Earth Heritage

The Geological and Landscape Conservation Magazine

ISSUE 57
Summer 2022

Introducing Purple Horizons

Ice Age Ponds

Earth Lines: Geopoetry and Geopoetics

Maximising Scotland in Miniature: Arran Geopark Development

Obituary - Professor Chris King

Earth Heritage

Cover: **Cross-section view of solitary Rugose coral *Koninckophyllum*. Rugose corals have a hollow in the top surface known as the calice, where the animal (polyp) would sit. This fossil is from Petershill Nature Reserve in West Lothian. Large-scale rock excavation was causing significant damage to the geological interest of the reserve. Find out more on p.35. Photo by Katie Strang**

INSIDE

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NatureScot Scotland's Nature Agency Buidheann Nàdair na h-Alba

Cyfoeth Naturiol Cymru Natural Resources Wales

Geologists' Association 1858

Natural England

QRA Quaternary Research Association

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EDITORIAL

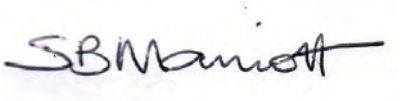
This issue brings reports on several Nature Recovery Network (NRN) projects that have been given impetus by the Government's 25 Year Environment Plan and Environment Act 2021. The aim of the network is to connect wildlife-rich places across the country, including urban areas, to help deal with the challenges of climate change, biodiversity loss and well-being. In so doing, amongst other objectives, establishing the network will reinforce the natural, geological and cultural diversity of the landscape, and protect the historic natural environment. There are further details on the NRN in Colin Prosser's article on page 14 - 16.

The Purple Horizons Project is a 4-year landscape-scale recovery project working across parts of Staffordshire to give better connectivity between Cannock Chase AONB and Sutton Park, near Birmingham. Details on this project can be found on page 17. Although not specifically NRN projects there are reports on progress in the Ice-Age Ponds projects in Herefordshire and Norfolk. These are ongoing projects aimed at increasing biodiversity thus helping to fulfil some of the objectives of the NRN. Other projects reported on in this issue demonstrate good examples of collaboration with all kinds of organisations. This is a skill we will all need if we are to engage in Nature Recovery Strategies.

Geoconservation is a time-consuming process and relies a lot on volunteers. Some groups were able to make progress during the lockdowns, however, and a couple of reports show how clearance work has re-exposed important sections of the Arden Sandstone in the Midlands and the Coralline, Norwich and Red Crags in Suffolk.

October 6th 2022 is the date set for the first International Geodiversity Day and events are planned all around the world. Check out the official website (https://www.geodiversityday.org/) for information and resources and share details of your local events on social media (#GeodiversityDay).

The Earth Heritage Editorial Board has started to plan Issue 58 and will be happy to feature articles about both new and ongoing geological and landscape conservation projects. To contribute, please contact the most appropriate editor (list on left).



Susan Marriott - Guest Editor

Celebrating International Geodiversity Day: What Will You Organize?

The importance of geodiversity has long been underappreciated, but that could all be about to change with the first International Geodiversity Day on October 6th. Now fully proclaimed as a formal commemoration of UNESCO, this day offers a new and exciting annual opportunity to engage the public with all the aspects of geodiversity. So how will you be involved?

On October 6th there will be events all around the world:

- online talks that inspire a new generation of geoscientists;
- exciting fieldtrips that promote the conservation of geoheritage;
- museum tours that explore the important resources geodiversity provides;
- visits to schools to bring to life students' local earth history.

It's an opportunity to promote better policy, to seek change from policymakers and for organizations to communicate the significance of geodiversity. But we need people in communities all around the world, organising events and promoting geodiversity, so that everyone has an opportunity to engage with this increasingly important topic.

If you would like to organize something, you can find more information and resources on the official website, geodiversityday.org. We are also encouraging people to share their event information—big or small—on the website, so we can promote the breadth of engagement via our map of events. Please also consider personal and organizational posts on social media using #GeodiversityDay.

For too long, the importance of the non-living elements of nature, from rocks and soils to fossils and landscapes have been overlooked. With your help, we can start to change that.

International Geodiversity Day Logo

By Jack J Matthews,
Oxford University Museum of Natural History

Precambrian rocks at Bradgate Park, Leicestershire. Photo by Jack Matthews

https://www.geodiversityday.org/

Geologists' Association Geology Photographic Competition 2022

A great opportunity for imaginative photography of geosites and geoheritage!

Up to three photographs on any geological topic can be entered. All entries will be put on display at the GA's Festival of Geology on 5th November 2022.

Amateur photographers only. But otherwise open to all – not just GA members.

First Prize £100, Second Prize £50, Third Prize £25.

Your entries will also be considered for inclusion in the 2023 GA Calendar which will be on sale at the Festival and may be published in the Geologists' Association magazine and used for publicising and promoting the work of the Association (full credit will be given).

It's easy to enter. To download the Geology Photographic Competition rules and entry form, please visit: https://geologistsassociation.org.uk/photocomp/

By Gerald Lucy, Geologists' Association

Spectacular folding of Palaeozoic rocks in the South Stack sea cliffs on Holy Island, Anglesey, Taken by Gary Eisenhauer. Second prize winner in the 2021 GA Photographic Competition.

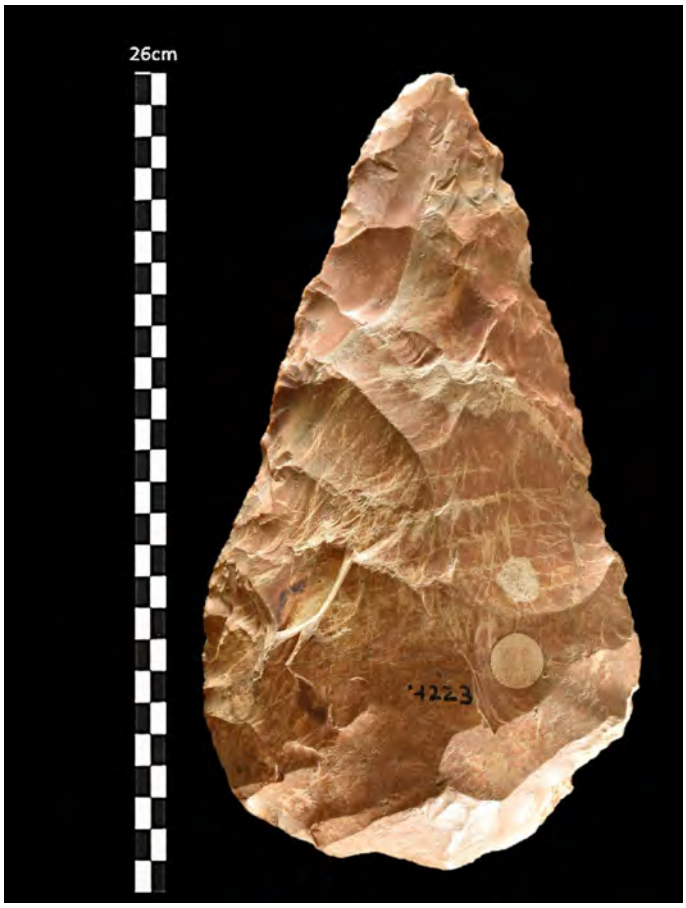
QRA Geoconservation Award

The Quaternary Research Association (QRA) has a Geoconservation Award which provides grants of up to £1000 to deliver Quaternary geoconservation projects and activities. Applications for the QRA Geoconservation Award can be for site-based works and off-site projects.

For Quaternary interpretation and public engagement projects, the QRA has an Outreach Fund https://www.qra.org.uk/outreach-funding/. For projects that combine Quaternary outreach and geoconservation, it is possible to apply to both funds at the same time.

The QRA Geoconservation Award and the QRA Outreach Fund both have two deadlines each year, 1st March and 1st September, although urgent applications will be considered throughout the year. For further information and application details, please contact the QRA Conservation Officer (conservation@qra.org.uk) and/or the QRA Outreach Officer (outreach@qra.org.uk).

By Michael Dempster, QRA Conservation Officer and James Lea, QRA Outreach and Liaison Officer

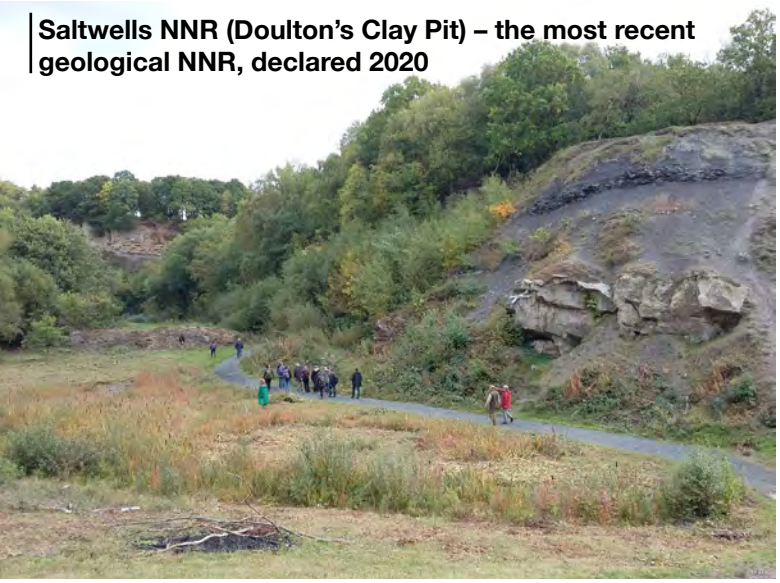


Quaternary Research Association

In 2019, Herne museum was awarded a grant from the QRA Geoconservation Award, to help with upgrading its facilities to house, conserve and curate these collections which are of local and national significance (reported in *EH*55) such as this massive subcordate handaxe collected by Dr Tom Armstrong Bowes from Whatmer Hall gravel pit, Sturry. Photo by Pete Knowles

Festival of National Nature Reserves 2022

Wren's Nest NNR (reef knolls and Wren's Nest Estate) – the first geological NNR, declared 1956. Photos by Jonathan Larwood



Saltwells NNR (Doulton's Clay Pit) – the most recent geological NNR, declared 2020

To find out more about the Festival of NNRs, join an event or organise an event please take a look at the Festival website: www.NNRfestival.com

This year Natural England is celebrating 70 years of National Nature Reserves (NNR) and on the 19th May the Festival of National Nature Reserves was launched to coincide with the declaration of the first NNRs on 19th May 1952.

Today, more than ever, NNRs are places where we are working together to achieve nature conservation, a better understand of the natural world through research and learning, and to connect with, discover and be inspired by nature.

Cavenham Heath (Suffolk), Ham Street Woods (Kent), Holme Fen (Cambridgeshire), Kingley Vale (West Sussex), Moor House (North Pennines), Yarner Wood (Devon) and Piltdown Skull Site (East Sussex) were the first group of NNRs to be declared in 1952. For the geologist, perhaps Piltdown Skull Site immediately stands out as this was the first geological NNR in England encompassing the location of the Piltdown Skull discovery. Even more uniquely, Piltdown became the first NNR to have its NNR status revoked when, in 1955, the Piltdown Skull was proved to be fake—one of the most infamous hoaxes in the history of science (see *EH* 40, page 15).

