralogical Geological Conservation Review sites which constitute the best and most representative mineralogical sites in the country.

Most of these sites have statutory protection as Sites of Special Scientific Interest. Scottish Natural Heritage is facilitating the production of the scientific justification for the country's network of mineralogical sites. Known as the *Mineralogy of Scotland Geological Conservation Review* volume, this work will be published in late 2016 or early 2017 in the *Proceedings of the Geologists' Association*. Former BGS geologist Graham Smith and National Museums Scotland mineralogist Alec Livingstone are finalising the volume, which will aid the conservation management of these nationally and internationally significant sites.

– Colin MacFadyen, Scottish Natural Heritage

Park Tunnel, Upper College Street, cuts through the Sherwood Sandstone. Photo by Don Cameron

Geraldine Marshall and Jenny Parry at the GA ice breaker in Ye Olde Trip to Jerusalem. The walls and ceiling are carved into the Sherwood Sandstone. The large clasts pick out the bedding plane. Photo by Ruth Siddall

GA delves into underground Nottingham for its annual meeting

The Geologists' Assocation (GA) annual meeting *Building our Future* at the British Geological Survey's Keyworth premises, on the theme of building stones (see *issue 44*), visited some of the famous caves in Nottingham, where 'buildings' were constructed leaving stone *in situ*.

The soft nature of the local Sherwood Sandstone made it perfect for the hand excavation of the caves, which were used for habitation, cellars, malting kilns, tanneries and air-raid shelters. It is thought that the sandstone extracted from the caves was also used for building, either as blocks or as sand, and there are substantial systems of sand mines. Six of the cave complexes, which comprise more than 400 caves in total, are scheduled as ancient monuments, including the Drury Hill Caves beneath the Broad Marsh Shopping Centre, now open to the public as the City of Caves. These formed part of the GA visit, under the guidance of Tony Waltham, whose detailed review of Nottingham caves can be consulted in the *Mercian Geologist* (1992, vol. 13, pp. 5–36; see also **http://tinyurl.com/juxtugn**). Also visited were caves with ornate supporting columns beneath the garden of the 18th Century Willoughby House.

Tony Waltham shows the loose sand which constantly trickles off of the walls in the brick-floored cave due to a draft from the outside world. Photo by Don Cameron

The conference had begun with an informal evening ice breaker in Ye Olde Trip to Jerusalem, England's oldest inn which is built into the caves – a good taster for the later field excursion. A more detailed report of the meeting will appear in GA Magazine (September 2016).

– Naomi Jordan and Diana Clements, Geologists' Association

Scotland's Geodiversity Charter continues to evolve

Scotland's Geodiversity Charter promotes geodiversity and how everyone can contribute to ensuring it benefits present and future generations.


Scotland's Geodiversity Charter
Update Summer 2016

UK-wide Geoconservation Annual Gathering, Edinburgh - Friday 28 October 2016
Local geosites for people and conservation

Geodiversity audit on a shoestring – just add local expert volunteers

Celebrating Hugh Miller

Some highlights of the activities that have taken place over the last year that have promoted, celebrated and helped conserve Scotland's world-class geodiversity, have been published in the Charter's Update Summer 2016 available at **tinyurl.com/hgyxukv**

Being a time-limited document, the business of revising the Charter will begin toward the end of 2016. The participation of existing and potential signatories will be sought and Scottish Ministerial support canvassed. Additional publications will be prepared to present the Charter to a range of audiences.

In autumn 2017, a planned conference will celebrate achievements to date, outline challenges ahead, and launch the refreshed Charter. To take part in developing the vision for Scotland's geodiversity contact the Scottish Geodiversity Forum.

– Colin MacFadyen, Scottish Natural Heritage

Why conserving South Downs geology is so important

Rory Mortimore

Hardly a day passes without a new observation being made on South Downs geology, whether it is a fossil that is new to the Chalk, or new to the South Downs, or a new sedimentary or tectonic structure. Such observations reinforce the need to maintain as many exposures as possible covering the complete stratigraphy of the 30 million years of Earth history locked into the Chalk.

Lateral variations in lithology (also reflected in chemical signals such as stable isotopes used to identify seawater temperature and climate cycles), the fluctuations in range, abundance levels and diversity of fossils all help us interpret past sea-levels, climate and ecological niches of the Cretaceous Chalk seas. The coastal cliffs from Eastbourne to Brighton provide the most complete slice through the geology of the South Downs and, to a large extent, provide the key sections around which the concepts for mapping formations and identification of marker beds evolved. For example, the cliffs of the Seven Sisters (*below*) illustrate the division of the Seaford Chalk Formation into three groups of beds (Mortimore, 1986) and illustrate the marker beds of flint used to correlate the Chalk across the entire Anglo-Paris Basin as well as through the South Downs to Winchester (Mortimore & Pomerol, 1987).

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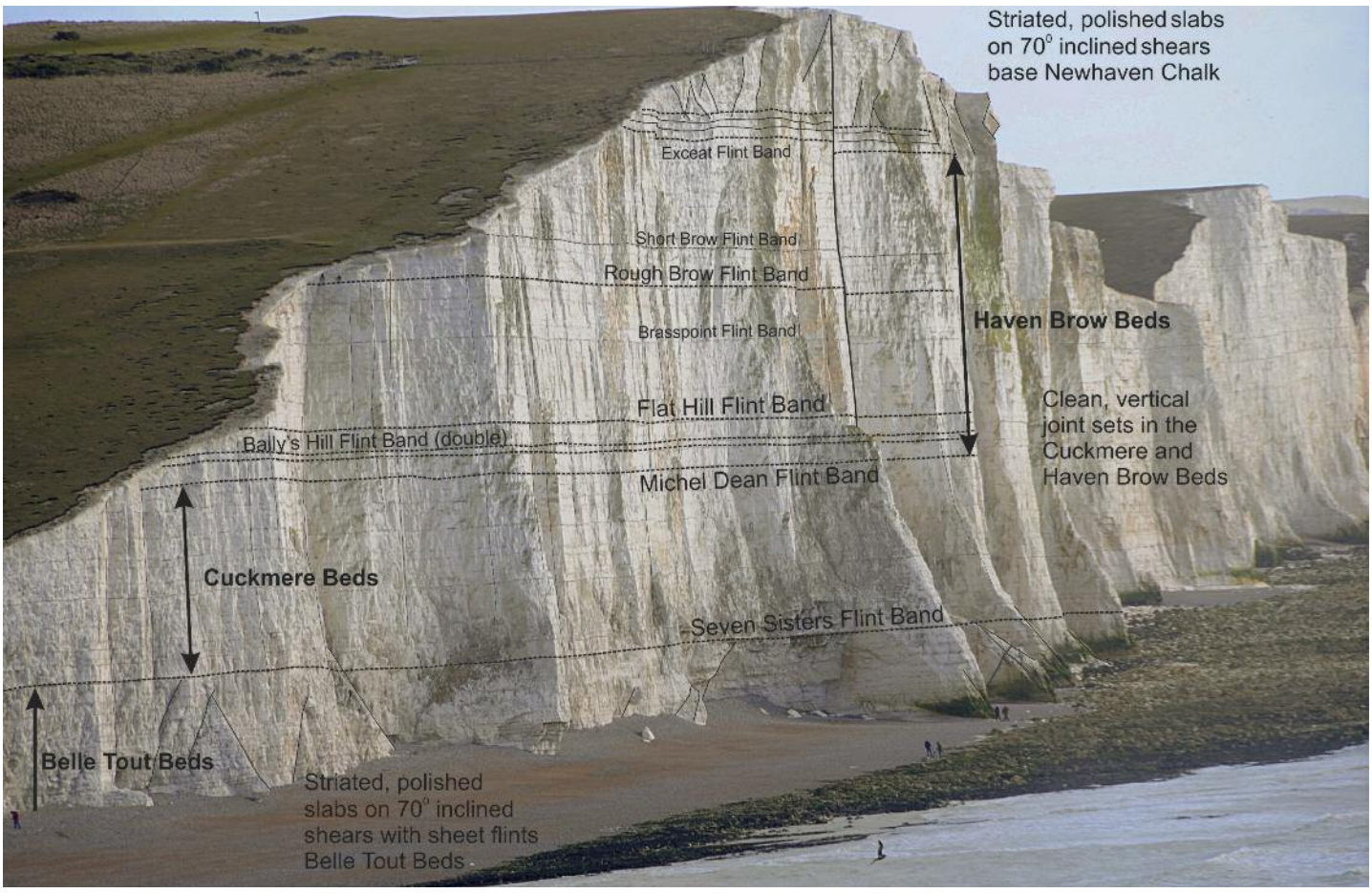
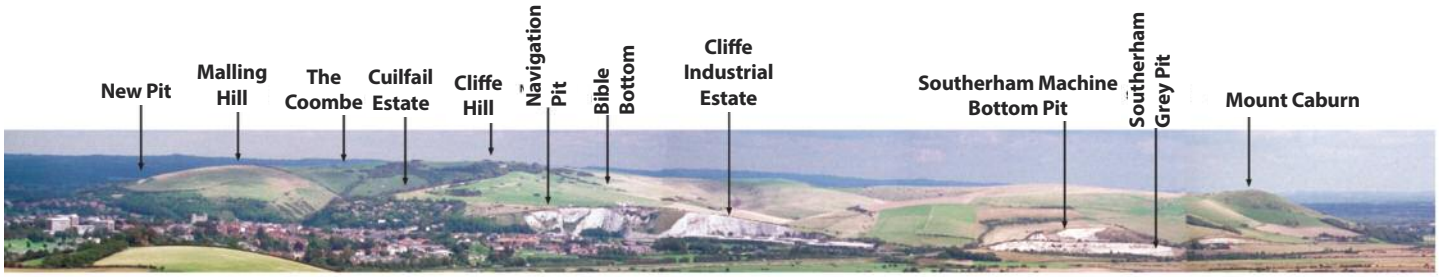


The coastal cliffs of the Seven Sisters at the eastern end of the South Downs provide a key 'type' section illustrating the Seaford Chalk Formation and its beds and marker beds (from Mortimore, 2014).



Looking east over Lewes to Mount Caburn from Kingston Ridge

The River Ouse valley quarry exposures at Lewes, Sussex, showing some of the key marker beds and a tectonic fold typical of the South Downs (from Mortimore *in prep*.)

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The Seven Sisters Flint Band, associated with the same fossils found at Cuckmere Haven, is present in the River Ouse valley, in former quarry faces at Lewes. This flint band and the marker marl seams identified in the photograph pick out the shape of a tectonic fold, the Caburn Syncline with its complementary Kingston Anticline to the South. Many such folds are present in the South Downs. In general, the Chalk beds dip southwards away from the central Weald towards the English Channel. This dip direction, combined with changes in the lithological types of Chalk, creates a series of escarpments and dip slopes imparting a special character to the South Downs landscape. Each Chalk formation produces a unique shape to the ground (*e.g.* below) and this makes it possible to map the formations throughout the chalk-lands of southern England (Bristow *et al*., 1997).

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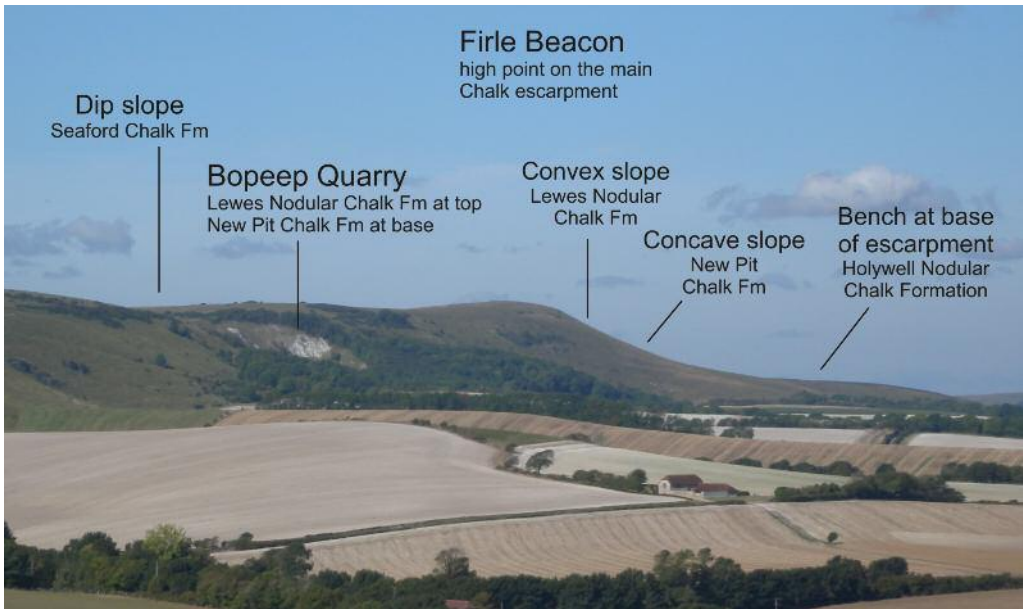

A view of the South Downs main escarpment from Wilmington near Lewes. Each Chalk formation produces its own shape and a different type of field brash when ploughed (from Mortimore *in prep*.).

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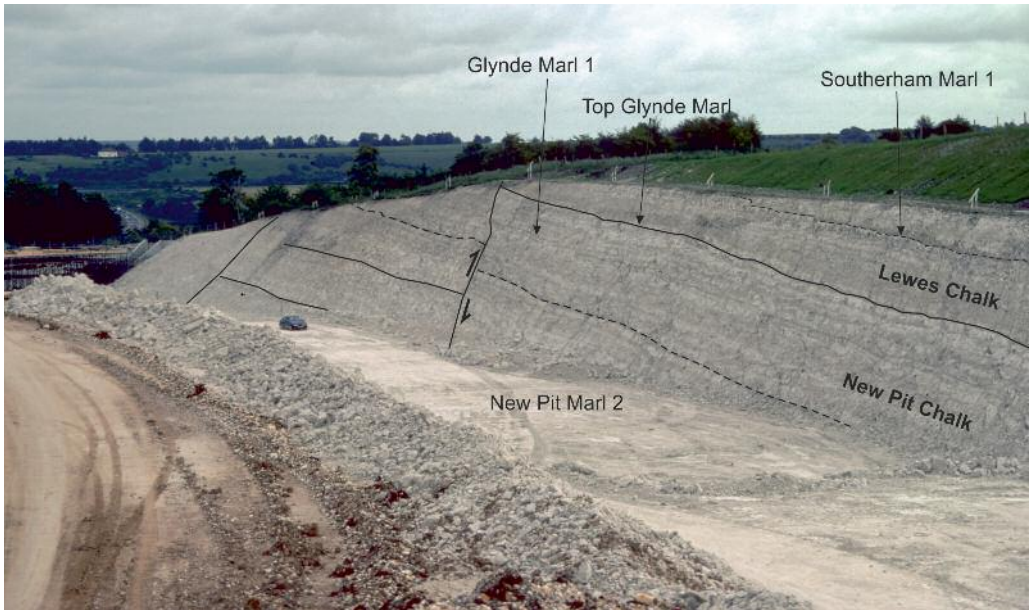
New engineering works such as the M3 motorway cuttings at Twyford Down, Winchester (below), offer a unique insight into South Downs geology, making it possible to correlate beds and determine lateral changes as well as yielding unique structures such as the way the Chalk has weathered to produce beds of calcrete and cave systems. The M3 Spitfire Bridge Cuttings exposed the Seven Sisters Flint Band and all the same flints and fossils shown in the Seven Sisters cliffs.



M3 Twyford Down cutting looking north over the low ground along the east-west Winchester Anticline. The M3 cuttings here and at Spitfire Bridge to the north made it possible to identify formations and marker beds in the Chalk at the western end of the South Downs that were first recognised in the Downs around Lewes. (Modified from Mortimore, 2014)

A difference compared to East Sussex is the presence of major hard, mineralised beds at the boundary between the Lewes and Seaford Chalk formations (the Bar End Hardgrounds). The M3 Twyford Down Cuttings as well as exposing the key marker marl seams and flint bands through the entire Lewes Nodular Chalk Formation also illustrated the increase in numbers of flint bands in the upper part of the New Pit Chalk Formation. Having time to record the details of the geology from such new exposures is essential to advancing our knowledge of the Chalk and the South Downs. Leaving and conserving such exposures in an area where there are very few chalk pits or other exposures is vital for future studies.

Old and abandoned quarries are as important as any new exposure. Each year new scientific techniques allow more refined analyses of the chemistry, and improved palaeontology provides further insights into the impact of environmental change on the geodiversity of the Chalk seas. Old Chalk pits that expose different parts of the Chalk succession need to be revisited and sampled to apply or develop these new techniques and new ideas. Conserving such sites in the South Downs National Park and making them accessible to research and visiting geologists is essential. A key part of such work is local site recording and site management. In the South Downs we are lucky to have such a record maintained at the Sussex Wildlife Trust at Woods Mill managed by Henri Brocklebank and the Sussex Geodiversity Group. Records of all the geological SSSI and RIGS as well as any other exposure of interest are kept and maintained here.

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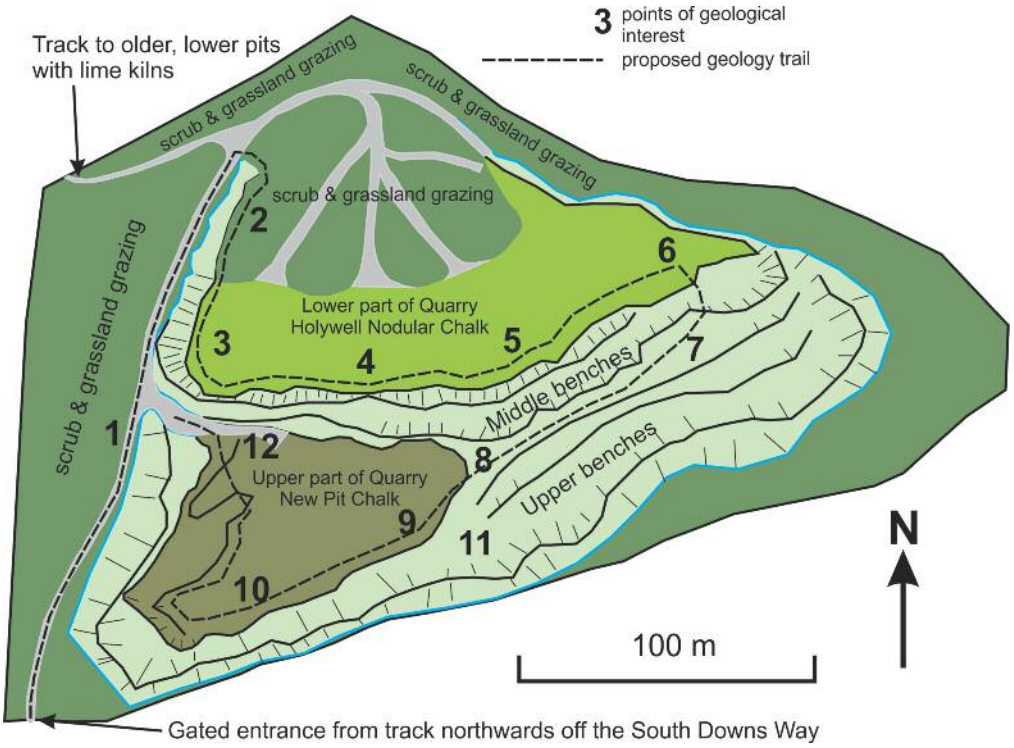
An example of an abandoned Chalk pit that the South Downs Rangers and the landowner are keen to make more accessible to geologists is Cocking Pit, north of Chichester. The site is a rare exposure at the boundary between the Holywell Nodular Chalk and New Pit Chalk formations. This is a key interval illustrating major changes in Chalk Sea oceanography and ecology with the change from mytiloid-dominated bivalve assemblages below to brachiopod and inoceramid bivalve-dominated assemblages above. Much more research is required to understand fully this interval of Cretaceous time and Cocking Pit will be important in these studies.



This map of Cocking Pit shows the layout of a proposed geological trail that will enable detailed study of the various points of interest.

Further reading

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Skye's extraordinary dinosaur discoveries

Stephen Brusatte, University of Edinburgh

It was a typical April day on the Isle of Skye – cold and windy, with occasional splashes of sun breaking through the low clouds, a lingering mist. And there was gorgeous scenery – rocky cliffs, breaking waves, green rolling hills – stretching before me in all directions.

I was walking along the beach on the far northern tip of the island, in the shadow of the ruins of the 14th Century Duntulm Castle, my eyes peeled to the ground. This was no sightseeing trip. I was on the hunt for fossils. A geologist friend had worked near Duntulm many decades ago and found the small jawbone of a Jurassic-aged crocodile, so my team and I caught the scent and set out to see what we could find.

For several hours we scoured the beach, on our hands and knees, picking up the tiny fossilised bones and teeth of prehistoric fish. That's all we were finding, much to my dismay. I'm a vertebrate palaeontologist who specialises in dinosaurs, birds, and crocodiles. Those were the fossils I so desperately wanted to collect, to take back to study in my lab at the University of Edinburgh.

But while I was shivering and cursing my luck, my Edinburgh colleague Tom Challands was grinning through his thick ginger beard. Tom studies fossil fish, and to him each fossil was a piece of treasure.

By the time the sun began to set and the tide started to come in, we had collected bags and bags of fishy bits. Enough was enough. My stomach was growling and it was getting colder, so I decided to call it a day. We packed up our gear and set back to the cars, my students racing ahead in anticipation of the pasta dinner that my Italian PhD student Davide Foffa was set to cook.

As Tom and I followed, chatting about the day's work and our plans for tomorrow, we both suddenly stopped. There was something weird in front of us: a large hole in the rock, about the size of a car tyre, filled with water from the previous high tide. We had been so focused on the miniscule fish fossils that we hadn't even noticed this huge divot right in the middle of the coastal rock platform.

Steve Brusatte (left) with dinosaur track finds and colleague Tom Challands. Photo by Mark Wilkinson

Tom and I looked at each other with puzzled expressions. It didn't sit right… you normally don't see deep holes in solid rock, particularly this concrete-hard lagoonal limestone.

And then we noticed another depression, and another, and another – arranged in a zig-zag sequence, left-right, left-right, left-right. All were consistent in size and shape.

It took only seconds before it dawned on Tom and me that we had seen similar things elsewhere in the world, but never in Scotland. These were dinosaur tracks.

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We had found many trackways woven together, made up of both handprints and footprints. They were left by colossal sauropods: the familiar long-necked, pot-bellied, plant-eaters of the *Brontosaurus* and *Diplodocus* mould. Their ancient Scottish cousins had left hundreds of prints at the Duntulm beach, some 170 million years ago during the middle part of the Jurassic Period, when Scotland was much warmer and this area was a shallow lagoon.

A scene from the Middle Jurassic with foraging sauropods. Illustration by Jon Hoad

Imagine the scene: a herd of 15-metre-long, 20-tonne dinosaurs, wading through shallow water, each one three times the size of an elephant, splashing along, munching on seaweed, and keeping their eyes peeled to the dry land in the distance, where sharp-toothed cousins of *T. rex* lurked.

Largest dinosaur site in Scotland

What Tom and I found that April day in 2015 turned out to be the largest dinosaur site discovered in Scotland. It also happened to be one of the few dinosaur footprint sites from the Middle Jurassic known from anywhere in the world, and some of the best evidence that sauropod dinosaurs frolicked in the water. We're used to thinking of these behemoths as purely land dwellers, which shook the ground with each step. But the Duntulm trackway shows that they also spent time in lagoons.

In December 2015 we described the tracksite in a paper in the *Scottish Journal of Geology*. The popular media took note, with all of the major British daily newspapers publishing articles, the BBC featuring it on its evening newscast, and even National Public Radio in the USA treating it as one of the lead stories of the day. Journalists couldn't get enough of the so-called 'dinosaur disco', the remarkable record of some of the planet's biggest-ever animals going about their daily business in ancient Scotland.

Discovering the Duntulm tracksite with Tom is one of the highlights of my career. But it is merely the latest discovery on the Isle of Skye, which has recently emerged as one of the most important places globally for preserving fossils from the Middle Jurassic. This time interval, from about 175-165 million years ago, is one of the most poorly known swaths of geological history. There just aren't many fossils from that time. But Skye is special: it was a hotbed of dinosaur life during the Middle Jurassic, and it was criss-crossed by so many rivers and lakes that there were plenty of places to preserve fossils.

Amazingly, the first dinosaur fossils from Skye were described in the 1980s. More keep coming every year, and the bountiful potential of Skye is one of the main reasons that my colleagues and I founded the PalAlba group, a consortium of Scottish researchers who have banded together to recover, record, and research vertebrate fossils from our home country. But we're only scratching the surface. People have been searching for dinosaurs in England and western North America for over 200 years now. Just imagine what remains to be found on Skye!

Below, a dinosaur track crosses the intertidal platform at Duntulm, Skye, evidenced by a series of footprint traces. The footprints appear in relief, most likely because they were filled with another harder sediment that has been eroded more slowly than the surrounding rock. Photo by Tom Challands

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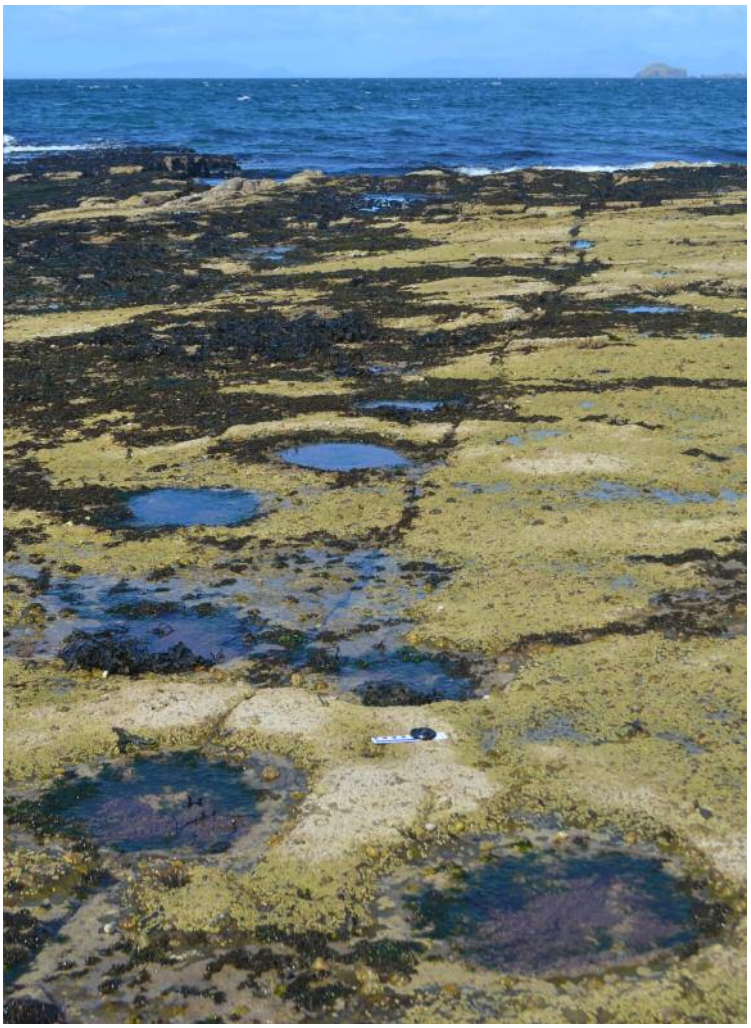
Conservation challenge

One of our biggest challenges is conservation. Because of our busy academic schedules of teaching and grant writing and other fun bureaucracy, we can only visit Skye a few weeks a year. We work closely with Dugald Ross, a Skye native who founded and operates the amazing Staffin Museum, but Dugie has a day job and can't be out constantly collecting. There are some great amateur and avocational collectors who frequent Skye and ethically collect following the Scottish Fossil Code, and it is instrumental that we continue to foster relationships with this community, and give them the support and guidance they need. This activity augments the effort led by Scottish Natural Heritage to stimulate voluntary effort to help conserve Skye's fossils (see *issue 44* of *Earth Heritage*).