Fortunately, geology and NNRs have grown in strength and shortly afterwards, in 1956, the Wren's Nest NNR (Dudley, West Midlands) was declared to take the accolade of the first geological NNR in England. The most recent geological NNR was added in 2020 when Saltwells NNR (see *EH* 54, pages 23–26) was declared only a couple of miles from the Wren's Nest.

Today there are 225 NNRs in England and much geodiversity to be discovered. The purpose of the Festival is to connect more people and more diverse audiences with nature through NNRs, and Festival events aim to provide opportunities for more active participation, promote community engagement, and communicate the benefits of nature to society around the festival themes of 'Nature Recovery', 'Nature Discovery' and 'Nature Connection'.

By Jonathan Larwood, Natural England

Curling Stone Places

As many following Britain's recent Winter Olympics curling success may know, all modern curling stones are made by a single company out of microgranite from the small island of Ailsa Craig in the outer Firth of Clyde. The stones are in fact made of two types of microgranite: hard 'blue hone' is used for the running band (base) of the stone and Common Ailsa (also known as Green Ailsa) is used for the main body of the stone because it does not chip when impacting other stones. However, historically, curling stones were made by many different companies out of rock from many sources, with 19th century adverts offering stones from places such as 'Crawfordjohn', 'Burnock Water' and 'Muthill'. Crawfordjohn stones are known to have come from Craighead Hill Quarry near Abington, South Lanarkshire, which is now a GCR site and SSSI for its Carboniferous-Permian nepheline monzogabbro (Essexite). However, the exact source of many other curling stones is unclear. With considerable detective work, the Historical Curling Places website is compiling a location and information map, called 'Curling Stone Places', including information on both historical curling stone companies and historical curling stone quarries or sources.

By Rachel Wignall, NatureScot

Curling Stone Places website:
https://sites.google.com/view/historicalcurlingplaces/curling-stone-places

A pair of curling stones from 'Crawfordjohn' that came from Craighead Hill Quarry near Abington, in southern Scotland. Photo by Bob Cowan

Scottish Geology Festival 2022

Scotland's iconic landscapes and rugged coastlines have been shaped by the elements over countless millennia. The rocks beneath our feet hold the secrets of our planet's past. They are our foundation, influencing our culture and legends, and providing endless opportunities for enjoyment and discovery. Geology is not just a thing of the past; the Scottish Geology Trust aims to inspire people everywhere to understand, love and care for Scotland's incredible geological heritage and its role in creating a sustainable future.

This year the Scottish Geology Festival 2022 will tell the stories of Scotland's rocks and landscapes through a programme of activities from the 1st of September to the 9th of October. The Festival Programme will be launched online on the 5th of August and events will range from coastal walks and fossil hunting, to online and in-person talks. You will have the opportunity to explore extinct volcanoes in Edinburgh and the North West Highlands UNESCO Geopark. You'll encounter evidence of ancient tropical seas and coral reefs in Fife and learn how the ice age helped shaped Scotland's incredible landforms.

We are inviting organisations and individuals to submit events to the Festival, if you are interested please visit: www.scottishgeologytrust.org/festival or contact Dr Katie Strang on engagement@scottishgeologytrust.org

By Katie Strang, Scottish Geology Trust

Image © Dr Vivien Cumming

The Radical Road below Salisbury Crags within Holyrood Park. This route normally provides access to the locations made famous by James Hutton but was blocked by a rockfall event in 2018. The creation of virtual access will provide an interesting route for learning and engagement for this important geosite until visitors are permitted again. Find out more on p.45. Photo by Lorne Gill/NatureScot.

PUBLICATIONS

First the world - now England: *Exploring Geoscience* textbook

This article was drafted by Chris King, ready to accompany the *England* version of his major *Exploring Geoscience* online textbook. The *England* version was published on the IGEO website very recently, just as Chris was told that he was terminally ill. Sadly, he died on 17th February 2022 (please see his obituary in this issue on p 49). What a wonderful legacy to a truly remarkable man if this initiative were to be widely used and followed by many other customised versions of the book.

Peter Kennett

Most authors are distinctly unhappy if people plagiarise their work, but here is a book with a difference. *Exploring Geoscience Across the Globe* was written with the hope that it **would** indeed be plagiarised—and here we show how to do it.

We want to encourage geoscientists and geoscience teachers across the world to develop a textbook for their own country, region, state or even city. We have shown the way by developing *Exploring Geoscience Across the Globe – England*.

To do this, we took the original open source *Exploring Geoscience Across the Globe* (at: http://www.igeoscied.org/teaching-resources/geoscience-text-books/) and five of us worked together to:

- replace 280 of the 500 international photographs with photos from England;
- write forty new 'interest boxes' of interesting geological features in England, to add to the sixty international interest boxes; all intended to enhance the core text which just addresses the international geoscience syllabus (what we believe all sixteen-year-old students should know about geoscience, at: http://www.igeoscied.org/activities/international-geoscience-syllabus/);
- record the time all this took us.
- make available the result, which can now be seen at Exploring Geoscience across the Globe – England I International Geoscience Education Organisation (igeoscied.org)

Having done this, we can reveal to the waiting world that for the investment of 200 hours of time distributed among five people (i.e. 40 hours each on average, or just one working week), we were able to prepare a geoscience textbook for England. Such a thing has never been done before.

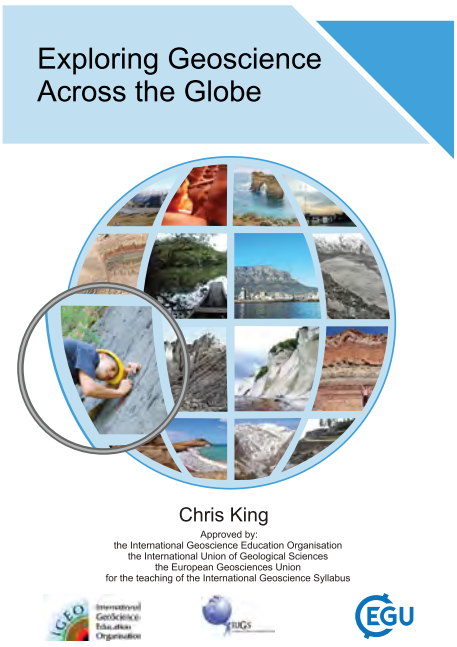
So wake up Scotland? Where are you Wales? What can you do in Ireland? A textbook for the Isle of Man? Anglesey? Yorkshire? Bristol?

If you live in a non-English-speaking area, you can do this too. The Turkish translation of *Exploring Geoscience Across the Globe* took Hükmü Orhan, recently retired from the Department of Geological Engineering at Konya

University, some 180 hours, with the help of his colleagues. So wake up world! For around 200 hours, you too can have a textbook of your own—educating and enthusing schools, teachers and students across your country.

Just contact Tanja Reinhardt at Reinhardtt2@ukzn.ac.za for a 'Word' version of the textbook and carry on. When you have finished, send it to us so that we can add a customised cover and a unique ISBN number and post it for free download on the International Geoscience Education Organisation (IGEO) website.

Research shows that the textbook resources in geoscience available to schools across the world are generally moderate, poor or non-existent. So what can you do?—write them a textbook! Between us we can educate the world for geoscience.



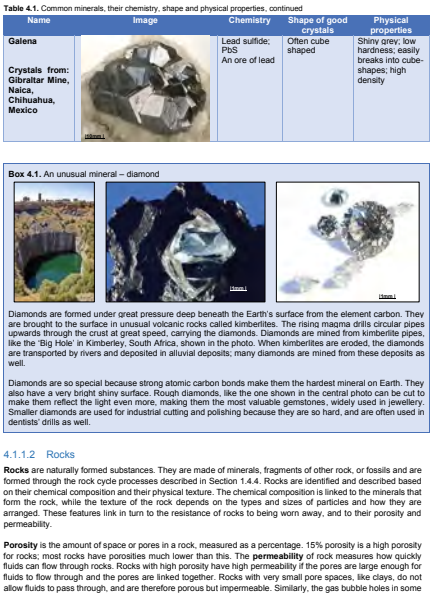


Table 4.1. Common minerals, their chemistry, shape and physical properties, continued

Name	Image	Chemistry	Shape of good crystals	Physical properties
Galena **Crystals from: Gibraltar Mine, Naica, Chihuahua, Mexico**		Lead sulfide; PbS An ore of lead	Often cube shaped	Shiny grey; low hardness; easily breaks into cube-shapes; high density

Box 4.1. An unusual mineral – diamond

Diamonds are formed under great pressure deep beneath the Earth's surface from the element carbon. They are brought to the surface in unusual volcanic rocks called kimberlites. The rising magma drills circular pipes upwards through the crust at great speed, carrying the diamonds. Diamonds are mined from kimberlite pipes, like the 'Big Hole' in Kimberley, South Africa, shown in the photo. When kimberlites are eroded, the diamonds are transported by rivers and deposited in alluvial deposits; many diamonds are mined from these deposits as well.

Diamonds are so special because strong atomic carbon bonds make them the hardest mineral on Earth. They also have a very bright shiny surface. Rough diamonds, like the one shown in the central photo can be cut to make them reflect the light even more, making them the most valuable gemstones, widely used in jewellery. Smaller diamonds are used for industrial cutting and polishing because they are so hard, and are often used in dentists' drills as well.

4.1.1.2 Rocks

Rocks are naturally formed substances. They are made of minerals, fragments of other rock, or fossils and are formed through the rock cycle processes described in Section 1.4.4. Rocks are identified and described based on their chemical composition and their physical texture. The chemical composition is linked to the minerals that form the rock, while the texture of the rock depends on the types and sizes of particles and how they are arranged. These features link in turn to the resistance of rocks to being worn away, and to their porosity and permeability.

Porosity is the amount of space or pores in a rock, measured as a percentage. 15% porosity is a high porosity for rocks; most rocks have porosities much lower than this. The **permeability** of rock measures how quickly fluids can flow through rocks. Rocks with high porosity have high permeability if the pores are large enough for fluids to flow through and the pores are linked together. Rocks with very small pore spaces, like clays, do not allow fluids to pass through, and are therefore porous but impermeable. Similarly, the gas bubble holes in some

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4.1.1.6 Metamorphic rocks

Metamorphic rocks are formed when sedimentary, igneous or older metamorphic rocks recrystallise in the solid state under increased heat and/or pressure. Rocks do not melt during metamorphism, otherwise they would become igneous rocks.

Most metamorphic rocks result from the increased heat and pressure of the mountain-building caused by plate collision. This is **regional metamorphism**. Under the intense conditions, some minerals are transformed into other minerals, some minerals recrystallise to become thinner and longer, while other minerals rotate until they are lined up at right angles to the direction of the pressure.