As I write this article I'm getting excited... in just a few days Tom and I are heading back to Skye, students in tow, to meet up with Dugie and start collecting again – of course with the necessary consents as per the Scottish Fossil Code, and having agreed that any specimens we find be accessioned into the collections of the Staffin Museum or National Museums Scotland in Edinburgh. Who knows what we'll end up finding – more dinosaur footprints, or perhaps bones this time? Or maybe we'll find fossils of some of the incredible creatures that lived alongside the dinosaurs: our mouse-sized furry mammal ancestors, dog-sized crocodiles, tiny lizards and frogs, and yes, even fish…



Sauropod footprints form a trackway across the intertidal platform at Duntulm. Photo by Tom Challands

Colin MacFadyen of Scottish Natural Heritage comments:
These discoveries demonstrate superbly that despite the wealth of data already found in our classic localities, there is always something new to be discovered and researched. This underscores the importance and value of the system of Sites of Special Scientific Interest to the continuation and development of geological science.

Steve Brusatte is in the School of GeoSciences at the University of Edinburgh. He specialises in the anatomy, genealogy and evolution of dinosaurs and other fossil vertebrates. He has written nearly 100 peer-reviewed papers, five books (including the leading textbook *Dinosaur Paleobiology*), and has named more than 15 new species of fossil vertebrates. He is the 'resident palaeontologist' for the BBC's *Walking With Dinosaurs* programme, appears often on television and radio (including as a presenter for National Geographic Channel's *T. rex Autopsy*), and is writing a popular science book for adults called *The Rise and Fall of the Dinosaurs*. Information on his research and his lab in Edinburgh can be found at tinyurl.com/glxuw79/. Information on the PalAlba research group can be found at tinyurl.com/h7muouh.

Field trip signals global importance of Wales

Raymond Roberts, Natural Resources Wales

Members of the International Geoscience Programme (IGCP) converged on south-west Wales, the cradle of Lower Palaeozoic science research, for a field meeting following the closure of their IGCP Project 591 conference in Ghent, Belgium.

Project 591 sits within one of the IGCP's main themes, **Global change and evolution of life: evidence from the geological record**. It was set up to bring together the research community to look at the early Ordovician to early Devonian interval which contains several of the most significant palaeoclimatic and palaeobiological events in Earth history.

The IGCP is a joint UNESCO project with the International Union of Geological Sciences (IUGS) to bring together researchers from different disciplines and countries. Its other themes comprise:

- **Geohazards: mitigating the risks**
- **Hydrogeology: geoscience of the water cycle**
- **Earth resources: sustaining our society**
- **Geodynamic control of our environment**

The field trip confirmed the importance of Wales' geological heritage at an international level. Delegates from China, Japan, Brazil, Canada, USA, Russia and Europe attended the post-conference field trip to study rocks of Cambrian, Ordovician, Silurian and Devonian ages (spanning nearly 200 million years). Focussed on the rocks of the Welsh Basin, delegates made forays to a range of Geological Conservation Review (GCR) sites and RIGS, including Caerfai Bay, Marloes Sands, Freshwater West and Llangrannog.

All sites visited during the field trip highlight the importance of Wales' geodiversity as an international scientific research and teaching resource. It also allowed key workers engaged in Palaeozoic research to share knowledge with geologists from Natural Resources Wales.

The Three Chimneys at Marloes GCR site form a prominent landmark some 50 m from the top of the Skomer Volcanic Group. There is a long history of study of the classic exposures at Marloes Sands, beginning with Murchison in 1839.

At the New Quay RIGS Jerry Davies explains how rocks of the Llandovery Series formed in deeper parts of the Welsh Basin.

Keith Nicholls of NEWRIGS guided a field trip group around his PhD area between Ynys Lochtyn and Llangrannog. Keith has found impressive trace fossils in this RIGS, which may also warrant GCR status in parts. Photos by Raymond Roberts/ Natural Resources Wales

HAVE YOUR SAY!
How do we control damage to vital sites?

Colin MacFadyen, Scottish Natural Heritage

***Issue 45* of *Earth Heritage* chronicled the severe consequences to geology of setting fire to three wheelie bins against the internationally significant Agassiz Rock in Edinburgh. Although an act of vandalism, it's fairly certain that the firesetters did not set out with the intention of destroying the last visible evidence of ice movement demonstrated at the Agassiz Rock Site of Special Scientific Interest (SSSI).**

What is rather more concerning is damage to a classic site that is a deliberate consequence of hammering by geologists – in flagrant disregard of well-established and widely disseminated codes of conduct. A recent case is provided at Hutton's Unconformity in North Newton Shore SSSI on Arran. This internationally significant exposure was hammered, sometime in early March 2016, and several kilos of rock excavated, evidenced by the quantity of debris around the rock face and in the nearby stream.

It is generally accepted that a measure of responsible hammering may be required to reveal a fresh surface for examination in field situations. Rock sampling is essential for research. However, hammering at a classic site to dislodge several kilos of rock without the necessary consent to remove material for scientific purposes constitutes reckless damage. Is this an isolated incident? One would hope so. However it does suggest that some quarters of the geological community have yet to heed the message about responsible use of sites.

Hutton's Unconformity, within North Newton Shore Site of Special Scientific Interest, is heavily used by student groups and an increasing number of geotourists. Is its gradual diminution acceptable or do we act? If the latter then what ought to be done?
Photo by Colin MacFadyen, Scottish Natural Heritage

Codes of conduct rely on goodwill and trust, so what approach can be taken to ensure our geoheritage, particularly at classic sites, is protected from the activities of some users? Is the removal of 10 kilos of rock on an occasional basis every five or so years something that is sustainable and we just have to live with accepting the inevitable diminution of a scientific, educational and tourism resource? After the Arran incident, some within the geological community have suggested a blanket ban on hammering in SSSI. Others would like Scottish Natural Heritage actively to employ special provisions for dealing with instances of reckless damage under the Nature Conservation (Scotland) Act 2004. However, a majority consider that these routes may be counter-productive, particularly prosecution, only drawing unwanted wider attention to bad practice within the geological community. Instead it has been suggested that there is continued promotion of the codes and the acceptance of almost inevitable, but infrequent, damage with bans and prosecution utilised only when absolutely necessary. It begs the question: has that point has been reached when considering Hutton's Unconformity on Arran?

Opinions and ideas welcome. Write to me at Colin.Macfadyen@snh.gov.uk

Checking and managing Scotland's geo-heritage

Rachel Wignall, Scottish Natural Heritage

Since 1998 Scottish Natural Heritage (SNH) has monitored the condition of geological and geomorphological features in Scotland's Sites of Special Scientific Interest (SSSI). These 'notified features' are underpinned by the Geological Conservation Review which identifies and records sites with geology or geomorphology of national or international importance. As of April 2016 there were 653 notified Earth Science features in Scotland's SSSI, and around a dozen more will be added this year under our rolling programme of noting and describing additional features within existing SSSI.

Site Condition Monitoring (SCM) of protected sites in Britain runs on a six-year cycle. While it monitors features on SSSI, Special Areas of Conservation, Special Protection Areas, and RAMSAR internationally important wetland sites, only SSSI contain geological or geomorphological features.

In Scotland, SCM Cycle 1, started in 1998, aimed to monitor all features in protected areas, and the majority of SSSI geo-features were indeed monitored. The following SCM cycles have aimed to monitor a set proportion of protected features. Features not due for 'full SCM' monitoring now undergo a more rapid Site Check. Cycle 3 is due for completion by April 2018.

Volunteers start clearing gorse from outcrops of Dinantian sandstones at Kinnesswood GCR site, Bishop Hill SSSI in the Lomond Hills, Fife.
Photo by Rachel Wignall, Scottish Natural Heritage

The programme shows that currently 98% of Earth Science features in Scotland are in favourable condition or recovering to favourable condition due to management intervention. Data on the condition of all notified features in Scotland are now available through 'Scotland's environment' website (**http://tinyurl.com/njkuhtv**). This site also lists factors having a negative impact on features (referred to as 'pressures'), and a summary of change between 2010 and 2015. The database is searchable by site and feature type, and for areas such as National Parks and Local Authority Areas. For example, in Aberdeenshire, between 2010 and 2015, the condition of four geo-features improved, the condition of three geo-features declined, and the condition of 33 geo-features remained unchanged. There are no comparison data for six features because they were monitored for the first time during this period.

In the last six years, SNH has applied management interventions or 'remedies' at over 20 sites where the geo-feature has been assessed as being in unfavourable condition. The most commonly required action is tree or scrub clearance, but there has also been graffiti removal, management to reduce dune erosion, measures to prevent dumping and clear dumped material (including six vegetation-covered vehicles at one site!). Remedial action will continue alongside the SCM programme.

Re-exposing the Carboniferous of Northern England

John Knight, Yorkshire Geological Society
Jonathan Larwood, Natural England

A successful collaboration between the Yorkshire Geological Society and Natural England has led to the re-exposure of some of the classic Carboniferous strata of Northern England.

In October 2015, the Yorkshire Geological Society (YGS) co-ordinated a visit to a series of key Carboniferous sites by a group of international geologists, members of the Subcommission for Carboniferous Stratigraphy (SCCS) of the International Union of Geological Sciences. They visited reference sections (all Sites of Special Scientific Interest [SSSI]) across the region. However, before the visits extensive preparatory work was necessary.

Preparation for the visit

To ensure key geological characteristics could be reached safely, demonstrated and inspected, and to make key horizons accessible, significant clean-up work was carried out on some sites in advance of the international party visit. In all cases checks were made on permission for sample collecting.

For the SCCS to be a success some careful planning and preparation were needed. As the planned site visits were to SSSI, the YGS worked closely with Natural England and site owners to agreed advance conservation work. The YGS followed steps that could be valuable to anyone planning similar visits.

1. Locating the SSSIs: The MAGIC map system (Multi-Agency Geographic Information for the Countryside) **http://magic.defra.gov.uk/MagicMap.aspx** provided boundaries for all SSSI and helped locate the relevant SSSI for each of the Carboniferous sections. MAGIC also carries information about why each SSSI is important, a summary of recent site visits, and contact details for the relevant Natural England member of staff.

2. Visiting SSSI: With the help of Natural England, each site owner was contacted. Visits were made to assess what conservation work was required in advance of the international visit.

3. Getting permission: Having agreed the work required to improve the sections, Natural England was able to provide formal consent to SSSI owners for clearance work and sampling by the visiting party.

4. Clearing the sites: A site clearance and preparation programme was organised over June-September 2015. More than 20 volunteers from YGS and associated local geological societies took part. Activities included vegetation clearing, lopping branches, digging out silted sections, inspecting geological sections and marking up of key reference levels. Care was taken to avoid upland-bird nesting periods and to ensure cleared vegetation didn't hinder stream flows. Enthusiastic interest by, and cups of tea from, site owners featured at a number of the sites - and they are gratefully thanked!

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Flattened goniatite *Cancelloceras cancellatum* (Bisat) from the Orchard Farm section, Staffordshire, one of the sites visited.
Photo by Patrick Cossey

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A future strategy for work on Carboniferous stratotypes

The advance site work ensured that the international party had a unique opportunity to review important aspects of the Carboniferous geology of Northern England, and to mark the work, YGS organised a symposium in March 2016, at the British Geological Survey in Keyworth. Presentations included some preliminary results of the sampling programme, and also focussed on revised interpretation of some of the successions in the light of modern techniques. These highlighted both shortcomings and positive features of sections as points of international reference. Many of the sections under discussion offered important information to link with research programmes being undertaken elsewhere in the world.

As a reflection of the continuing international interest in these sections, the YGS has willingly agreed to continue to work with Natural England and is exploring how it can help document and maintain these newly cleared sections as well as other geological SSSIs. Plans are already afoot to return to Northern England with the International Congress on Carboniferous and Permian Stratigraphy in 2019.

The international party visits the Asbian stratotype, Little Asby Scar, Kirkby Stephen, Cumbria. Photo by John Knight

Further reading

Cleal, C.J. & Thomas, B.A. (1996). *British Upper Carboniferous Stratigraphy*. Geological Conservation Review Series, No. 11, Joint Nature Conservation Committee, Peterborough.

Cossey, P.J. *et al.* (2004). *British Lower Carboniferous Stratigraphy*. Geological Conservation Review Series, No. 29, Joint Nature Conservation Committee, Peterborough.

Waters, C.N. *et al.* (2011). *A Revised Correlation of Carboniferous Rocks in the British Isles*. Geological Society of London, Special Report, 26.