Metamorphic rocks also form when rocks are baked by a nearby hot igneous body. Since the mineral recrystallisation here is mainly by heat, and there is no tectonic pressure, the crystals in the new rocks are randomly orientated.

The type of metamorphic rock formed either by heat and pressure (regional metamorphism) or mainly by heat (**thermal metamorphism**) depends on the make-up of the rock it originally came from, as in Table 4.8.

Table 4.8. Classification of metamorphic rocks

Mineral composition		Quartz and clay minerals in mudstone or shale	Quartz in sandstone	Calcite in limestone
Common regional metamorphic rock types – see Table 4.9				
Increase in heat and pressure	Low-grade	Slate	Metaquartzite (or quartzite)	Marble
	Medium-grade	Schist		
	High-grade	Gneiss		
Common thermal metamorphic rock types				
Increase in heat		Hornfels	Metaquartzite (or quartzite)	Marble

Since metamorphic rocks are made of interlocking crystals, they are usually impermeable and resist scratching more than most sedimentary rocks. The regional metamorphic rocks can be identified from their aligned minerals. In fine-grained slate, they produce weaknesses in the rock, which can be broken into thin sheets along the weaknesses or cleavage planes. In coarser-grained schist, the aligned minerals can be seen reflecting the light in flashes when a specimen is moved. The minerals form bands in gneiss; sometimes the bands are deformed into complex folds. It is difficult to see any mineral alignment in metaquartzite or marble and so difficult to tell regional from thermal metamorphic metaquartzite and marble. Metaquartzite is like an impermeable hard, sugary sandstone; marble also can look sugary, but reacts with dilute hydrochloric acid. Hornfels is also hard and, being a thermal metamorphic rock, is formed of randomly orientated minerals, but these are usually impossible to see in this fine-grained rock.

Table 4.9. Common metamorphic rocks

Metamorphic rock	Images		Source of exposure image
	Specimen	Exposure	
Slate			Slate in a road cutting protected by rock anchors and wire mesh, Rothaar Mountains, North Rhine, Germany Devonian age

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The version of the freely available book Exploring Geoscience Across the Globe, customised for use in England.

Professor Emeritus Chris King was:
Adviser (past-Chair and instigator) of the Council of the International Geoscience Education Organisation (IGEO) and also a Past Chair of ESTA (the Earth Science Teachers' Association).

Excavation of a cursus trial pit on the Isle of Arran with the presenters from Glasgow's Jambo! Radio, the local community African-Caribbean Radio Station in Scotland. The smallest but perhaps most exciting find from the cursus excavation was this tiny piece of worked pitchstone. Pitchstone from Arran was traded across northern Britain predominantly in the Early Neolithic. Find out more on p.31. Photo by Gavin MacGregor, Northlight Heritage.

ARTICLES

Geodiversity as part of Nature Recovery – making the case

Colin Prosser, Natural England

Nature recovery and geodiversity

Nature Recovery and establishment of a Nature Recovery Network (NRN), delivered in a large part through the development of Local Nature Recovery Strategies (LNRS), is now established as the Government's primary means of delivering nature conservation in England, see the Government's 25 Year Environment Plan, the Environment Act 2021 and Nature Recovery Network - GOV.UK (www.gov.uk).

With a clear focus on nature recovery there are real opportunities for geodiversity as a fundamental element of nature. Geodiversity will both benefit from and contribute to the four aims of the NRN including the enhancement of designated sites, improving landscape resilience and, most importantly, reinforcing the geological diversity of our landscapes, and enabling us to better connect with nature. In detail the four aims are:

- enhance sites designated for nature conservation and other wildlife-rich places - newly created and restored wildlife-rich habitats, corridors and stepping stones will help wildlife populations to grow and move;
- improve the landscape's resilience to climate change, providing natural solutions to reduce carbon and manage flood risk, and sustaining vital ecosystems such as improved soil, clean water, and clean air;
- reinforce the natural, **geological**, and **cultural diversity** of our landscapes, and protect our historic natural environment;
- enable us to enjoy and connect with nature where we live, work and play - benefiting our health and well-being.

Furthermore, the Purple Horizons Nature Recovery Pilot Project, which is featured in this issue (see pages 17-22), provides an example of where geodiversity has been fully integrated into nature recovery already benefiting geodiversity and biodiversity—if it can be done here, it can be done in other places too.

Making the case for the inclusion of geodiversity and geoconservation in LNRS or specific nature recovery projects may be challenging, especially given that most partners setting priorities will have different aims and objectives. With this in mind, the following thoughts and checklist might be useful in making the case for the recognition of geodiversity in nature recovery and for an approach that delivers for all of nature in an integrated way.

Why is geodiversity relevant to nature recovery?

- Geodiversity is: *'The natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features, including their assemblages, structures, systems and contributions to landscapes'.* This is clearly an integral part of nature and the aim of 'Nature Recovery' is to recover 'nature'.
- England's geodiversity is extremely rich and of great importance for science, education, recreation and tourism.
- It is a product of natural processes operating in the past as well as those shaping our landscapes at present. It provides the only record we have of past environmental change and the evolution (and extinctions) of life on Earth.
- Geodiversity underpins and defines the character and distribution of our wide range of varied and locally distinctive landscapes, the nature and distribution of habitats, species and land use, and the cultural, social, and industrial identity and character of different parts of the country. It provides the 'stage' on which our wildlife and cultural heritage 'perform'.
- Geodiversity, like all elements of the natural environment, is subject to a range of threats, many of which arise from anthropogenic activity. Action to conserve, recover and enhance geodiversity will enrich nature and nature recovery.

What does good look like?

- Geological features and static geomorphological landforms are protected, visible and both physically and intellectually accessible;
- Geomorphological processes such as coastlines, rivers and mass movement are functioning naturally and helping support biodiversity;
- Geodiversity site series, including UNESCO sites, SSSIs, NNRs and Local Geological Sites, are recognised, conserved and recovered;
- Geodiversity and its relationship with landscape, ecology and cultural heritage is being used to help local people protect, understand, interpret and engage with nature, environmental change and cultural history;
- Where appropriate, geodiversity features are helping to support wider ecological nature recovery (e.g., through geomorphological processes and bare rock) and ecological features on biodiversity sites are, in turn, contributing to the conservation and recovery of geodiversity;
- 'Nature Recovery' strategies, plans and projects are holistic and integrated, conserving and recovering all of nature.

What are the benefits of including geodiversity in nature recovery?

- A more integrated holistic approach to nature recovery;
- A strong narrative for connecting, 'past', 'present' and 'future', and the opportunity to use geodiversity to engage with and connect local communities with nature;
- Engagement and interaction with the geodiversity/geoconservation community, tapping in to their evidence and expertise;

- Increased conservation and recovery of geodiversity through taking opportunities on existing biodiversity features and sites;
- Increased conservation and recovery of biodiversity through taking opportunities on existing geodiversity features and sites.

Getting involved

Local Nature Recovery Strategies (LNRS) are one of the main mechanisms for setting out priorities for nature recovery. It is anticipated that there will be around 50 county-based LNRS covering the whole of England, which will be developed through local partnership and collaboration. To become an NRN Delivery Partner and bring geological expertise, advice and time please contact Natural England's NRN Partnership Team at: NDPNaturerecovery@naturalengland.org.uk

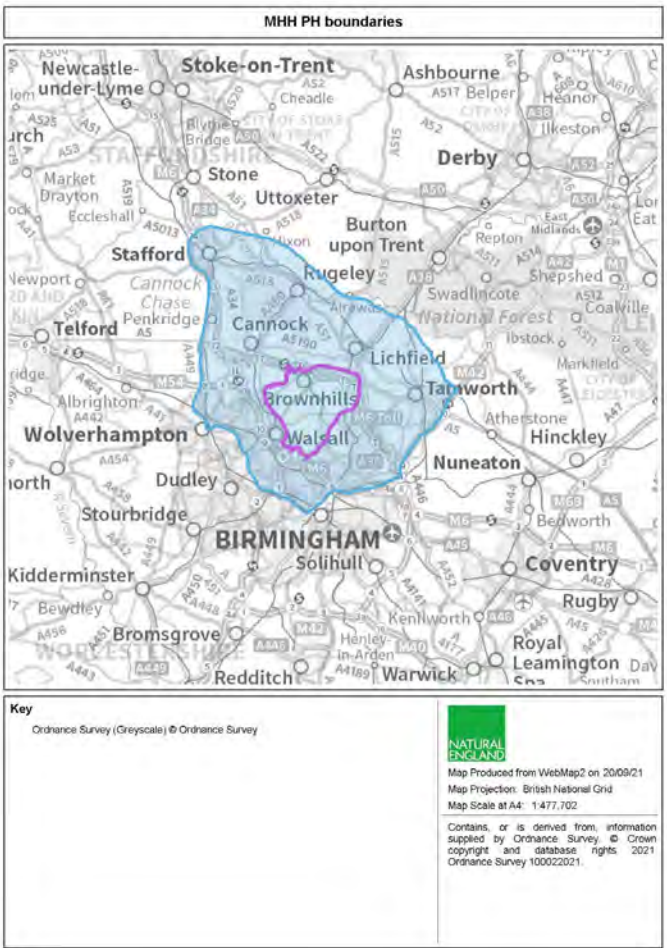
Checklist to assist in the inclusion of geodiversity within nature recovery

1) Is there any recognition of geodiversity as part of nature within the strategy, plan or project? ☐
2) Is the strategy, plan or project holistic and integrated with the conservation, recovery and promotion of geodiversity included within the scope of the plan, its objectives or the actions being taken? ☐
3) Is the presence of Local Geological Sites, geodiversity SSSIs and NNRs, and where appropriate UNESCO Global Geoparks/World Heritage Sites recognised and included? ☐
4) Is the designation of geodiversity features and management of geodiversity sites identified as a means of enhancing nature? ☐
5) Is the importance of naturally functioning geomorphological features and processes recognised and promoted? ☐
6) Are designated geodiversity sites being used to help recover biodiversity, and biodiversity sites being used to help enhance/recover geodiversity? ☐
7) Are local geodiversity/geoconservation groups and bodies involved in the scoping and delivery of the plan? ☐
8) Is geodiversity being used as a means of engaging with local communities, e.g., in promoting understanding of dynamic environmental change such as on coasts and rivers, in relation to climate/environmental change over time, or in making links to industrial/cultural heritage, especially in urban areas? ☐
9) Are sources of geodiversity evidence being used in planning and delivering nature recovery? ☐
10) Are there clear conservation and recovery outcomes for geodiversity arising from the proposed delivery plan? ☐
11) Are the outcomes in terms of the conservation/recovery of geodiversity being assessed? ☐

Introducing Purple Horizons - Geoconservation, landscape 'capability' and species recovery in the Black Country's urban fringe

Graham Worton, Keeper of Geology, Dudley MBC and coordinator of the Black Country UNESCO Global Geopark

The Purple Horizons project on the northern fringe of the Black Country UNESCO Global Geopark adopts a multi-disciplinary landscape approach as a new National Nature Recovery Project. It aims to re-establish a mixed mosaic of heathland habitats similar to one that existed naturally from the end of the last ice age (the Devensian), which had been the stable habitat balance here for thousands of years but became fragmented by human activity. Successful rewilding of this landscape to its original natural state requires the deep holistic understanding of its geology, topography, climate and ecology that this project will adopt. Purple Horizons also aims to develop better techniques for the management of the land through acquiring new knowledge and new themed interpretation exploring the area's geological connections should result in a deeper, more integrated, understanding of the heathland landscape.



Background to the Purple Horizons Project

The Purple Horizons is a four-year (2021–2025) landscape-scale Nature Recovery project extending across parts of Staffordshire, West Midlands and North Warwickshire. The core area covers approximately 10,000 ha and has been identified as a key location where there is a need for better habitat connectivity between Cannock Chase AONB and Sutton Park to the north of Birmingham. This overlaps with the northern edge of the Black Country UNESCO Global Geopark. It is the first flagship National Nature Recovery Project to be supported by Defra, and delivery of the project is part of Natural England's work delivering the Nature Recovery

The boundaries of the Purple Horizons project area and the Midlands Heathland Heartland Partnership area in relation to local authorities in the West Midlands region. (c) Natural England, contains Ordnance Survey data (c) Crown Copyright and database rights 2021 Ordnance Survey 100022021.

All photos by Graham Worton unless otherwise stated

Network element of the Government's 25 Year Environment Plan. In terms of the Geopark, two Geosites (Barr Beacon Local Nature Reserve and Shire Oak Quarry Site of Importance for Nature Conservation) are playing important roles in this project.

Geodiversity in this project is seen as key to success in improving habitats and attracting wider public interest. The team behind the scheme recognises the fundamental dependence of heathland habitats on specific geological and soil characteristics that are naturally present here and vital for the success of the heathland project as a whole.

Purple Partners, Vision and Priorities

The Purple Horizons partnership currently is a broad-based group of key stakeholders and a strong, trusting, cross-disciplinary and focussed partnership for the project has been established. This includes two Local Authorities, Natural England, the Environment Agency, Wildlife Trusts/EcoRecord, The Black Country UNESCO Global Geopark, The University of Birmingham, and others including 'Green Economy' partners in the private sector.

The vision for the project is to:

> *'create a thriving nature recovery network that is resilient to climate change. We want to see improved biodiversity, geodiversity and landscape value, enjoyed by people in a sustainable way. We will use a holistic, inclusive partnership approach to deliver change. We want to better manage, protect, expand and enhance lowland heathland and associated complementary habitats...'*

Whilst this is a dominantly biological, resilience-based project, deep understanding of the history of the landscape, its ability to support ecosystems and their ability to adapt to change are essential in planning and taking appropriate

Changes in vegetative cover (Scrub, Bramble & Sycamore self-set) at Pinfold Lane Quarry Barr Beacon Geosite as demonstrated by fixed point photography over 13 years, from 2009 at the top to 2022 in the bottom image.

and intelligent action. These actions, whilst designed to deliver desired biological outcomes also deliver on geodiversity objectives and interlinked Sustainable Development Goals (SDGs) established by the general assembly of the United Nations in 2015 as key objectives in delivering environmental objectives. The Purple Horizons project priorities are:

- Actions that will counter/reverse ongoing biodiversity loss;
- Actions that will establish a natural landscape that is more resilient to adverse climate change;
- Actions that foster better human interactions and enhance appreciation of the local landscapes and improve access and enhance well-being.

What a Difference A Year Makes!

In the first year of the project, discussions defined a set of immediately useful actions on the ground—a set of 'baseline interventions' that establish a foundation to build on and allow impacts to be monitored to inform future decisions and direct future actions. In these discussions the loss of habitat, particularly for heathland pollinators, was identified as a particularly significant issue. The Geopark team was able to introduce the evidence of significant and ongoing loss of important pollinator habitats due to significant scrub and bramble encroachment on important rockface habitats at Barr Beacon and Shire Oak Geosites. Fixed point photography spanning 20 years shows how much the accessible rockface had changed in that time, particularly through bramble and sycamore sapling spread.

Similar vegetative encroachment on green spaces in other green areas of Walsall Metropolitan Borough had seen significant change in biodiversity. A programme of immediate on-the-ground interventions was drawn up, funded by the project and executed

Changes in vegetative cover (Scrub, Bramble & Sycamore self-set) at Shire Oak Quarry Geosite as demonstrated by fixed point photography over 20 years, from 2002 at the top to 2022 in the bottom image.

well in advance of the nesting season in 2022. This included the return of these rockfaces and soil profiles to much more favourable conditions for pollinators, in particular burrowing bees and wasps, with the added benefit of additional geological exposures.

Interpreting the Geodiversity and its importance to heathland habitats

When carrying out such extensive works on the ground, particularly where they appear to be damaging the green landscape, it can attract uninformed criticism. In anticipation of this, experienced teams were ready to talk and present information about the works to any enquirers, particularly why works were occurring and the larger purpose. This has very effectively dealt with concerns expressed and has begun the awareness campaign at the same time.

An important part of the first-year actions was to design and get in place quickly interpretation and public information. To date the provision of more detailed site-based information and online sources has been the focus. An early decision to make these attractive and sculptural was taken and a design team was appointed. Geopark and Local Authority representatives advised on storylines and information with designers suggesting presentation style. This takes the theme of the 'Sands of Time' reflecting the fundamental role that sandy rocks, passing time and soils have in the heathland ecosystem and its sustainability.

The project is also gathering important new information about the habitats and best practice in managing them. Monitoring will assess the particular ecosystems on these sites, the management practices and observe change over the coming years. Dedicated to this is a PhD research project with the University of Birmingham and the Wildlife Trust for Birmingham and the Black Country/ EcoRecord. This project will survey biodiversity regularly at the sites where groundwork has occurred. This will observe maturing geodiversity and biodiversity changes, climate change responses and help to understand which particular interventions are most effective.

Queen Red-Tailed Bumblebee and wasp burrow observed at Shire Oak Quarry rock exposures shortly after clearance works in February 2022.

Examples of the new themed 'Sands of Time' interpretation to be installed at Barr Beacon's Pinfold Lane Quarry and Shire Oak Quarry. Photos by Jeff McBride

Sustaining the purple heartlands

The relative lack of dynamic active erosion systems, or extensive grazing in inland settings such as the Midlands lowland heathland means that sustaining these habitats will require adjustments in existing management practices. Without grazing and natural erosion/active quarrying, or active human intervention, the landscape will ultimately default to forest. The key to maintaining heathland in the least intrusive way is through understanding all the factors that keep them healthy and vibrant, and the timescales over which different interventions take effect and last.

The Purple Horizons Nature Recovery project is therefore looking into a multitude of mechanisms to ensure that necessary interventions are understood and resourced in the future.

Another key element of the Purple Horizons scheme is working with emerging ideas and evolving schemes for financing environmental projects such as this. Agendas relating to biodiversity net gain, and carbon offsetting are creating a wider dialogue with developers and the business sector that can yield funding to maintain such schemes (from 2023, most developments will need to demonstrate that they can/will deliver a minimum of 10% Biodiversity Net Gain (BNG) as it will become mandatory as part of the Environment Act at that time). The BNG system does not cover certain works for obvious reasons (e.g., interpretation—as that does not directly yield more habitat/greater numbers of species for example) but it does yield opportunities for funding groundworks beneficial to biodiversity. Purple Horizons will help to demonstrate the role of geological sites in BNG and so create best practice suitable for further/repeat actions and funding under this mandatory requirement.

The project is also investigating the generic environmental and good-cause interest of businesses (including the leisure and tourism sector), both as a tool for publicity for companies and in terms of energy/carbon offsets and ethical green supply chains, so other funding mechanisms for 'natural' projects may emerge in this process.

Conclusions

Successful sustainable Nature Recovery projects depend on a wide understanding of all the elements of a landscape that is being restored. Both geodiversity action and biodiversity action are required to secure the best possible outcomes in such schemes, and both have been specifically designed into the Purple Horizons project in recognition of this. Significant groundworks on sites have occurred in year one of the project. These are targeted around heathland enhancement at two Geosites of the Black Country UNESCO Global Geopark. These have laid robust natural foundations for acquiring new knowledge and provide immediate areas of improved habitat for key groups of animals such as pollinators whilst simultaneously enhancing the geological assets of the landscape. Through this project we have already secured greater areas of rarer habitats such as bare soil and rock and created more resilient future natural 'purple' heathland landscapes. We have also told their deeper landscape story in attractive sculptural ways and have confidence that there will now be better understood, appreciated, and better managed landscapes on our doorstep as a result.

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Norfolk's Ice Age Ponds

Tim Holt-Wilson, Norfolk Geodiversity Partnership

Norfolk's Ice Age ponds are part of a group of relict, ground-ice landforms dating back to the last cold period (the Devensian, the last full glacial of the Pleistocene) which ended about 12,000 years ago. The Norfolk Geodiversity Partnership has joined a multi-disciplinary project aiming to enhance wetland biodiversity associated with these ponds. In the process we hope to learn more about their history and human interaction with the ponds.

We know the ponds formed in periglacial conditions associated with cold, non-glacial environments characterised by permafrost i.e. permanently frozen ground. Permafrost has an 'active layer' near the surface which thaws in summer. The effects of permafrost can be seen in East Anglian soils in the form of blotchy cropmarks. There are also examples of relict ground-ice depressions (GIDs), often containing ponds today. The great age of these ponds has been confirmed by analysis of fossil pollen in their mud, demonstrating late-glacial pollen assemblages of steppic and boreal forest types.

A relict ground-ice depression at Stow Bedon & Thompson Common. As well as containing fossil pollen dating back 10,000 years, the Common has a very diverse water beetle fauna. There is an isolated population of a rarity called *Hydroporus glabriusculus* with a boreal, northern European ecological range today, suggesting it has been surviving here for the past 10,000 years.
All photos by Tim Holt-Wilson unless otherwise stated

An aerial view of a lithalsa or palsa field in Lapland. Some ice mounds are actively growing while others have collapsed to leave ponds. Image courtesy Dentren at English Wikipedia, CC BY-SA 3.0 license, via Wikimedia Commons.

The periglacial ponds in Norfolk are typically between 10 and 30 m across and tend to have ramparted edges. They originated as ice mounds, formed through either injection ice or segregation ice. Pingo landforms are formed by injection ice, either where water is injected upwards under hydraulic pressure, e.g. above springs, to form a blister of ice, or where water is trapped between layers of frozen ground, becomes pressurised then erupts upwards. Palsa and lithalsa landforms are formed by segregation ice, where ice lenses grow in water-retentive materials: in peat (for palsas) and in mineral material (for lithalsas).