Geological background

Northern England is a classic area for the study of Carboniferous rocks (359-299 million years old). In part this reflects the ground-breaking research carried out between 1910 and 1980 on Carboniferous stratigraphy and the evolution of key fossil groups. The evolution of these groups defines the time stages that the Carboniferous Period is divided into. Each stage and sub-stage is represented by a physical stratotype, a definitive reference section.

The table shows the stages and sub-stages employed in Western Europe, reveals 15 stratotypes represented in the British Isles, 13 in Northern England. The international group visited eight of these, highlighted in red.

SYSTEM & SUBSYSTEMS		GLOBAL STAGES	WEST EUROPEAN STRATIGRAPHY		
			STAGES	SUB-STAGES	STRATOTYPES
CARBONIFEROUS	Pennsylvanian Subsystem	Gzhelian	Stephanian	Not represented in Northern England	
		Kasimovian			
		Moscovian	Westphalian	Asturian	No formal stratotype; to be designated in N. Spain
				Bolsovian	River Doe Lea, Bolsover, N. Derbyshire
				Duckmantian	Disused railway cutting, Duckmanton, N. Derbyshire
				Langsettian	River Little Don, Langsett, South Yorkshire
		Bashkirian	Namurian	Yeadonian	**Orchard Common stream section, Flash, Staffordshire**
				Marsdenian	**Park Clough, Hey Green, Marsden, W. Yorkshire**
				Kinderscoutian	**River Darwen section, Samlesbury Bottoms, Lancs**
				Alportian	**Blake Brook, Leek Moors SSSI, Warslow, Staffordshire**
				Chokierian	**Stonehead Beck, near Cowling, North Yorkshire**
	Mississippian Subsystem	Serpukhovian		Arnsbergian	Stony River, Slieve Anierin, Co. Leitrim, Eire
				Pendleian	**Light Clough, near Clitheroe, Lancashire**
				Brigantian	**River Eden at Janny Wood SSSI, Kirkby Stephen, Cumbria**
		Visean	Visean	Asbian	**Little Asby Scar, near Ravenstonedale, Cumbria**
				Holkerian	Barker Scar, Holker Hall, Cumbria
				Arundian	Hobbyhorse Bay, Dyfed, South Wales
				Chadian	Chatburn by-pass road section, Clitheroe, Lancashire
		Tournaisian	Tournaisian	Ivorian	Yvoir Railway Station section, near Dinant, southern Belgium
				Hastarian	Near Hastière-Lavaux Church, near Dinant, southern Belgium

30 years of funding Earth science projects

Susan Brown, Geologists' Association Curry Fund

2016 marks the 30th anniversary of the Geologists' Association's Curry Fund. Through grants and interest-free loans the Fund has supported a huge range of Earth science projects that may otherwise never have been financed.

Over those three decades, Curry Fund grants have helped introduce many young people to geology and learn about its importance to the world. Projects have included geology festivals, displays, talks and other activities highlighting all aspects of geology.

For instance, the Methodist College in Belfast and Foyle College in Londonderry both received grants for fossil moulds and plaster of Paris for student use in colleges and at family fun days staged in museums and shopping centres. Fermanagh County received £4,535.58 for a field guide and allied resources for A-level students explaining the geology of the Marble Arch Geopark area. This was distributed free to schools and colleges teaching A-level geology in Northern Ireland and the Republic. Earth Science Ireland received a grant of £2,350 for a comprehensive Earth Science resources pack covering the Northern Ireland primary school curriculum, for free distribution to all primary schools in Northern Ireland.

Using the resources provided by the Curry Fund to the Methodist College in Belfast. Photo by Curry Fund

Many local geology groups, Geology Trusts, RIGS groups and Festivals of Geology have been awarded grants for family-focused events that encourage children, their parents and the wider public to try a range of geo-activities, hands-on things to make and do, talks, lectures and geological walks to enjoy with a local geologist. They are usually free, very lively and welcoming events. Many similar groups have had grants to cover static displays such as geological walls and gardens, as at St Andrew's University, the University of Worcester and Stevenage Museum. Then there are play areas like the Rock Circus at Box in Wiltshire and the stratigraphic column at High Lodge in Thetford Forest that explains the Breckland landscape through geology and art (a project conceived after consultation with children and adults) and the collection of trees planted in Suffolk to illustrate a typical Pliocene Forest.

Rockwatch student conference

Rockwatch, the junior club of the Geologists' Association, received a Curry Fund grant towards its first student conference, for Y8 and Y9 students from schools in London. The conference helped expose students to aspects of geology before they chose which GCSE subjects to study. Dudley Metropolitan Borough Council received a grant for a Wren's Nest National Nature Reserve geological trail guide. The guide was developed and written by children from the Bramford Primary School Wildlife After-School Club. This was a marvellous example of how creative and responsive to local needs young children can be.

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Museums, universities and visitor centres have also benefitted widely from Curry Fund grants. Grants have been awarded for a new display case for the Barrington Hippopotamus skeleton at the Sedgwick Museum; display boards and fossil collection at Beaminster Museum; a Plesiosaur set in a lit display case in the floor in the Somerset County Museum; a Hertfordshire Pudding Stone display at Hertford Museum; and conservation of fossils in Peterborough, Bristol, Dorchester, Birmingham and Leicester museums. A grant was awarded to At-Bristol Museum to broaden the scope of what it offered to pre-booked school parties and visiting children and their parents out of school time. The Charmouth Heritage Coast Centre in Dorset has had a number of grants including one for microscopes for visitor use, one for fossil-display cabinets and another for an interactive display board.

Cardiff University had a grant to help support the development of the National Botanic Garden of Wales. Oxford University was awarded a grant towards its display 'Fast and Furious: witnessing the birth of Africa's new ocean' at the Royal Society's 350th anniversary summer exhibition which attracts many school groups and their teachers. The University of Plymouth received a grant to help with a research student conference. Leeds University got a grant towards a 3D Earth Science library. This is a new, free, education and outreach initiative from the School of Earth and Environment at Leeds and it is hoped that it will also encourage public engagement in the Earth sciences.

Bramford schoolchildren celebrate publication of their guide to Wren's Nest NNR geology with (back row) teacher Mark Sergison, Wren's Nest Warden Anna Gorski, Dudley Mayor David Stanley and Curry Fund Secretary Susan Brown. Photo by Dudley MBC

Miller's spirit lives on in writing competition

Lara Reid, freelance Geoscience writer

"You touched the cold enamel scales of *Osteolepis macrolepidotus*, cracked open from its sea-washed nodule. A story opened, a page in an ancient book, a folktale whispered from the rocks. You: part sennachie, part religious scientist. May be it is not only the Earth that holds deep time and folded complexities but also ourselves."
From *Learn to make a right use of your eyes* by Jane Verburg; first prize in prose, The Hugh Miller Writing Competition 2015-2016.

Winners and judges from the Hugh Miller Writing Competition outside Hugh Miller's Cottage in Cromarty. Left to right: competition judge Simon Cuthbert, under-16 poetry winner MacKenzie Robbie, prose winner Jane Verburg, third prize poetry Michael Davenport, organiser and chair of judging panel Lara Reid, third prize prose Jim Gilchrist, first prize poetry Justin Sales, highly commended poetry Elizabeth Pickett, competition judge Kenny Taylor and third prize poetry Jim Mackintosh. Photo by Ian Rhind

The legacy left by Hugh Miller (1802-1856), self-taught pioneering Scottish geologist, folklorist and social campaigner, has been boosted in recent years following the success of several projects, the most recent being the first ever Hugh Miller Writing Competition.

The competition, which concluded in March 2016, invited prose and poetry entries inspired by the landscape and geological writings of Miller, with the aim of encouraging a wider appreciation of both Miller's work and the wonderful diversity in Scotland's geological heritage.

The idea for the competition stemmed from a conversation I had with Angus Miller of the Scottish Geodiversity Forum. Angus had already suggested the idea of a writing competition to boost interest in Scottish geology. He had spent time on Arran reading Hugh Miller's Cruise of the Betsey for the first time and was struck by Miller's unique use of language, his delightful metaphors and the simple beauty of his writing. Angus and I decided to run a writing competition with Miller as the inspiration behind it.

Over the next few weeks, we worked to secure project partners, including The Friends of Hugh Miller, Our Dynamic Earth, Lochaber Geopark, Scottish Centre for Geopoetics, St Andrews University Geobus and Edinburgh Geological Society.

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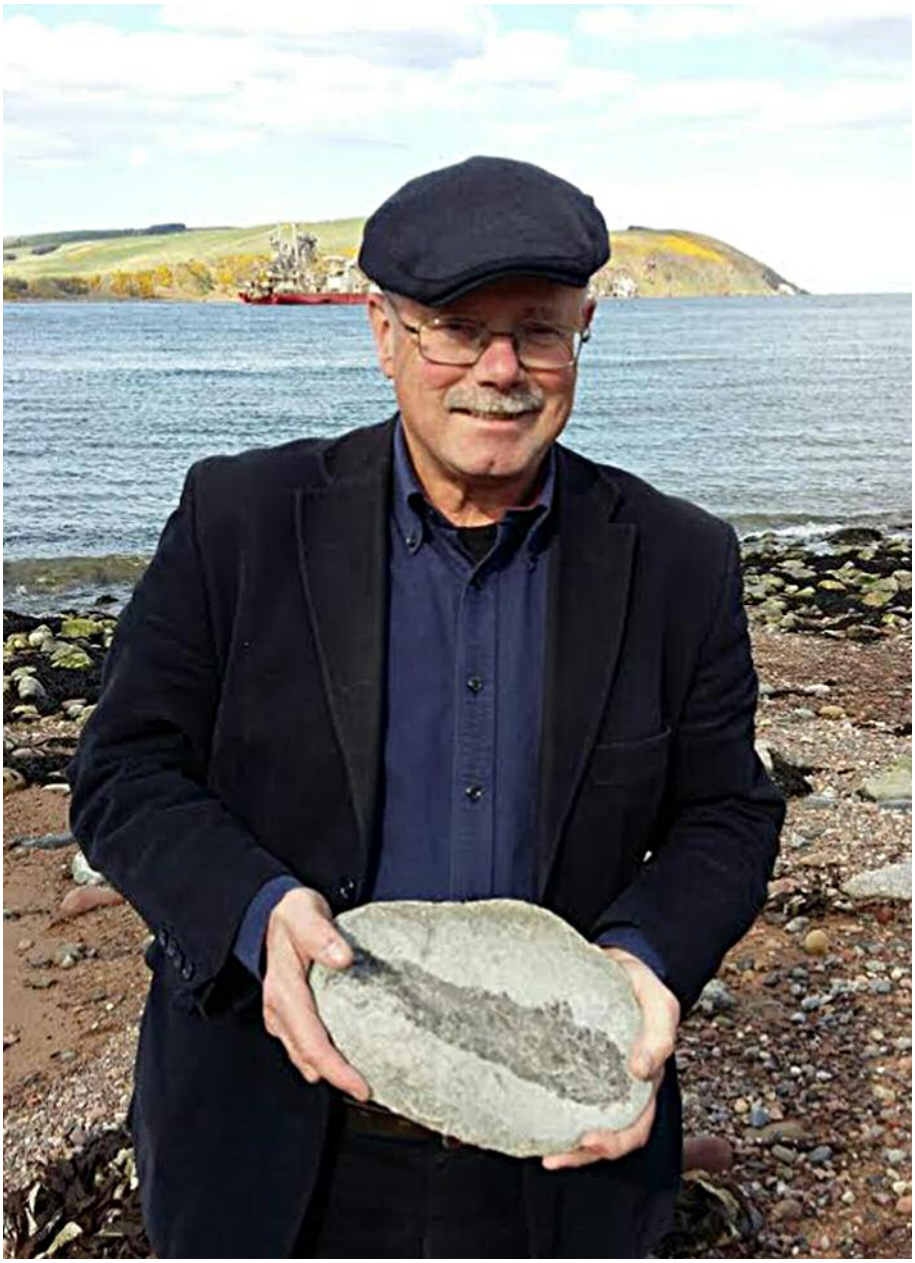
The first Hugh Miller Writing Competition was launched on 10 October, 2015, the anniversary of Miller's birthday. It was a resounding success, with many entries not only sharing in the spirit of Hugh Miller but also extending his legacy. The judges – Lara Reid (chair), writer and naturalist Kenny Taylor, geologists Ruth Robinson and Simon Cuthbert, and poet Norman Bissell – were delighted with the high quality and wonderful variety of the entries.

Nine winners were selected, among them a few well-known names and including two under-16s. Prizes were awarded at a ceremony in Miller's home town of Cromarty on 14 May 2016. First prize in prose went to Cromarty resident, Jane Verburg, for her poignant evocation of Miller's spirit. Jane wrote a lovely, approachable piece that calls for people to look at Miller and his work afresh. She was inspired by Miller's 'call to arms' to 'make a right use of your eyes.' As it bridges the boundaries between prose and poetry, just as Miller himself often did, the judges felt it was a stand-out piece.

First prize in poetry went to Edinburgh-based writer Justin Sales. His ambitious and well-executed poem brings Miller up-to-date, as well as digging deep into the reality of working as a geologist, and the endless search for evidence to fill gaps in our knowledge.



Jim Gilchrist, retired journalist and competition 3rd prize in prose winner, with the fossil fish he found on the beach at Cromarty on the day of the awards ceremony. The find was identified by Nigel Trewin as *Cheirolepis trailli*, a Devonian top predator. Nigel commented that it was an extremely rare find, both as a fish in that locality, and as a complete specimen in perfect condition. Photo by The Friends of Hugh Miller

Prior to the prize-giving ceremony, the winners had a guided tour of Hugh Miller's birthplace cottage and museum in the village. The awards ceremony at the Old Brewery, hosted by The Friends of Hugh Miller, was well-attended. Following the ceremony, I gave a talk entitled 'Why Miller Still Matters'.