When the ice mounds melt they typically form ramparted ponds. Ramparts develop during the cyclical growth and decay of the mound. As it grows, in summer time it shrugs off overlying surface layers which slump down round the edge to form a ring. This can go on for many seasons, but eventually the ice core melts, leaving a ramparted pond. Examples of likely ancient pingo and lithalsa ponds have been identified in Norfolk at Didlington, Foulden, Hockham, Thompson, West Walton and Wretham; several of them have a history of geological research.

Watering Farm is adjacent to the Thompson Water, Carr & Common SSSI. Old OS maps show clusters of relict GID ponds on the valley floor and there are damp depressions visible today in the fields south of the SSSI: there were evidently more ponds in the valley in the past. The Norfolk Wildlife Trust has bought these fields as part of a wetland ecological enhancement project. The idea is to excavate the depressions to create new biodiverse ponds. Work began in 2019 in partnership with the Norfolk Ponds Project (https://www.norfolkfwag.co.uk/norfolk-ponds-project/) to monitor water levels and evaluate the possibility of biologically viable seed banks entombed in the mud. Four depressions were excavated in 2019. The Norfolk Geodiversity Partnership (https://sites.google.com/site/norfolkgeodiversity/), Brighton University (https://research.brighton.ac.uk/en/persons/lorna-linch) and Dr David Robertson (@archaeologyeast) joined the project, gathering information about the

***Right*: Prof Carl Sayer (UCL) and Dr Charles Turner (Cambridge) checking the biodiversity regeneration potential of plant material in a core sample from site #2. There was a layer of dark, organic-rich mud containing fragments of prehistoric heat-crackled flint and bits of animal bone. This layer was overlain by diamictic sandy clay containing drainage pipes and bits of plastic—evidence of human disturbance. The basement was natural, periglaciated chalk.**

***Left*: A section through site #8, showing periglaciated chalk basement overlain by compressed, dark organic-rich mud; a sample of wood from this layer is being sent for radiocarbon dating. Above this, the diamictic, brown and yellowish coloured clayey layers are backfill by a farmer. Scale: 1 m.**

pond sediments and associated archaeology, as an exercise in 'rescue geo-archaeology' recording and sampling exposed features revealed by the destructive excavation process. A further five depressions were excavated in September 2021.

Further palaeo-environmental work is planned for 2022. Dr Lorna Linch (Brighton) has secured funding for pollen analysis and radiocarbon dating. The 'palaeo team' would like to obtain pollen core samples from relict pingo ponds in the adjacent Thompson Carr, to compare with those from the disturbed sites at Watering Farm. The project is an example of partnership working with benefits for Earth science and geoconservation. Preliminary findings suggest that the mud in the depressions in the field has low potential for plant regeneration from buried seed banks. It will be interesting to see how the new ponds become colonised over the next few years.

Conserving Herefordshire's Ice Age Ponds

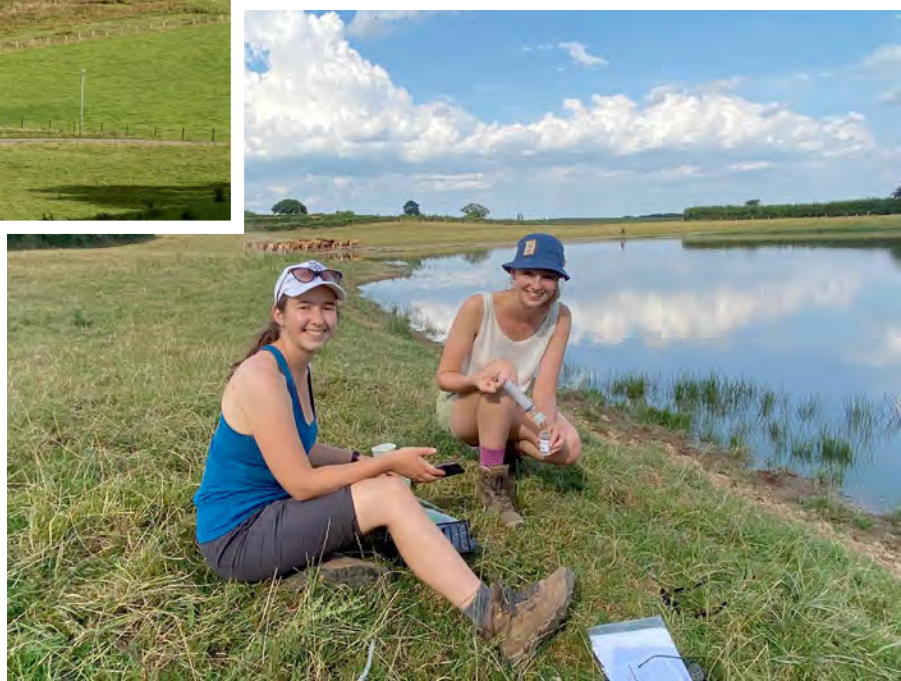
Beth Andrews, Herefordshire and Worcestershire Earth Heritage Trust

***Conserving Herefordshire's Ice Age Ponds* has been a partnership project delivered by Herefordshire Wildlife Trust, Herefordshire and Worcestershire Earth Heritage Trust and Herefordshire Amphibian and Reptile Team over the last three years. Funded by a £252,600 grant from the National Lottery Heritage Fund, the project has raised awareness of the geological story behind the formation of the ponds and the ecological value they have within the landscape today.**

Towards the end of the Devensian Ice Age, 23,000 years ago, a glacier from the Welsh mountains covered north-west Herefordshire and reshaped the landscape, leaving behind gentle hummocks and intervening depressions; some of these became ponds which still exist in the landscape today. Across the UK only 2% of ponds are thought to be natural ponds. Of these, probably only 1% are of Ice Age origin, but within Herefordshire this rises to 25% and the ponds are a significant natural resource. Many of Herefordshire's ponds do not hold water all year. Some are only wet during late winter and spring, making them more difficult to spot. They are poorly understood by the public and landowners and more prone to being disregarded, ploughed, drained or destroyed.

Despite the global pandemic, the project partners worked with volunteers throughout the project on desk-based surveys of both historic and modern maps, and later on walking surveys. This work

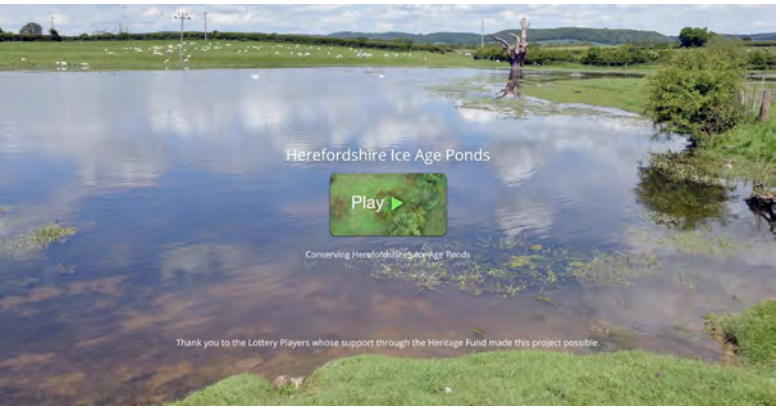
Ice Age ponds are typically found in areas of hummocky moraine, without source or outflow. They are important not only for the wildlife that they now contain, but also for the sediments, including peat, stored within them. These sediments can be up to 8 m deep and have a pollen record dating back over 10,000 years. Photo by Will Watson



The project has trained volunteers to carry out surveys of Ice Age ponds using maps and aerial photographs and to record their location, size and ecological details including water quality. Photo by Sarah King

The use of ground penetrating radar and electrical resistivity tomography to study the subsurface structure of Ice Age ponds, has allowed reinterpretation of the mode of formation to include ground ice depressions linked to the interaction of permafrost and the retreating glacier, and potentially small pingos, as well as previously described kettle holes. Photo by Olivia Verplancke

Interpretation produced for the project includes a free app that features walks, bike and driving trails around the region—including the option to capture a VR photo of some of the Ice Age megafauna. To make the information accessible away from sites there is a dedicated website: iceageponds.org. Photo by Ian Fairchild



The website iceageponds.org includes an excellent 11-minute video showing the project activities and interviewing participants. It demonstrates that this project has been an outstanding example of collaboration between geologists with some excellent outcomes. Photo from home page of iceageponds.org.

suggested that there were around 1600 potential Ice Age ponds within the project area and at least 600 of them still exist. Once practical training could recommence, using a mixture of online and in-person sessions, volunteers visited and carried out detailed pond surveys. To date over 100 ponds have been surveyed in detail and this work will carry on during the spring of 2022.

Despite the value of the ponds and the number of them in the project area, few studies have looked specifically at them. As part of the project the partners aimed to increase their understanding of different aspects of Ice Age ponds, and three student projects contributed to this. One student carried out pollen analysis on a peat core from a newly discovered Ice Age pond. An MSc student investigated modes of formation of Ice Age Ponds using practical geophysical surveys and comparative geomorphological mapping of contemporary glacial features using GIS. This work demonstrated that there are potentially several modes of formation for the ponds across the project area.

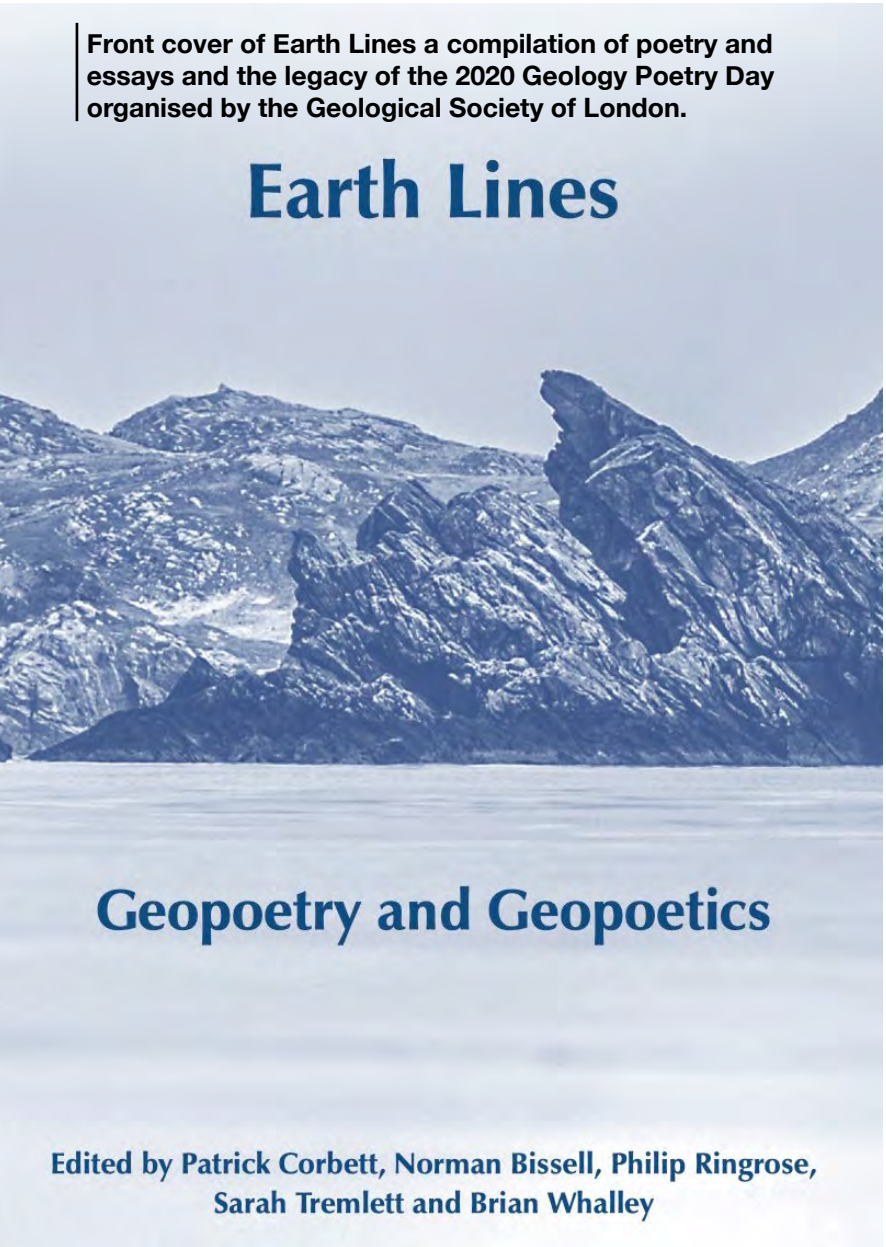
Ice Age ponds do not have inflows or outflows, making them very susceptible to localised inputs. Detailed water testing, carried out on 20 ponds, showed that nearly all of the ponds had raised levels of phosphate throughout the year but for the majority of sites, nitrate was not an issue. We have used this information to provide management suggestions to landowners to help preserve these ponds into the future.