The winners and their families then enjoyed a walk along the Cromarty shoreline led by local geologist Dr Peter Scott. The icing on the cake at the end of this special day was rather apt – to the astonishment and great delight of all concerned, one of the winners, Jim Gilchrist, found a complete, beautifully preserved fossil fish, *Cheirolepis trailli*, while out on the walk. The fossil has since been hailed as one of the best finds in the local area in years.

Hugh Miller's prose contains some magical elements, carefully and deliberately chosen to draw in an audience of all ages and from all walks of life. His spirit lives on, both in his writing and in the places where he lived and worked. The results of the Hugh Miller Writing Competition are a testimony to his life's work, and prove that his legacy can only go from strength to strength.

The winning entries are online at **www.scottishgeology.com/hughmiller**.

Saltscape builds new awareness of geodiversity's influence

Cynthia Burek, Cheshire RIGS & University of Chester
Veronica Cubitt-Caddy, Saltscape project officer for Cheshire RIGS

***Saltscape: Connecting Heritage, Nature and People in the Weaver Valley* is a Landscape Partnership scheme of 33 organisations, funded by the Heritage Lottery Fund together with the two local authorities Cheshire West and Chester Council and Cheshire East.**

From the project's inception, it was recognised that the underlying geology was an integral part of the way the environment, economy and culture of the Weaver Valley area of east Cheshire had developed. Our mission was to raise general awareness of and interest in the inextricable ties between the geology and human activity in the Saltscape area.

The project is led by Groundwork, Northwich and Cheshire RIGS has been an active partner. When the grant was initially awarded in July 2012 with a development fund of £48,800, the contribution of Cheshire RIGS was deemed fundamental and the group's share of the available resources was increased accordingly. The project got the green light in summer of 2014, since when Cheshire RIGS has been instrumental in delivering the project's aims.

Awareness raising

Cheshire RIGS' commitment was to raise general awareness of the geodiversity processes and products of the area and to safeguard key sites by auditing the area and identifying RIGS. Now half way through the three-year project, we have delivered eight free lectures (including one on the importance of geoconservation) which have attracted growing numbers of visitors. The most recent, on fossils, drew 51 attendees. Five more lectures are scheduled.

A cemetery in Middlewich formed the subject of an intriguing guided walk. Photo by Saltscape

We have also produced a laminated Saltscape bookmark with geological timescale and two cemetery/churchyard geodiversity guides. We had already published town trails for Nantwich and Frodsham. A third graveyard trail is planned, along with three further town trails for Northwich, Middlewich and Winsford – the salt towns. Wych is the old term for salt.

Free Saltscape guided walks in Frodsham, the Weaver Valley and two graveyards have attracted dozens of participants; a further two town walks, in Northwich and Middlewich, are planned; as is a south Saltscape walk around Winsford.

Most of the new RIGS are concerned with either the Weaver river or salt, as is to be expected. Brine springs, flashes (subsidence areas), meanders and other salt-related features will all be examined. So far two sites have been provided to the Local Authority for protection and one is in the pipeline with more to follow later this summer and next Spring.

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On 18 November 2016 we deliver the first of two one-day conferences with attached workshops. Entitled *Geodiversity & Geoconservation: An introduction for non-specialist audiences to community geoscience*, it is aimed at professionals wanting to know more about geoconservation and the Saltscape area. The day will be based on an accredited Geological Society course. Towards the end of the project, 24 June 2017, we will stage a free one-day conference for the public on geoconservation context and the local Saltscape area.

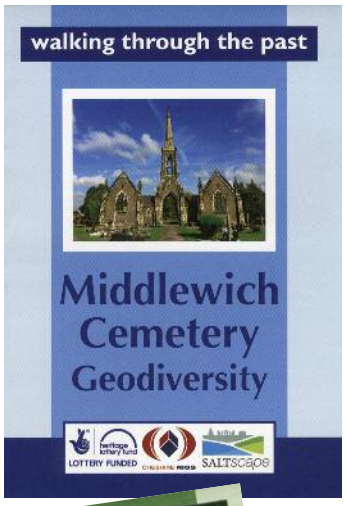
Positive feedback from questionnaire

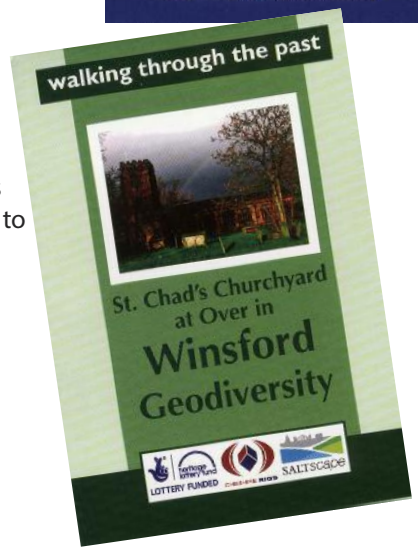
Feedback from a questionnaire survey of 35 people has been very positive, in particular from the older age groups, both on the lectures and walks. A common comment was on the surprising geodiversity in churchyards. Certainly the Vicar of St Chad's Church in Over, Winsford, learned much about the importance of geodiversity to his churchyard. He is responsible for the well outside the church and the waterlogged graves at the top of the hill (due to a lens of glacial till at the top of the hill overlying free-draining glacial sands and gravels in the valley).

Integration with other groups on the project is essential and filming of why geology is so important to the area was undertaken by media students from a local college. A workshop is also planned for schoolchildren and material has been given to the Lion Salt Works Museum to enhance the geodiversity content of displays.

By the end of the project we will certainly have raised the knowledge of local people about the importance of geodiversity although of course most already knew about the Northwich salt beds and salt subsidence, having worked and lived in the area for much of their lives.

Further information on any of the material above including the conferences from info:saltscape.co.uk **or 01606 723160,** c.burek@chester.ac.uk**,** veronicacubitt@hotmail.com





Cemeteries form fascinating repositories of various stone types and Saltscape has published self-guided walks to two of them.

A lecture on fossils stimulated plenty of interest from the public.
Photo by Saltscape

Films offer fresh insight of geological gems

Drone's-eye view of Siccar Point on the Berwickshire coast; the shallowly dipping rocks of Devonian age (*c.* 370 Ma) overlie steeply dipping sandstones formed in Silurian times (*c.* 435 Ma). Photo by Fergus MacTaggart/ Brian McIntyre/BGS/NERC

Katie Whitbread, British Geological Survey

BGS Scotland is turning the spotlight on Scottish geological sites with a series of short films revealing the fascinating stories held in our rocks and landscape.

Covering world-famous geoheritage sites, hidden geological gems and industrial excavations, the three films document Scotland's rich geology and the intimate relationships between its people and their land. Exploring sites from the ground and from the air, the films explore Scotland's dramatic landscapes from new perspectives and follow the geologist journeying into the past.

Scotland's breathtaking array of geological features ranges from ancient thrust faults that stacked older rocks on top of younger ones, to the frozen conduits of lava and ash formed within long-extinct volcanoes, and the shorelines of vanished lakes etched into the walls of glacier-dammed valleys during the last ice age. Scotland's rocks and landscapes tell stories of the passage of continents around the Earths' surface, the growth and decay of vast mountain ranges, and the power of water and ice to reshape the land.

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Many of Scotland's sites are pivotal in the early development of modern geological science. In *Siccar Point – the birthplace of modern geology*, BGS Scotland has used state-of-the-art aerial surveying to recreate views of the spectacular coastal cliffs that James Hutton, the 'father of modern geology' first witnessed as he sailed down the Berwickshire coast in 1788.

The film explores the angular unconformity in which Hutton recognised that the irregular contact between steeply dipping older rocks and overlying shallowly dipping younger rocks represented a vast span, perhaps millions of years, of missing time. As his friend and colleague John Playfair later reflected on this ground-breaking revolution in understanding of geological time "the mind seemed to grow giddy by looking so far into the abyss of time".

Spireslack surface coal mine, East Ayrshire. The pale-brown, sloping rock surface on the left of the void is the McDonald Limestone (part of the Carboniferous Lower Limestone Formation). Overlying strata of the Limestone Coal Formation, from which the coal was formerly extracted, make up the layered sequence of rocks that can be seen in the wall on the right of the void. Photo by Rachael Ellen/BGS/NERC

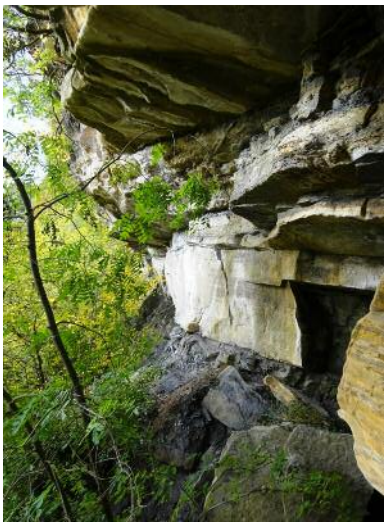
Yet long before scientists began recording their observations, Scotland's land was providing the raw materials from which our homes, communities and prosperity have been built. Coal has heated Scotland's homes and fuelled its industry for over 800 years. In central Scotland, the Scottish Mines Restoration Trust, in collaboration with BGS, is developing an innovative vision for the latest legacy of mining in the Scottish Coalfield. In the second film, *Scotland's Coal – Life after Extraction?*, aerial footage of the disused surface coal mine at Spireslack highlights the complexity of the geology under our feet. The site lies at the heart of an inclusive project aimed at developing the former surface mine to serve as both a recreational centre for the local community and an internationally significant research and geological training site (see *issue 45*).

Scotland's fascinating geology is not limited to the grand scale. Rich geodiversity can be found along many a highway and byway. The hidden geology of the Lower Nethan Gorge in the Clyde Valley is highlighted via the BGS 'GeoCam', in collaboration with the Clyde and Avon Valley Landscape Partnership. The camera follows a geologist's exploration of the Carboniferous rocks of the Limestone Coal Formation exposed in the steep crags of the gorge wall. It reveals a rich history of the rivers and forests that occupied central Scotland 300 million years ago, and highlights the legacy of coal and ironstone working by the local communities.

The three short films, the first of a series, can be found on the Scotland pages of BGS website and on the BGS YouTube channel. The next cinematic instalments, highlighting the spectacular geology and geoheritage of Arthur's Seat in Edinburgh and the Falls of Clyde near New Lanark, are currently in production.

Author email kwhi@bgs.ac.uk

Links:
www.youtube.com/user/bgschannel/videos
www.bgs.ac.uk/research/ukgeology/Scotland/home.html



The steep crags of the Lower Nethan Gorge; a thick pale-yellow channel sandstone overlies fine-grained grey mudstone containing coal bands and ironstone nodules. Photo by Katie Whitbread/ BGS/NERC

New Pebbles chipped from Rock Route block

Laura Hamlet, North West Highlands Geopark

The Scottish Natural Heritage (SNH) Rock Route has been providing landscape interpretation to visitors of the North West Highlands for almost 10 years. These sensitively placed panels inhabit remote lay-bys beside the A837, A894 and A893 roads which form the spine of the North West Highlands (NWH) Geopark, connecting Ullapool to Tongue. This can be navigated using a paper map available at tourist outlets or downloaded from the SNH website.

The route entices visitors north from Ullapool, achieving one of the key aims of the NWH Geopark. However, it has become apparent over the years that few visitors depart the main route to explore the side roads or spend time in the communities that lie there.

Responding to this challenge, NWH Geopark members coined the term Pebble Routes for several shorter driving routes which branch off the main Rock Route. The new routes were chosen by local communities and developed using advice from the 'Delivering Better Landscapes' workshops at the SNH event in Battleby in 2014. Part of this advice was to make the finished product tactile and collectable and so the routes are numbered chronologically. Kinlochbervie was the first community to publish its route, with Coigach (Achiltibuie), Assynt and Durness hot on its heels.

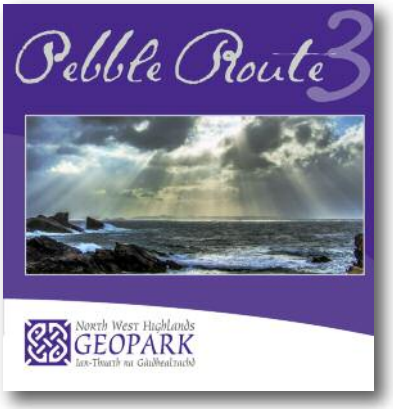
Each route contains two viewpoints, picked because local people agreed these were the views they would most like to 'show off'. They are easily accessible from safe parking spots. NWH Geopark staff collected stories and data to produce a brief geological and historical narrative for each view and worked with local children to produce associated artwork and poetry. Route details are available online and in print, with stunning photography, artwork, poems, information and interpretation all produced by local artists, children and other members of the community. A graphic artist provided mapping and design and the printing was funded by the Petroleum Exploration Society of Great Britain and Scottish and Southern Energy.

The route leaflets have proved extremely popular, flying off the shelves in local Visitor Information Centres and the NWH Geopark 'Rock Stop' visitor centre. Two further routes are planned for 2016, working with communities in Scourie and Tongue.

The start of each Pebble Route as it leaves the main Rock Route will be marked by a 'geopod' – a small wooden structure placed in lay-bys with good mobile phone signal. Geopods contain local information, mapping, landscape interpretation and a QR code to download the Pebble Routes. The geopods are useful advertising stands for small businesses, landmarks for anyone seeking mobile phone coverage and hubs for those exploring the geopark. At the time of writing the first geopod has been installed at the Kinlochbervie turn-off and NWH Geopark staff are seeking funding to build the rest.

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

Rhiconich Geopod – NWH Geopark Directors Murdo MacPherson and Stuart McHugh with the first geopod to be installed.
Photo by North West Highlands Geopark



Striking landscape photography by John McCarthy of Lochinver Landscapes www.lochinverlandscapes.com is a feature of the Pebble Routes' panels and literature.

Windows into the past form platform for future

Julie Harrald, English Geodiversity Forum and Geology Trusts

A one-day conference on geotourism in Buxton, Derbyshire was probably one of the first of its kind in England – because it was convened specifically to inform, inspire and listen to people from the local tourism industry… geologists not invited!

The conference was initiated by the English Geodiversity Forum as its first major public event since the Westminster launch of the Geodiversity Charter for England in October 2014. As well as supporting the aims of the Charter, the Forum's ambition was to break new ground by taking the concept of geotourism to a non-specialist audience.

The Peak District was chosen for the conference not only due to its central location and excellent geology, but because local enthusiasts there were, and still are, actively seeking to raise the profile of geodiversity and are exploring the possibilities of the area as a geopark, a concept that was explained to the conference audience.

The day was planned by local geologists, and representatives from the English Geodiveristy Forum, Peak District National Park Authority (PDNPA) and Visit Peak District & Derbyshire. Tourism officer advice was critical in shaping the day which was planned for November mid-week (low season), allowing time for networking, and providing delegates with a 'take-home' product to use after the conference.

The conference was advertised to a mailing list of 4,000 contacts by Visit Peak District & Derbyshire and by the Environmental Quality Mark Community Interest Company which recognises around 80 businesses in the Peak District that actively work to improve and safeguard the local environment and heritage. The PDNPA informed the most prestigious tourism attractions, including the stately homes and caverns, and further promotion was done by the planning group through personal contacts.

On the day, two outstanding keynote speakers introduced, in simple terms, the geology of the Peak District and its potential for geotourism, and the commercial benefits of geotourism linked to the idea of geoparks. These were followed by five excellent short talks describing ideas and successes from other parts of the country.

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Delegates at the Buxton geotourism conference. Photo by Julie Harrald

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A lunch-break exhibition was followed by group discussion where delegates voiced their thoughts about promoting geotourism and ideas for how it could work in the Peak District. The 'take-home' item was a colour brochure that delegates could later use with the public, their customers, encapsulating the first keynote talk on the rocks and landscape of the Peak District and the many geotourism attractions for visitors to explore.

In conclusion the discussion highlighted the benefit of geotourism in attracting more visitors and groups with a particular interest in the environment which can both extend the visitor season and act as a catalyst for action in local communities.

Most important for tourism professionals was the support and training that can be provided by geologists; widening their understanding of the value and relevance of geodiversity. In return, the experienced tourism industry can help target, shape, connect and market the geological story that we all want to tell.

The conference was very well received by an audience of around 50 from sectors including accommodation, outdoor activity providers, show caves, industry, local authorities, education and interpretation. A follow-up field day was requested and provided by Chris Darmon a couple of months later.

A full report of the event (presentations, discussion and conclusions) and a copy of the Geodiversity Charter for England can be downloaded from **www.englishgeodiversityforum.org**.

The conference was funded and supported by the Peak District National Park and English Geodiversity Forum. The Peak District geotourism brochure was designed by the British Geological Survey with the printing costs covered by a Geologists' Association Curry Fund grant.

Subjects and speakers were:

The Peak District - window into the past, platform for the future,
Chris Darmon, CEO Geosupplies and Past President YHA

Geotourism, geoparks and my business,
Nick Powe, Director Kent's Cavern & Chair, English Riviera Geopark

Ideas: Make it digital – 3D visualisation of landscapes in deep time,
Mike Brooks, smartphone app designer

Urban Ideas,
Graham Worton, Keeper of Geology at Dudley Museum

Walk Through Time,
Guy Kerr, Community Co-ordinator at the Jurassic Coast World Heritage Site

World Class Geology!,
Tony Devos, Programme Manager, Limestone Landscapes Partnership

Martley – the Geovillage model,
John Nicklin, Teme Valley Geological Society.

Families enjoy cycling along the Tissington Trail, but may not realise that the limestone in the cuttings is full of fossils.
Photo by Julie Harrald

Leaflets aim to draw geo-walkers to paths less trodden

Geraint Owen, Swansea University

***Scratching the Surface* is a set of 10 leaflets interpreting geology and landscape along short walking trails near Swansea. The project uses the lure of geology as a reason to visit rural areas and use local facilities such as pubs, cafes, accommodation and public transport.**

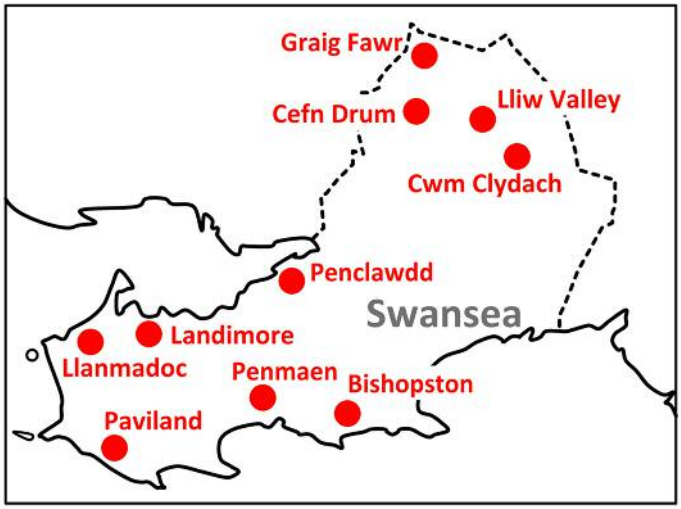
While the concept of 'virtual guided walks' is far from radical, the project demonstrates how careful design of outreach materials can promote the understanding of geology, geodiversity and landscape evolution and contribute to rural economic wellbeing.

The project was funded from 2012-2014 by the European Agricultural Fund for Rural Development and the Welsh Government under City and County of Swansea's Rural Development Business Plan. Funding covered time expended by Geraint Owen and Professor Siwan Davies, leaflet design (by Icon Creative Design of Newport, Gwent), Welsh translation (by Dr Dyfed Elis-Gruffydd), printing of 5,000 copies of each leaflet, and website design.

The *Scratching the Surface* leaflets (including bilingual versions of Llanmadoc Hill and Paviland Cliffs). The walk locations are illustrated below.

Two parts of the City and County of Swansea are defined as rural: the popular and geologically varied Gower Peninsula, designated Britain's first Area of Outstanding Natural Beauty in 1956; and part of the central Coalfield plateau north of the M4 motorway, a much less frequented area of rough upland grazing and former mining valleys. In keeping with the ethos of the Business Plan, the routes are in less popular parts of both areas rather than established 'honey-pots' such as Rhossili.

The target audience is non-geologists interested in the countryside. A maximum trail length of about 10 km makes the trails accessible to casual walkers and dedicated hikers. Route information is provided on Ordnance Survey 1:25,000 map extracts and in the text, where it is distinguished from geological information, making the leaflets effective for people looking for a stimulating walk, regardless of their interest in geology. The leaflets are bilingual and can fold to show either Welsh or English to aid usability in the field.



The trails are circular, but most have a destination such as a view-point or local attraction. Geological interpretations are based on observations but the narrative tells a story - as in an expert-led guided walk - rather than just pointing out features of interest. Most trails build an understanding of one or two key aspects, such as the formation of coal, coal-mining methods, geological structure or the glacial legacy in the landscape.

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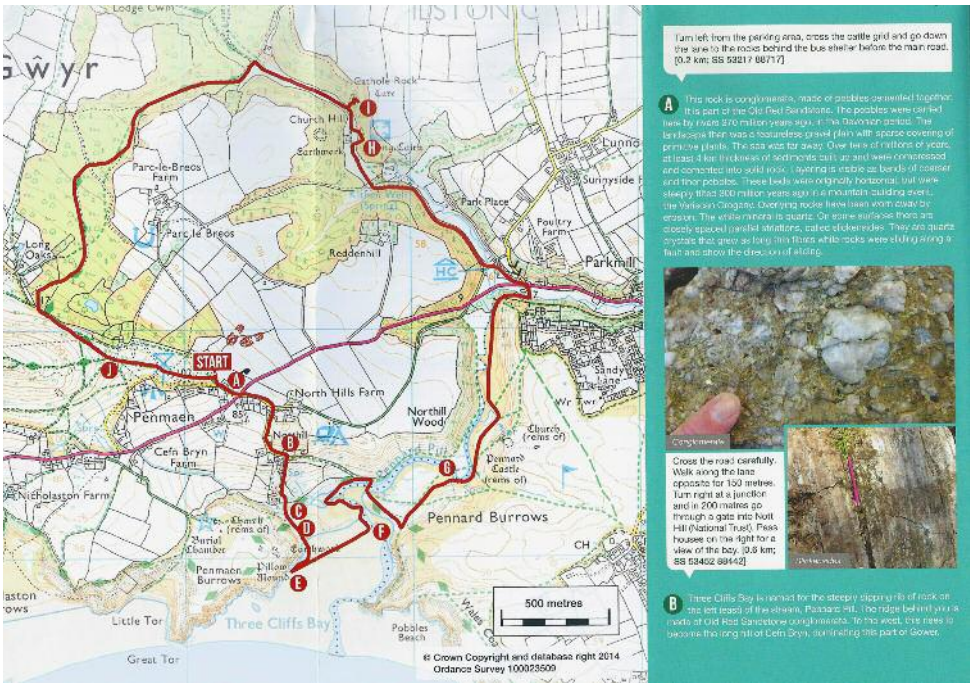
While paper leaflets may be thought by some to be an archaic medium, they were preferred for this project for their ease of distribution and practical use in the field. However, a website (**http://geography.swan.ac.uk/scratchingthesurface**) is being built as an integral part of the project. It will provide PDF downloads of the leaflets, audio recordings of three trails (funded through the project and made by Audio Trails Ltd), GPX files and route updates, as well as links to organisations such as the Geologists' Association, British Geological Survey, Gower Society, National Trust and local archaeology, conservation and history groups.

In the first year, 40% of the leaflets have been distributed, mainly through tourist attractions, caravan parks and public libraries. This reliance on existing tourist infrastructure means distribution in the less developed northern area is more challenging.

The leaflets give additional focus and rationale to 'live' activities such as talks and guided walks, for which there is an insatiable public appetite, and they provide a tangible, lasting product for such public outreach activities.

For a set of these free leaflets, contact the author at g.owen@swansea.ac.uk or @gerainthowen with a postal mailing address.



An extract from the trail guide to Penmaen and Three Cliffs Bay (Geology, prehistory and history in South Gower). The route information (pale background) is clearly distinct from the geological information.

Scratching the Surface of Cefn Drum in June 2016 with a group from Pontarddulais. Photo by Alastair Duncan, www.stillwalks.com

Meeting the challenge of displaying giant fossil

Nigel R. Larkin, www.natural-history-conservation.com
Caroline J. Buttler, Amgueddfa Cymru – National Museum Wales

Earth Heritage 43 **highlighted the importance and geotourism potential of Brymbo Fossil Forest, near Wrexham, North Wales. The star specimen of the former steelworks site is an exceptionally well preserved 300 million-year-old fossilised giant clubmoss comprising a large trunk and its broad *Stigmaria* 'root' structure found in 2004. However, conserving the site's huge flagship specimen has been an exacting project demanding innovative thinking and engineering.**

Cleaning, conserving and mounting the fossil required bespoke display, transport and health and safety solutions as it was in about 90 pieces, weighed almost a tonne and stood 2.25 m tall with a root span of 3.5 m.

After excavation, the specimen was laid out and stored for years in a former machine shop of the steelworks amongst hundreds of other plant fossils found on the Brymbo site. Among the pieces were three heavy sections of trunk weighing around a quarter of a tonne each and sections of root each weighing up to 20 kg. The items were covered in dust, bird and rodent droppings, cobwebs and other detritus from a decade of storage. Some of the surfaces were flaky and friable and some pieces had fallen off or broken apart. Earlier repairs had resulted in excess adhesive flowing out of repaired cracks.

Cleaning and conservation of the specimen

All cleaning and conservation work was as gentle, non-invasive and reversible as possible. The ethyl-methacrylate copolymer Paraloid B72 was chosen as an adhesive and as a consolidant (in acetone) because of its long-established suitability for use with fossil material. The initial cleaning involved using a soft wide artist's brush alongside a vacuum cleaner with gauze taped over the nozzle (to prevent the loss of small pieces). Stubborn areas of dirt, dried bird excrement for instance, required stiffer brushes and occasionally were cleaned with compressed airflow which, when necessary, was lightly laced with sodium bicarbonate powder. In turn, this powder was removed with compressed air, vacuum cleaner and soft brushes. Some excess matrix was removed with scalpels.

The proximal portion of the rear root (showing bird droppings and other dirt) before cleaning and consolidation (left) and after (right).
All photos by Nigel R. Larkin

After cleaning, a consolidant was brushed on to strengthen flaky and friable surfaces, to give long-term protection and to bring back the natural colour of the fossil which had become quite grey. Some smaller segments of *Stigmaria* root were stuck back together to form sections that were not so big and heavy that they would break under their own weight, nor were too difficult to lift. Any small gaps in the fossil were filled with plaster of Paris painted with artists' acrylic paints.

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The middle section of the trunk, stored since the excavation in a thick rubber mat secured with metal bands because it had been badly shattered in the ground, required a lot of consolidation and gluing. This was not easy as the specimen could not be manoeuvred without risking new breaks or worsening old breaks, so care was needed to control the flow of consolidant and adhesive.