Detailed ecological surveys of many ponds were carried out during the project. This revealed that Ice Age ponds are often the only recorded sites within Herefordshire for several species of plants and invertebrates—including some that had not previously been recorded in the county. As a result of the project a new Nature Reserve has been purchased by the Herefordshire Wildlife Trust which includes 4 Ice Age ponds, and geological and ecological aspects are being included in the management and interpretation of the site.

Earth Lines: Geopoetry and Geopoetics

W. Brian Whalley, Department of Geography, University of Sheffield

In October 2011, Dr Bryan Lovell—then President of the Geological Society of London (GSL) organised a *Geology Poetry Day* under the auspices of the GSL and held at Burlington House. The day brought together geologists and poets, and poet-geologists, to talk about and recite some 'geological poetry'. Although a successful meeting, it took nearly ten years before a follow-up event took place on National Poetry Day (1st October) 2020. This was to have been a live event with readings, talks and walks held in Edinburgh. As we all know, COVID-19 strictures rather upset plans and *GeoPoetry 2020* was held online. One advantage of the online event was the wide attendance (some 100+) worldwide. The event was organised by Patrick Corbett (Heriot-Watt University) for the Geological Society of London with a supportive team and sponsors including the *Scottish Poetry Library*, the *Edinburgh Geological Society*, the *Scottish Centre for Geopoetics* and the *Scottish Energy Forum*. The day's poetry and presentations were recorded and is available on YouTube. Importantly however, the legacy is also a book (Corbett *et al*., 2021) *Earth Lines: Geopoetry and Geopoetics* published by the Edinburgh Geological Society.



Front cover of Earth Lines a compilation of poetry and essays and the legacy of the 2020 Geology Poetry Day organised by the Geological Society of London.

The publication, from some 45 contributors, broadly follows the live presentations and covers a wide range of topics of *Earth Heritage* interest. As well as overviews of some poetry linked to geology and geopoetics and the legacy of early geologists to those of the present day, sections include, 'Stratigraphy', 'Geological processes', 'Geologists at Work', 'Geoidentity' and 'Geopoetics'.

Notable geologists of the past are present. Charles Lapworth has a photograph and mention in Michael Davenport's *Upheavals.* Also in Scotland's far north-west:

> *"Peach, Horn and Clough tough in tweed*
> *Unravelled your mysteries Old Boy,*
> *Gave you your name."*

in Stuart Graham's *Old Boy*.

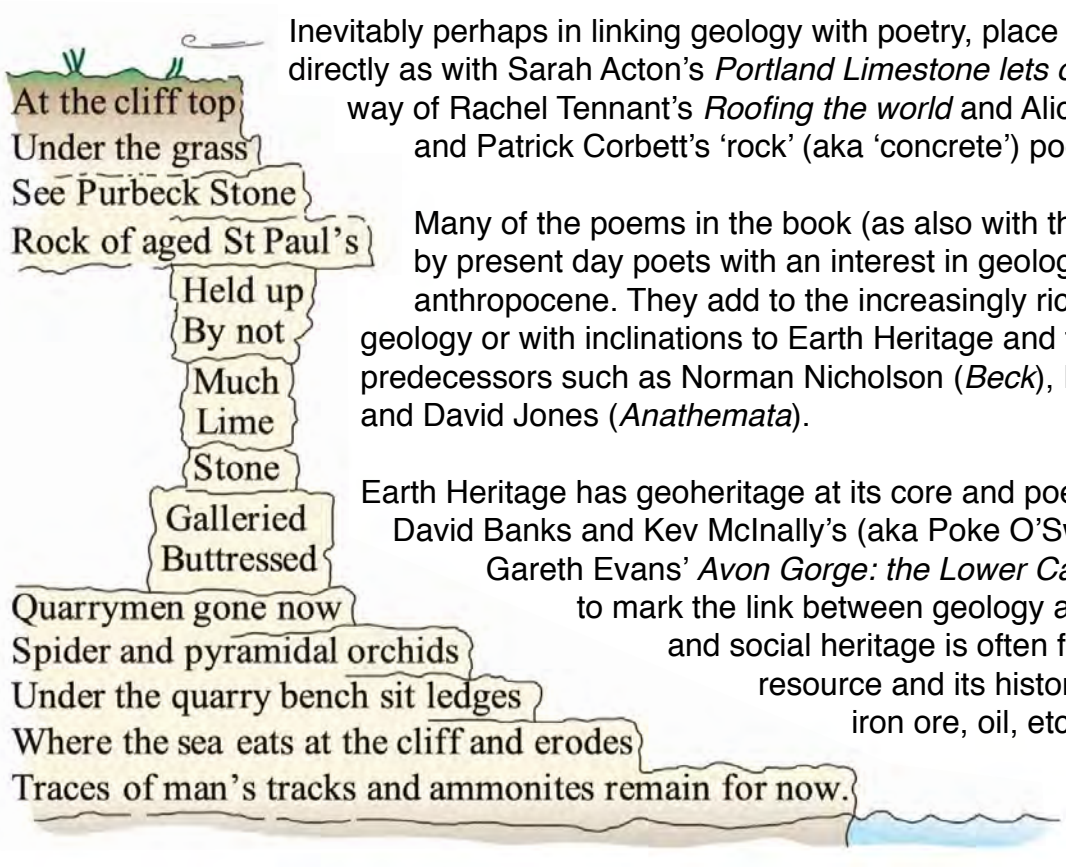
Another wrangler with complex sequences, this time in Cumberland, was John Marr who, in an 1890 notebook, complained:

"A plague upon lavas and ashes,
Agglomerates also be banned,
Away with contortions and smashes;
Such games I don't understand."

The poet Yvonne Reddick, whose interest in geopoetry stemmed from her father's occupation as a petroleum engineer, takes the reader on a geological scramble, *Voices of Rock,* around and up Arthur's Seat, noting above Salisbury Crags "They look like lines of poetry!". There are few better ways of considering Earth Heritage than to walk the paths and see the landscape that poets have turned into wordscape. In future, technology will also bring the sounds of their voices back to us.

"The first woman geologist in America", Florence Bascom, is commemorated in a poem by John Hegley whose accompanying cartoon shows her with a slab of rhyolite (remembering that metarhyolite was named by her). At the Geopoetry day, John Hegley also set a caption competition—the cartoon and winning caption indicate, perhaps, that not all geology has to be treated with respect!

The 2020 Geology Poetry Day caption competition, reproduced on p 15 of *Earth Lines*, was won by Vic Parsons with the entry: "All right clever clogs, so it's Neoproterozoic, it's still a bugger to move" .



***Purbeck Cliff Stone* a concrete poem by Patrick Corbett**

Inevitably perhaps in linking geology with poetry, place names conjure images, directly as with Sarah Acton's *Portland Limestone lets off steam*. Or indirectly, by way of Rachel Tennant's *Roofing the world* and Alice Major's *Mazama Ash* and Patrick Corbett's 'rock' (aka 'concrete') poem *Purbeck Cliff Stone*:

Many of the poems in the book (as also with those named here) are by present day poets with an interest in geology and/or the anthropocene. They add to the increasingly rich genre of poems about geology or with inclinations to Earth Heritage and to those renowned predecessors such as Norman Nicholson (*Beck*), Edwin Morgan (*Eohippus*) and David Jones (*Anathemata*).

Earth Heritage has geoheritage at its core and poems and songs such as David Banks and Kev McInally's (aka Poke O'Swedgers) *Vigo Lane* and Gareth Evans' *Avon Gorge: the Lower Carboniferous* serve well to mark the link between geology and heritage. Industrial and social heritage is often founded on a geological resource and its historical exploitation (tin, coal, iron ore, oil, etc.).

The poems, short essays and images in *Earth Lines* provide an introduction to exploring the longstanding poetic links between landscapes and landforms, geology and poetic-landscape writing, comment and imagery. *Earth Lines* should provide an excellent (and inexpensive) showcase of poets past and present that will be of interest to Earth Scientists and Earth Heritage from all directions. You never know, a theme of a 'National Poetry Day' of the future might be 'Earth Heritage'. This collection will hopefully show the way.