The roots assembled into position against the base of the trunk. All the white pieces in the specimen are where large gaps were filled with plaster of Paris to complete the root.

Manufacturing the permanent metal mount

A modular mount system was designed and welded in steel so the specimen could be easily assembled, dismantled and transported for display in various locations.

Given the 0.8 tonne combined weight of the main sections of trunk, the central mounting metalwork was designed to accommodate safely at least a tonne.
In addition, each section of the mount to support the roots and the trunk had to be light enough for people to move. This also ensured there could be a choice of which roots could go on display, depending on the space available at each location.

Although weighing over a quarter of a tonne, the lowest section of the trunk, against which the roots would be positioned, had to be easily manoeuvrable so it could be placed exactly where required on display or in storage. The mountwork therefore required sturdy, lockable wheels.

Below: the left root lying upside-down in its temporary support jacket ready for the metal brackets to be made.

Metal 'cradles' had to be constructed to support the undersides of each root section. To make these supports the roots had to be turned upside down whilst maintaining their exact three-dimensional relationships with one another. To enable this, resin jackets were made around the top surfaces of all the root. Sections of plastic sheet were draped over all the roots, then Jesmonite acrylic resin (AC100) and glass fibre were applied in layers to build a thick sturdy jacket. Multiple splints were added to each jacket as required, screwing wooden batons to one another and securing them in place with more Jesmonite resin and glass fibre. Each jacket was removed and turned upside down and the root sections overturned and laid in their correct association and position.

The steel brackets could now be made. Foil was placed between the metal pieces and the fossil to protect it from the heat of welding. The welding itself was undertaken in short bursts, again to minimise possible heat damage and the risk of the metal becoming distorted.

Making the welded steel mount on wheels to support the base of the trunk.

The middle and upper sections of the trunk were so heavy (approximately 210 kg and 265 kg, respectively) that they presented serious health and safety challenges if they were to be placed on top of one another and on top of the base section of the trunk, as well as posing a significant risk of damaging the lowermost section – particularly as the specimen was to be displayed in successive locations. It was therefore decided to make moulds of these two sections to produce painted casts to place on the lowermost section of the trunk. However, due to the size and weight of the fossils and the fragility of the middle section, which had been extensively consolidated and repaired, even making the moulds was difficult.

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The large specimens had already been cleaned, consolidated and placed on Plastazote foam on sturdy bespoke permanent pallets. To prepare both sections for moulding, extra consolidant was applied to protect the surfaces. Cracks and gaps in the specimens were filled to prevent the moulding rubber penetrating the fossil (if this happens, the rubber can rip when it is removed, or even take some pieces of fossil with it).

Gaps were filled with reversible water-soluble putty made from polyethylene glycol 4000, glycerol, water and precipitated chalk. As two-part moulds were to be made, a Plasticine 'dam' was constructed along the midline of each specimen, so the 'flashline' (where the two pieces of the cast join) would be least visible and also so that the mould would come apart most easily. The Plasticine was shaped to produce 'keys' to lock the two halves of the mould together securely. The casts were made from Jesmonite acrylic resin and fibre glass coloured with artists' acrylic paints.

Left: the completed mount on wheels for the base of the trunk. Right: the mount in place under the base of the trunk with the unpainted casts in place on top.

The fossil and its mount were disassembled, carefully packed and transported to Wrexham Museum. It was installed in January 2016 as the star specimen in a six-month exhibition entitled *Swamp Land: Brymbo 300 Million Years Ago* telling the story of the Fossil Forest. The two heavy sections of trunk were displayed on their pallets behind the mounted root system and the cast of the trunk. Ultimately, the specimen is intended to be a permanent display at the Brymbo Heritage site itself but in the interim the specimen is stored in Cardiff where it may also be put on display temporarily.

Discussion

Large Carboniferous *Stigmaria* with their trunks preserved are very rare, and mounted specimens on display are rarer still. This specimen has proved popular in Wrexham with local people taking great pride in their heritage. The mounting system is strong but not too intrusive. The brackets supporting the roots have the appearance of rootlets that would have existed in life. It is also fitting that the structure is created from steel, the material made for over a century on the heritage site where the fossil was discovered. There are more images and further details at **http://tinyurl.com/zeouffv**

The complete *Stigmaria* specimen installed at Wrexham Museum, January 2016.

The partnership

The project was only possible due to partnership working with Amgueddfa Cymru, Brymbo Heritage Group, Wrexham County Borough Council, Natural Resources Wales and Brymbo Developments Limited. This collaboration will continue as Brymbo Heritage Group hopes to excavate the fossil area to expose more plants, including *Calamites* standing where they grew, with a protected boardwalk system for visitor access, all enclosed within a single structure.

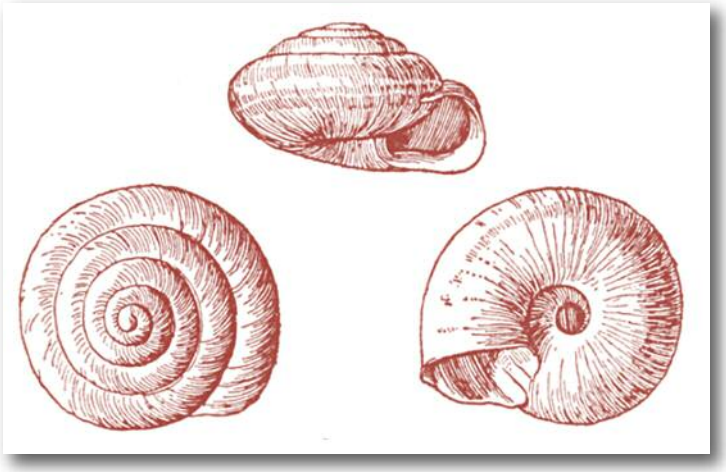
Working with community on brick pit's heritage

Diana Clements, Laurie Baker
London Geodiversity Partnership Sites Working Group

In 2009 the London Geodiversity Partnership proposed North End Pit as a Regionally Important Geological Site (RIGS) in its planning document *London's Foundations*. Although Bexley Council had not formally adopted the site in its plan, when Orbit Homes applied for planning permission for what is now Erith Park, the Council inserted a condition for conserving and interpreting the geology and the developers met on site with the London Geodiversity Partnership. In 2014, with the plans becoming a reality, the Partnership was invited back to the site to firm up on plans.

The site is within a worked-out pit in the Crayford Brickearth, one of many in the area, and the only one where the Brickearth is visible as a cliff. The original tower blocks within the old pit were being demolished in phases and low-rise housing built in their place. The displaced residents were encouraged to participate in aspects of their new community under the leadership of Caroline Field and Francois Jensen, both working for the Regeneration Community Engagement Project.

Three of us were invited to talk to residents about the geological, archaeological and economic importance of the site and to present ideas for site interpretation. Paul Rainey carried out painstaking local library research to reveal how the pits had developed from north to south through Erith and Crayford, starting before 1800 and finishing in 1922. North End Pit was worked as part of the Great Erith Brickearth Pit from 1840s to 1907. We discussed the owners of the brick pits and the geologists who had worked alongside them when the pits were dug. We were able to tell the residents about the animals that roamed here about 200,000 years ago and of the famous find by Spurrell of a Neanderthal working floor. Pictures of the molluscs found within the Brickearth provided evidence of the environment at the time of deposition. One of the gastropods has been named after the area, *Candidula crayfordensis*. Kennard's 1944 publication had a geological map of the area which we had coloured appropriately. Image copies were left with residents so they could think how they would like to see the story told.



The gastropod *Candidula crayfordensis* is found in the brickearth and named after the locality.
Image by Kennard (1944)

We arranged a visit for interested residents to the Natural History Museum where Beccy Scott showed them the re-fitted flint and flint tools found on the site. They were excited that Neanderthals had lived and worked on the site 200,000 years ago. Simon Parfitt showed them bones of some of the animals that lived alongside the humans, such as lion, woolly rhinoceros, deer and even a nest of ground squirrels. The rhinoceros jaw had a flint embedded in it, providing evidence of interaction with the Neanderthals. Finally we took them to the public galleries to see the giant skull of the Steppe Mammoth, with its enormous tusks, that was found in the brickearths at Ilford, dating from the same period. The residents then came up with the final design of a six-foot-wide panel featuring the geological map re-orientated 90º to match the orientation of the viewer and superimposed with insets explaining the separate stories.

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This reconstruction shows Early Neanderthals preparing flint tools at Crayford and depicts the Thames with woolly rhino, and giant deer in the background. Image by Craig Williams

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Preparation of the text and images was very much a team effort involving working with residents to tweak and modify text. Orbit Homes then erected the finished panel on site.

The panel was not the only means of interpretation. In phase 1 of the development the street names, championing local heroes, were chosen by the residents. The names have a by-line telling who the person was. We have suggested names of brickpit owners and geologists working in the area for phase 2 of the housing.

Another of the residents' initiatives was an app - *Walk the Talk* – to record area stories. Residents enlarged on the local heroes by speaking down a phone line for one minute. We added our geological story to the app, expanding on the text on the panels. There are little signs around Erith Park inviting residents and visitors to dial up to listen to the relevant stories on their smart phones. The signs were unveiled during a street party organised by Orbit Homes.

Further reading

Kennard, A.S. (1944). The Crayford Brickearths.
Proceedings of the Geologists' Association, **55**,121-168.

The unveiling of our six-foot panel, designed with help from the residents. The insets tell the stories. Laurie Baker and Paul Rainey are on the right. Photo by London Geodiversity Partnership

A-level lifeline for geology in Scottish schools system

Emma Smith, Gairloch High School

Until 2015 the Scottish Qualifications Authority (SQA) offered Higher Geology courses to Scottish school students. Despite a campaign to save the course, the subject was excluded in the refreshed Curriculum for Excellence Highers with the SQA citing a lack of uptake as the reason. The solution for Gairloch High School to meet the demand of its students seeking to attain a geology qualification no longer available in the Scottish State system: A-level Geology.

With correct support, A-level Geology can provide pupils with a relevant, engaging and useful qualification that otherwise would not be available to them in the Scottish State system.

The plight of geological education in Scottish schools with the demise of the SQA Higher Geology course was reported in earlier issues of *Earth Heritage*. Pupils studying Higher Geology were few (just 17 in Scotland in 2012, rising to 64 in 2013), not helped by the retirement of several key Geology teachers trained before the 1980s. In recent years, efforts to keep the teaching of geology going included tutors visiting schools and being part of the Highland Council's distance learning scheme.

Earth Science Education Scotland (ESES), a group made up of university academics, industry representatives and teachers, was formed to promote Higher Geology teaching in schools and liaise with the SQA. It achieved significant publicity but the SQA held its line about lack of interest. Geology content has been dispersed as units amongst other courses, allowing pupils to gain only unit passes in geology. Some schools (including Gairloch, Fortrose and Ullapool in Highland) have offered these units this year (15/16). However, the units are not a full Higher course with a final exam, which is confusing for parents, pupils, teachers (who may be happy and keen to deliver the subject), universities and those in industry. A survey in 2013 by the University of St Andrews demonstrated that no fewer than 130 Scottish teachers would be interested in delivering geology as a qualification, with the right support.

ESES is currently putting a business case together for having an Earth Science Award made to pupils completing the three geology units. The SQA has indicated that if this proves popular, it may consider a new Geology course. However, it would not carry the same weight as a Higher and so would be another point of confusion. University Geology departments may support it for university admission but the stance of other departments is unknown. The SQA appears to have generated a circular argument of "show us that pupils are doing this non-course which doesn't attract pupils and we'll think about making a course which does attract pupils".

A-level Geology at Gairloch High School

As a result of this conundrum, and due to pupil demand, I am now providing A-Level Geology to Gairloch High School pupils in S5/6, with the course starting in June 2016. Having had the opportunity to take Higher Geology in S6 at Dingwall Academy, I studied Geology at undergraduate level, was involved in school teaching and outreach alongside ESES academic member Dr Ruth Robinson, and completed a Professional Graduate Diploma in Education in Geography at the University of Edinburgh. I undertook postgraduate training at Keele University's Earth Science Education Unit in 2014, completing a Teaching and Learning in Geoscience module alongside colleagues from across England and Wales.

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With this, I became the first newly trained Geology teacher in Scotland since 1985. This course provided familiarity with the rigorous A-level course and contacts within English and Welsh exam boards which offer A-level Geology.

Gairloch High School's A-Level Geology class on its first fieldwork session at Gairloch Beach where Lewisian gneiss is in contact with Torridonian rocks providing a challenging introduction to geology. Photo by Emma Smith

I worked with the WJEC (now Eduqas) exam board, which provided full support. Teaching began with a class of eight AS-level pupils. In addition, one pupil who has previously studied Intermediate 2 Geology units (a stepping stone to the old Higher) is undertaking both AS and A2 courses in one year. Gairloch High School has been fully supportive, keen to provide more opportunities for its senior pupils, especially in a subject that is so locally relevant and broaches much of the STEM curriculum (STEM is a curriculum based on educating students in Science, Technology, Engineering and Mathematics using an interdisciplinary and applied approach).

Highland Council supportive

Highland Council has also been supportive, confirming that exam fees will be paid as with SQA qualifications. There has been support from ESES, Scottish Geodiversity Forum, other members of the geological community in Scotland and the UK-wide Earth Science Teacher's Association. Field safety equipment has been generously donated by Gordon Montgomery, funding for compass clinometers given by the Edinburgh Geological Society and contributions to cover textbooks and some field costs by the Tomlinson-Brown Trust. Partners from industry have offered their expertise in delivering sections of the course (Mott MacDonald, Atkins for unit GL3) and the University of the Highlands and Islands/Highlands and Islands Enterprise STEM team is providing support to build contacts, secure equipment and develop the course with a view to future implementation across a wider area.

Pupils have already begun to build foundational geology skills but what has stood out is their changed attitude towards their local area and trying to solve the geological mysteries which they see in the North West Highlands. Fieldwork will be rooted in local geology and it is hoped that trips farther afield to Skye and (if funding can be found) Arran, will stir a passion for geology that will stay with the pupils long after they leave school.

The A-Level course has started successfully, largely down to partners who have come together to show their commitment to the continued delivery of Geology in Scottish schools. Our Scottish geological community is full of talent and knowledge about specialist areas beyond the scope of one teacher! If you can contribute ideas, tell pupils a bit about your career, run a workshop or lead fieldwork in an area you know well, please contact me via emma.smith@gairlochhigh.org.uk **or Twitter,** @EmmaEarth.

What the A-level comprises

A-level Geology comprises six modules taken over two years. The first year (AS-level) modules comprise the foundations of geology; geology and the human environment; and a field or inquiry based research project. The second year (A2-level) comprises three modules – a core module on interpreting the geological record, a choice of two themed modules and a detailed investigation made up of both field and lab work. It is assessed by undertaking summer exams and submitting coursework. Across these six modules pupils encounter aspects of geography, biology, chemistry, environmental science, physics, maths, engineering, outdoor learning and learning for sustainability. They develop many field, lab, map and decision-making skills. Leaver destinations for those having studied A-Level Geology in England and Wales see many students going on to pursue courses in Geology and STEM subjects at university. A-level Geology is well regarded in terms of university entry both in Scotland and the rest of the UK and is accepted as a science course where one is required. Research by Earth Science Education Unit (ESEU) Director Chris King found that 82% of those who studied A-Level Geology went on to university, 43% choosing to study Geology.

As part of *Earth Heritage*'s support for furthering education about geodiversity, we are publishing the work chosen as the best submitted to the University of York's Post-graduate Diploma in The Geology of Yorkshire and Northern England

Origins of Whitby Jet

Andrew Sanderson

Whitby Jet, the origin of the phrase 'jet black', represents the preserved remains of the *Araucaria* tree, an ancient type of conifer. The closest living relative of this tree is the *Araucaria araucana* or quirkily named 'monkey puzzle' tree that is native to Chile.

The trees that ultimately went on to form jet lived in what is known as the Toarcian stage of the earliest Jurassic – about 180 million years ago. As they fell, some were transported to the sea by rivers flowing from the hinterland of Pangaea – a supercontinent consisting of all the continental landmasses that existed at that time. Pangaea formed in the late Permian period, around 260 million years ago and existed for around 40 million years before finally breaking up in the Triassic. However, in the Jurassic, the continental plates were still very close to each other.

Normally, if wood falls in to the sea it will decompose, providing food for many organisms. Fossilised wood is therefore rare, and, on decomposition, it normally forms a cavity within the sediment that is replaced by mud, which creates a cast of the original. However, in the earliest Jurassic, during an episode known as the Toarcian Oceanic Anoxic Event (the T-OAE), the sea was severely depleted in oxygen and thus the *Araucaria* wood did not decompose. The T-OAE was a global event of major biological impact, but it's not entirely clear why seawater oxygen levels fell so dramatically. At this time, Earth had a 'greenhouse' climate, with high global temperatures and virtually no ice at the poles. For a good analogy think about what happens to tepid champagne…..warm liquids are able to hold less dissolved gas, which is why warm champagne goes flat very quickly. In the Toarcian the Earth was hot; the oceans became warmer and were able to hold less oxygen and oceanic circulation was poor.

Around this time, large igneous eruptions were also occurring in the south of what is now known as Africa (Sell *et al*., 2014). Huge amounts of volcanic gases were emitted into the atmosphere during the eruptions. The gases included carbon dioxide, a greenhouse gas, which would have added to the overall warming of the Earth and to rapid climate change. It is also possible that increased nutrients in the oceans led to a proliferation of plankton or 'primary productivity'. Vast amounts of plankton would deplete even more oxygen from the seawater, also adding to the anoxia.

So, let's return to the *Araucaria* wood that, during the Toarcian, was sinking to the anoxic sea floor where no organisms existed to devour it. After landing on the seafloor it was progressively buried by muddy sediment that was carried downstream by the same rivers that brought the wood itself to the sea. The added weight of sediment slowly compressed the wood to form jet, leaving the cell walls intact; and these can still be seen with a microscope. The other cellular contents, and the material between the cells, eventually turned into a form of oil. If you are lucky enough to find a piece of jet still in place in the rocks at Whitby, you may be able to smell the oil.

Millions of years after burial, the whole area was uplifted, bringing the jet rock back to the surface. In the early days, Victorian jewellers cut and polished these remarkable remains into fashionable items, and it is known that Queen Victoria wore jet jewellery in mourning for her beloved Prince Albert. However, jet is still loved and coveted today, commanding a high price on the high street.

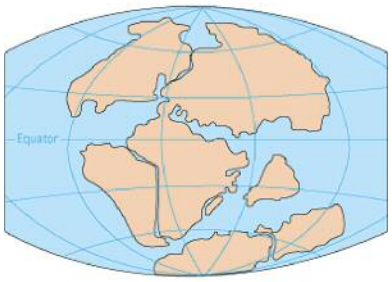
Further reading

Sell, B., Ovtcharova, M., Guex, J., Bartolini. A., Jourdan, F., Spangenberg, J.E., Vicente, J.C. & Schaltegger, U. (2014). Evaluating the temporal link between the Karoo LIP and climatic-biologic events of the Toarcian Stage with high-precision U-Pb geochronology. *Earth and Planetary Science Letters*, **408**, 48-56.

***Araucaria araucana* is the closest living relative of the original Whitby jet *Araucaria*.**
Photo BillyKwiki, CC BY-SA 3.0

System Period	Series Epoch	Stage Age	Age Ma
Jurassic	Lower	Toarcian	175.6±2.0
		Pliensbachian	183.0±1.5
		Sinemurian	189.6±1.5
		Hettangian	196.5±1.0
			199.6±0.6

The Toarcian Stage within the Jurassic
Table from Geological Society Stratigraphy Commission



Pangaea in the Jurassic
Illustration US Geological Survey

Jet jewellery
Detlef Thomas, CC BY--SA 2.0

Using Neighbourhood Plans for geodiversity

Mick Stanley, Geodiversity Consulting

Local parishes, groups of parishes or other defined areas can now control their own destiny, and geoscientists can help to ensure that geodiversity features in planning applications and development control.

The Localism Act 2011 introduced exciting new powers for communities in the form of Neighbourhood Planning to prepare their own planning policies and site allocations. These Neighbourhood Plans (NPs) have real power as planning applications and appeals are assessed against them. NPs also bring funds through the Community Infrastructure Levy (CIL), that every NP has if the Local Plan of the District or Unitary area is in place. This funding replaces Section 106 agreements that some geoscientists have used in the past. In the Act are also Neighbourhood Development Orders where communities can grant planning permission for the types of development they want to see in their area. This could be on a single site for affordable housing or a community facility or a protected space.

NPs are much simpler than producing a council's Local Plan but there are processes that must be followed, evidence gathering to inform policies and public consultation, so they should not be undertaken lightly.

The Yorkshire city of Ripon, with a population of just under 17,000 people, applied for an NP in 2012 and the Ripon City Plan, as the NP is known, is nearing its final public consultation over four years later. Setting a policy is relatively easy (provided that you have retired planners on the team! – Ripon has two) compared to the time taken gathering the evidence to prove the case for the policy. **Http://tinyurl.com/7u8arfh** takes you to the regulations for NP 2012 Neighbourhood Planning Regulations.

Ripon's Geodiversity policy

The Ripon City Plan environment policy combines geodiversity and biodiversity in a holistic approach to nature conservation. It sets out to safeguard biodiversity and geodiversity inside and outside the city boundary. It has a number of provisos to conserve Green Infrastructure in support of healthy communities, cultural value, a buoyant economy and aiding resilience to climate change. To meet these criteria, development proposals will not be permitted if they harm any of several sites. These include international (Special Areas of Conservation), national (Sites of Special Scientific Interest) and regional (Local Nature Reserve) plus other locally designated wildlife and geology sites (Sites of Local Importance for Nature Conservation). The City Plan policy states that, where possible, developments should incorporate beneficial biodiversity and geodiversity conservation features, including those that will help wildlife to adapt to climate change where appropriate. It also expects developers to seek opportunities to work collaboratively with other partners, including Local Nature Partnerships, to protect and improve geodiversity and biodiversity based on local priorities and evidence. Developments should achieve net gains for nature, and must contribute to conserving and enhancing the geodiversity and biodiversity and reduce pollution.

Ripon is a city that holds a unique mix of geodiversity. Overleaf is a summary of its intriguing properties.

Ripon's geodiversity

Ripon's unique geodiversity has had a huge influence over how the area has been developed.

The city sits near the northern end of the Southern Magnesian Limestone National Character Area (NCA 30) defined by the underlying Permian Zechstein Group, formerly known as the Magnesian Limestone. The limestone creates a north-south ridge that forms a prominent landscape feature stretching from Thornborough, North Yorkshire to the outskirts of Nottingham. The geology has influenced many aspects of the landscape, from use of its limestone resource as a local building material to the specialised biology of limestone grasslands. In Ripon and outlying villages to the north and south, it produces unstable land, but also a particular topography that has defined human settlement history and limited the area's development geographically.

Ripon is 54ºN and 1.5ºW and sits 30 m above sea level in a post-glacial landscape on fluvio-glacial and river terraces that form the higher land between the river valleys of the Ure, Laver and Skell. In the recent past these rivers cut deeply into the underlying Permian deposits when the flow greatly increased with meltwater from the glaciers of the Devensian Stage of the last Ice Age. The Laver and Skell now sit as 'misfit' rivers in deep gorges best seen on the Laver at Bishopton on the footpath to Galphay Lane from the Riverside Caravan Park, and on the Skell at Fountains Abbey: the Ure gorge is seen at its best at Hackfall near Grewelthorpe.

Dissolution

Ripon's position is unique because its geodiversity and particularly the process of dissolution has had a profound effect. The gypsum dissolution described below has controlled where development can take place, but the dissolution of the monasteries in the early 16th Century created new landowners. Land using the misfit streams and gorges of the Skell and Ure provided landscape features adapted by John Aislabie to create the Studley Royal Water Gardens in the early 18th Century. These were expanded by his son William to include land adjacent to the ruins of Fountains Abbey to create what is now the premier World Heritage Site in Yorkshire. William in the late 18th Century also created Hackfall Garden in the Ure Gorge at Grewelthorpe, linked by a carriage drive to Fountains. The Aislabies, sitting as Ripon MPs for almost 100 years between them, and the successor families at Studley Royal, undertook most of the development in the City in the 18th and 19th centuries.

• ***Continued next page***

The River Skell disappears underground in the Valley of Seven Bridges (Skell Gorge) at Fountains Abbey, Studley Royal.
Photos by Mick Stanley

The landscaping of the Skell Gorge with Fountains Abbey in the background is a memorable sight.

• *From previous page*

Gypsum dissolution

The rocks beneath the City consist of superficial deposits (riverine sediments, glacial sands, gravels and boulder clay) overlying Permian limestones that have two distinct layers of gypsum, and there are mudstones and marls. These dip gently eastwards and in turn are overlain by the Sherwood Sandstone of Triassic age. The distribution of the solid geology is further complicated by small outliers of younger strata across eastern half of the City due to localized foundering of strata caused by gypsum dissolution beneath. There are approximately 10 m of gypsum in the Roxby Formation, and 35 m in the Edlington Formation, and both beds rest on two limestone aquifers, the Cadeby Formation and the Brotherton Formation. The dip from west to east allows water to feed down the dip into the gypsum beds. It then migrates into the over-deepened valley of the River Ure buried by sands and gravels. Dissolution gypsum cave systems have developed, resulting in large surface collapses of up to 30 m across and 20 m deep. The subsidence occurs in a pattern related to the jointing in the rocks, and there is significant subsidence every few years. These events show that some zones are more active than others, with land either side of the Ure more prone to subsidence caused by the escape of water from the caves into the buried Ure valley gravels. The fluvio-glacial and river deposits fill and cover many of the historic solution hollows and breccia pipes in the City and the subsidence caused by dissolution makes construction difficult to impossible. The best approach is good site investigation and hazard avoidance that can cope with any expected subsidence. Linear structures such as roads and bridges are very prone to subsidence damage, and the BGS has published often about Ripon's problem and mitigation measures and development control, (**http://tinyurl.com/jegvnsg**).

Sink holes and large surface collapses are caused by Ripon's unstable geology and have led to the formulation of an Unstable Land Policy that goes further than many current local authority regulations. Photo by BGS

The Ripon City Plan's Unstable Land Policy goes much further than the current Harrogate Borough Council policy that only requires a competent person to prepare a report and sign a declaration form. RCP Policy No. 3 Unstable Land requires any development where gypsum is present below ground to have a Ground Stability Report and a Ground Stability Declaration Form prepared and signed by a Registered Ground Engineering Specialist or Advisor. It will not be acceptable for the design of any mitigation measure(s) to be the subject of disclaimer.

The dramatic Welsh coast has outstanding geology and scenery which attract researchers from around the world. Members of the International Geosciences Programme recently visited south-west Wales to view key Palaeozoic research sites. Many were GCR sites and RIGS, reinforcing the importance of conserving a comprehensive network of sites for research at the highest academic level. Ynys Lochtyn (above), near Llangrannog, provides exceptional views of the south Ceredigion coastline but also informative exposures spanning the Ordovician-Silurian boundary.

Photo by
Raymond Roberts/Natural Resources Wales

Earth Heritage in print

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