Further Information

Scottish Centre for Geopoetics:
http://www.geopoetics.org.uk/

Recording of the '*GeoPoetry 2020*' online event:
https://m.youtube.com/watch?v=Xzs5YMhJiAk

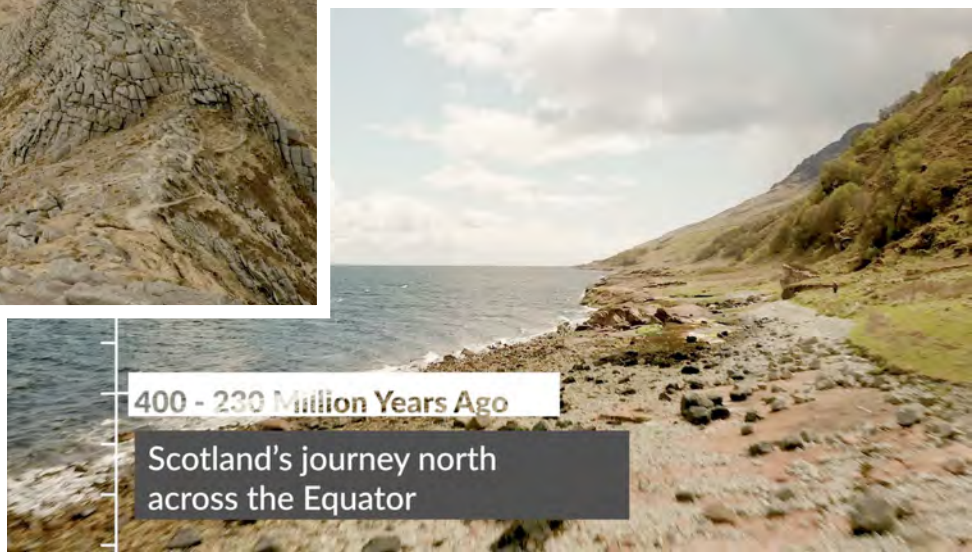
Publication details of *Earth Lines* on the Edinburgh Geological Society publications pages:
https://www.edinburghgeolsoc.org/publications/geological-excursion-guides/

Maximising Scotland in Miniature: Geopark Development on the Isle of Arran

Malcolm Wilkinson, Project Coordinator, Arran Geopark

'Scotland in miniature' is the old moniker for the Isle of Arran, situated in the Firth of Clyde on Scotland's south-west coast. Our oldest rocks in the north of the island, outliers of the rocks of Highland Scotland, are separated from younger rocks in the south by the Highland Boundary Fault; echoing mainland Scotland's Highland and Lowland geology and also its topography. The rich variety of rock types and structures on Arran has provided a world-class teaching ground for generations of students. A third of the island's 430 square kilometres are protected for their geological interest and the island is home to 13 Geological Conservation Review sites. The record of shifting continents and ancient environments that stimulated James Hutton's thinking, continues to captivate those who crave a deeper understanding of the island and its place in Earth's history.

Our island's geodiversity records an extraordinary story, and it was this story that Arran Geopark was formed to champion—back in 2017. It is this geoheritage that forms the basis for a whole host of other stories. As an aspiring Geopark, working towards UNESCO Global Geopark status, we endeavour to "*promote the links between geological heritage and all other aspects of the area's natural and cultural heritage".* In doing so we aim to show that *"geodiversity is the foundation of all ecosystems and the basis of human interaction with the landscape".* In summary: it's not all about the rocks!



Screenshots from the Arranology series of films which showcase the island's unique blend of heritage and its stunning landscape. The professionally produced films are presented by local people and were generously supported by Highlands and Islands Enterprise. Left: Arran's granite ridges: the view from Goatfell towards North Goatfell. Caisteal Abhail is the leftmost peak, with the prominent cleft of Ceum na Caillich (Witch's Step) to its right. Right: Permian sandstones exposed on the raised beaches of Arran's north coast near Laggan. Photos from Arranology, The Big Story.

'Gaelic in the Landscape' guided walk at Fallen Rocks, near Sannox. The boulders are Devonian conglomerate. Arran's north coast presents a diverse range of geological, geomorphological, archaeological, and historical sites. Photo: Arran Geopark

How do we integrate our geoheritage with our natural and cultural heritage; both tangible and intangible? This was the question that we mulled over as we developed the Geopark over the last few years. One answer is summed up in the term "Arranology" which celebrates our proud heritage of geology, ecology, and archaeology. It is the melding of all these things which together form the beautiful island that we are proud to call home. This concept was distilled in a series of films produced last year, each celebrating one of these interlocking specialisms.

Conservation and sustainability are crucial areas of work for all Geoparks and here on Arran, where our natural heritage is our most valued resource, we strive to take an active role. Last season the Geopark formed a Ranger Service, funded by NatureScot, which was tasked to manage the island's most popular sites; in a season that saw a dramatic increase in visitors to Scotland's countryside. The Ranger Service encouraged responsible behaviour and undertook practical action such as litter picking, path maintenance, non-native invasive species work, led guided walks, and organised volunteer meets.

Promotion of our intangible heritage has been another area of growth for the Geopark. Language, especially indigenous languages, are intertwined with nature and landscape—reflecting the once close connections that people had to the land and providing unique insights into past ways of life. As a result, we have begun an exploration of the influence of Gaelic language and culture on the island through a series of guided walks, events, and development of interpretation materials. On an island that lost its last native speaker almost half a century ago, we believe that it is vital that we take care for the conservation of Gaelic—just as we take seriously the conservation of our land and waters. This project has been kindly supported by North Ayrshire Council.

***Right*: The cursus trial pit excavation with the presenters from Glasgow's Jambo! Radio, the local community African-Caribbean Radio Station in Scotland, who have teamed up with Dig It!, the hub for Scottish archaeology, as part of a Heritage Lottery funded project. A podcast series is due to be released on the Archaeology Podcast Network resulting from the collaboration. Photo: Gavin MacGregor, Northlight Heritage.**

***Left*: The smallest but perhaps most exciting find from the cursus excavation was this tiny piece of worked pitchstone. Pitchstone from Arran was traded across northern Britain predominantly in the Early Neolithic. Photo: Gavin MacGregor, Northlight Heritage.**

Facebook/Instagram/Twitter: @ArranGeopark
Website: www.ArranGeopark.co.uk
Email: info@ArranGeopark.co.uk

Research is another area the Geopark is keen to support and to highlight to a wider audience. Although fieldwork has been curtailed over the past couple of years, there have been some interesting developments on the island. One of the first field studies following lockdown was from Aberdeen University, who developed extremely high-resolution 3D models of a number of important geosites. The first to be published is of Drumadoon sill, a spectacular outcrop on the west coast. Arran is also fortunate to be entirely covered by a detailed LiDAR study; analysis of which has uncovered a multitude of new archaeological sites. Perhaps the most significant is of a cursus, a Neolithic ceremonial structure, formed of earthworks and over a kilometre long. A trial pit was excavated last year by Glasgow University and Northlight Heritage; more extensive investigations are being planned.

The effects of increased frequency and severity of storms means that island communities are particularly attuned to the changing climate. They are also perhaps well placed to lead efforts of adaption, mitigation, and education. We commissioned a flood risk assessment to look at the future of an important section of the Arran Coastal Way, one of the island's busiest sections of footpath,

Aerial view of the Palaeogene columnar jointed sill at Drumadoon, near Blackwaterfoot. The sill was recently modelled in a detailed unmanned aerial vehicle (UAV) survey by researchers from the University of Aberdeen. Photo: from Arranology, The Big Story.

which is highly vulnerable to coastal erosion. The assessment included a public information event to increase awareness of the likely impacts and timescales of the change. It is hoped that lessons from the management of the route, as the coastline retreats, can be used elsewhere on the island and in other coastal communities.

The next step for Arran Geopark is to begin work on the application to UNESCO, which starts the almost 2-year validation process. We continue to work building partnerships with the community, businesses and other organisations to promote our heritage and the value that the UNESCO designation could give to the island. We are keen to hear from interested individuals or groups who feel they could participate in this process as we develop the Geopark.

Further Information

Global Geopark Network, Mission Statement - https://globalgeoparksnetwork.org/?page_id=202

Arran Geopark, "Arranology" Films focussing on the geology, archaeology and ecology of the island - www.arrangeopark.co.uk/arranology

Local Priorities of North Ayrshire Community Planning Partnership - http://northayrshire.community/your-community/arran/our-local-priorities/

NatureScot press release concerning a funding boost to improve Scotland's visitor hotspots - https://www.nature.scot/funding-boost-improve-scotlands-visitor-hotspots

Gaelic in the Landscape - https://www.nature.scot/doc/gaelic-landscape-place-names-north-west-highlands-ghaidhlig-air-aghaidh-na-tire-ainmean-aite-ann-iar

3D model of Arran's famous Drumadoon Sill (Jess Pugsley, VOG Group) https://v3geo.com/model/307

Scottish Government's Scottish Remote Sensing Portal, LiDAR for Scotland Phase II DSM, https://remotesensingdata.gov.scot/data#/map

CANMORE, Site Record for Arran's, Torbeg Neolithic archaeological site - https://canmore.org.uk/site/360276

Study of coastal erosion effects on the Fisherman's Walk path in Brodick (Arran: Flood Risk Assessment & Options Appraisal) - https://www.arrangeopark.co.uk/fishermans-walk/

Petershill Nature Reserve: the challenge of conserving an overexploited resource

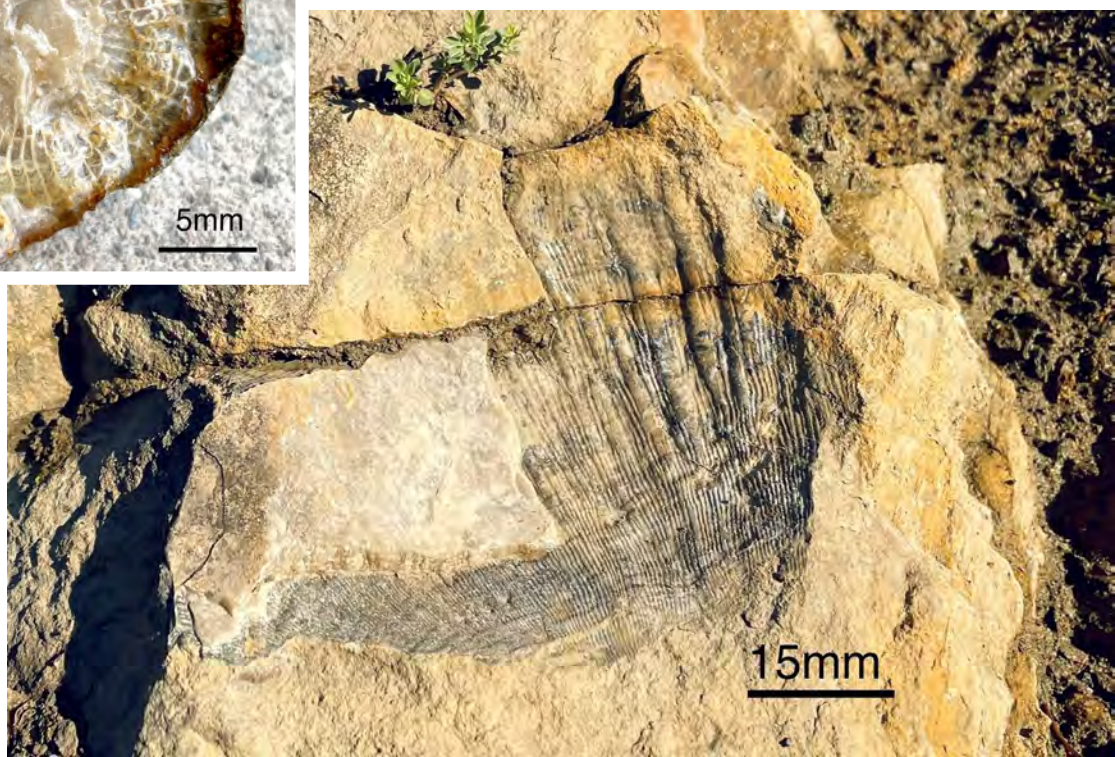
Dr Katie Strang, Scottish Geology Trust and **Dr Rachel Wignall**, NatureScot

Petershill Nature Reserve in West Lothian, managed by Scottish Wildlife Trust (SWT), is part of a Site of Special Scientific Interest (SSSI) for its rich geology and grassland biodiversity. In the summer and autumn of 2021 repeated incidents of large-scale rock excavation were causing significant damage to the geological interest of the reserve. Could the damage be halted?

Nationally important geology

Petershill Nature Reserve is nestled within the rolling Bathgate Hills of West Lothian, which rise gently from the surrounding grasslands, farmlands and woodlands to form a belt of high ground stretching from Bathgate to Linlithgow. The hills are formed of a thick pile of lava erupted in the early Carboniferous period, interbedded with sedimentary successions of shale, siltstone, sandstone and limestone. Standing here today, with views of the iconic Firth of Forth and Ochils in the distance, it is hard to imagine that this region was once a powerhouse of industry. As you scan the horizon, interspersed between the protruding volcanic hills are rounded mounds and ditches. These relics are all that remains of extensive colliery and oil-shale bings (colloquialism for heaps of waste material); over time their harsh outlines are slowly being diminished and softened as nature reclaims them.

***Left*: Cross-section view of solitary Rugose coral *Koninckophyllum*. Rugose corals have a hollow in the top surface known as the calice, where the animal (polyp) would sit. *Below*: Image showing an *in-situ* Brachiopod *Gigantoproductus*, preserved in life position at Petershill. Brachiopods were abundant during the Palaeozoic and are one of the most common macro fossils at Petershill and an obvious target for collectors. Photos by Katie Strang unless otherwise stated**



Petershill Reserve itself is the site of a historic limestone quarry, one of a series of sites which worked the band of Petershill Limestone as it cropped out across the Bathgate Hills. The first phase of quarrying started in the 18th century and remained active until the quarries were converted into drinking water reservoirs in 1886 and in 1905, before being decommissioned in the 1980s. Since then the underlying calcareous bedrock has provided the perfect habitat for a wide variety of plants, birds, mammals, amphibians, and insects.

The history of Petershill spans much further than just the last few centuries—it extends back over hundreds of millions of years to the Carboniferous when Scotland lay close to the equator; recording evidence of tropical seas, changing climates and large scale tectonic activity. The Petershill limestone is a 30–40 m thick sedimentary succession which represents an interval of quiet in volcanic activity, allowing sedimentation to occur around the edges of the lava flows. The limestone preserves an excellent tropical reef environment containing a rich fossilised fauna of solitary corals and mounds of the colonial coral *Siphonodendron junceum,* as well as beautifully preserved brachiopods, sponges, gastropods, crinoids and echinoids.

The occurrence of a bioherm in the southern portion of the reservoir is of particular geoscientific importance. A bioherm is a biogenic reef mound, formed by a build-up of calcifying organisms such as coral and stromatolites. These biogenic reefs have been hotspots of biodiversity throughout the Phanerozoic, however the geological record shows that reef growth and diversity through time have experienced cyclical lows and highs. Evidence suggests that these cycles are partly attributable to changes in environmental conditions such as rising global temperatures. This bears a stark

Damage to Petershill SSSI caused by unconsented extraction of large fossil-bearing blocks from the steep reservoir bank in the autumn of 2021, and one of the temporary 'no collecting' signs first installed in January 2022. Photo by Rachel Wignall/NatureScot

similarity to what we see in the present day, where climate change is predicted to significantly alter and damage reef ecosystems. Understanding the ecological impacts of past reef environments exemplified at Petershill can help provide important insights into the fate of contemporary coral reef ecosystems in the current climate crisis. This underscores the conservation value of the site and the need for its ongoing sustainable management.

A resource under pressure and the value of monitoring

Petershill became an SSSI in 1984, however, a national monitoring programme for SSSI features in the UK was not instigated until 1999. The Lower Carboniferous geological feature of Petershill SSSI, which includes the SWT Petershill Nature Reserve, was first monitored by NatureScot (then Scottish Natural Heritage) in 2001. Signs of unconsented collecting were noted from the visually spectacular *Gigantoproductus* limestone pavement area in the reserve. However, prior to 2004, damage to SSSIs by third parties (as opposed to the owner or occupier) was not an offence and SWT felt that signage requesting people not to collect fossils might simply advertise the presence of fossils and attract more collectors.

A Site Check in 2013 observed no notable increase in collecting activity. However, monitoring both by NatureScot and Lothian and Borders Geoconservation, in the summer of 2021, alerted us to an alarming level of damage at the site. It is likely that this was sparked, or certainly exacerbated, by heavy use of the reserve during COVID-19 lockdowns as a local green space for nearby Bathgate. This will have made significantly more people aware of the presence of fossils at the site many of whom would appear to be unfamiliar with the best practice guidance in the Scottish Fossil Code and of the need to collect responsibly. Modern social media also ensures that no fossil locality remains a secret long and reports of ‘great fossil collecting’ at Petershill are not hard to find on social media platforms.

Damage to the site includes loss of around a sixth of the limestone pavement since 2001, probably by piecemeal levering up of blocks along its edges. However, more alarming in 2021 was the excavation of large fossiliferous blocks from the steep reservoir bank. An exposed face left by excavation, was first recorded in 2007 in the steep bank. However, by summer 2021, a second exposure had been created and over the next few months, until December 2021, the site was repeatedly damaged by large blocks being excavated from both these localities. The excavation work must have required considerable planning and utilised industrial tools including crow bars. The scale of the excavation suggests that the purpose was likely commercial, although as yet no identifiable material from the site has appeared for sale.

During this period, volunteers from both Lothian and Borders Geoconservation and Scottish Geology Trust assisted in recording damage to the site. A site meeting of volunteers, NatureScot and SWT in December 2021 initiated actions including formally reporting the possibility of a Wildlife Crime to Police Scotland and seeking funding and appropriate wording and designs for signs to discourage damaging collecting activity and promoting the Scottish Fossil Code. This was followed up in March 2022 by an on-site meeting with Police Scotland staff from both local and national wildlife crime units.

Representatives from Scottish Wildlife Trust, Police Scotland, NatureScot and Lothian and Borders Geoconservation, with the new permanent 'no collecting' sign at Petershill east gate. Petershill underscores the importance of partnership effort in resolving challenging resource management issues.
***Inset*: A close-up view of the permanent version of the 'no collecting' sign at Petershill west gate installed March 2022. It is hoped that this signage will encourage visitors to appreciate the rich palaeontological heritage of the Nature Reserve and whilst deterring those that ignore best practice guidance in the collection of fossils. Photos by Rachel Wignall/NatureScot**

The power of signage

Since the Nature Conservation (Scotland) Act 2004 intentional or reckless damage to an SSSI feature by anyone is a wildlife crime. Signage at geological SSSIs can therefore alert people that hammering and extraction of rock outcrop is a wildlife crime, allowing a strong clear message to be presented. In spring 2022 signs were installed at each gate to Petershill Nature Reserve, with additional temporary signs at outcrops. The signs, supported by the Police Scotland logo, highlight a key message of 'no fossil collecting without permission', that reckless or intentional damage such as hammering rock outcrop is a wildlife crime, and ask people to assist in reporting any suspicious activity to Police Scotland. Installation of the signs has been supported by social media posts by NatureScot and volunteers, including posting appropriate conservation messages on platforms where Petershill has been promoted as a good site for collecting fossils. Since the first signs were installed on the site in January 2022, no further excavations have taken place to date (April 2022). This is great news, and it is hoped that the signs, the continued active support of Police Scotland, and an increased social medial campaign will prove the key to protecting this site for the future.

Working with our Suffolk Coast and Heaths AONB

Caroline Markham, GeoSuffolk

The very name 'Coast and Heaths' conjures up geology—heathland developed on sands, with exposures in the sea cliffs. Suffolk's cliffs have wonderful exposures of Red and Norwich Crags. They are designated SSSIs and need little management, although close monitoring is essential. The heathland is dotted with small, historic excavations in the Crags (for gravel, shells and coprolites, etc.) which have existed for generations—reminders for the people of Suffolk of the ancient history of their coastal area. These degrade over time and GeoSuffolk has joined forces with Suffolk Coast and Heaths (SCH) AONB in a management programme to refresh some of the Crag pits on the heath. Starting in 2014, in Work Parties of about 8–12 with only hand tools, we have braved winter weather to clear vegetation and talus from eleven sites (so far…).

Four pits with public access designated as County Geodiversity Sites (CGS) have been cleared for the benefit of visitors. This has also required liaison with the owners – the RSPB, English Heritage, the Forestry Commission and Westleton Parish Council. Mostly a light touch is all that is needed. One of the delights of south-east Suffolk is the glimpses of red amid the vegetated heath (see photo of Alderton House Pit taken after management in February 2019). This is a good introduction to the Red Crag and some of our management has strived to keep this aspect of the landscape intact. Sometimes it is enough just to keep that flash of bright red visible from the footpath.

***Left*: An enticing flash of Red Crag in Alderton House Pit is visible from the footpath, after management work in February 2019.**

All photos by Caroline Markham

***Right*: The Coralline Crag at Orford Castle Pits, was still well-exposed when surveyed by GeoSuffolk in January 2022, having been cleared by a Suffolk Coast and Heaths AONB Work Party in 2014.**

The Suffolk Crags range from about 4 million years to 2 million years in age. Coralline Crag, the oldest, is unique to Suffolk, cropping out in the central section of the AONB. Red Crag is found throughout much of south-east Suffolk and has important exposures in the cliffs here. Norwich Crag, the youngest, is exposed in our northern cliffs. They are all full of marine shells—from an ancient shore without human footprints. The mix of extinct and extant species, a reminder of our not-too-distant past, with its relevance to climate change issues, is attracting increased research attention. These sites, SSSIs and under private ownership, have needed minimal management in order to maintain access to their exposures.

We have begun to witness the longer-term fruits of our labour. In July 2019, following on from two visits with SCH AONB Work Parties, GeoSuffolk placed a panel on Westleton Common CGS interpreting the Norwich Crag gravels for visitors. The photo shows GeoSuffolk supporters with the panel on a CGS monitoring visit in October 2021. In December 2021 GeoSuffolk surveyed the Coralline Crag at Sudbourne Park pit SSSI for Natural England—two visits with SCH AONB Work Parties (the photo shows the March 2020 session) ensured this received a good write up. In January 2022 GeoSuffolk monitored the Coralline Crag pit at Orford Castle, which was cleared by a Work Party in 2014—there were still good exposures of the 'Rock Bed' (see photo)—it is part of the Orford Castle Scheduled National Monument.

***Top*: GeoSuffolk and the AONB Work Party volunteers carry out work on the Coralline Crag at Sudbourne Park Pit, March 2020**

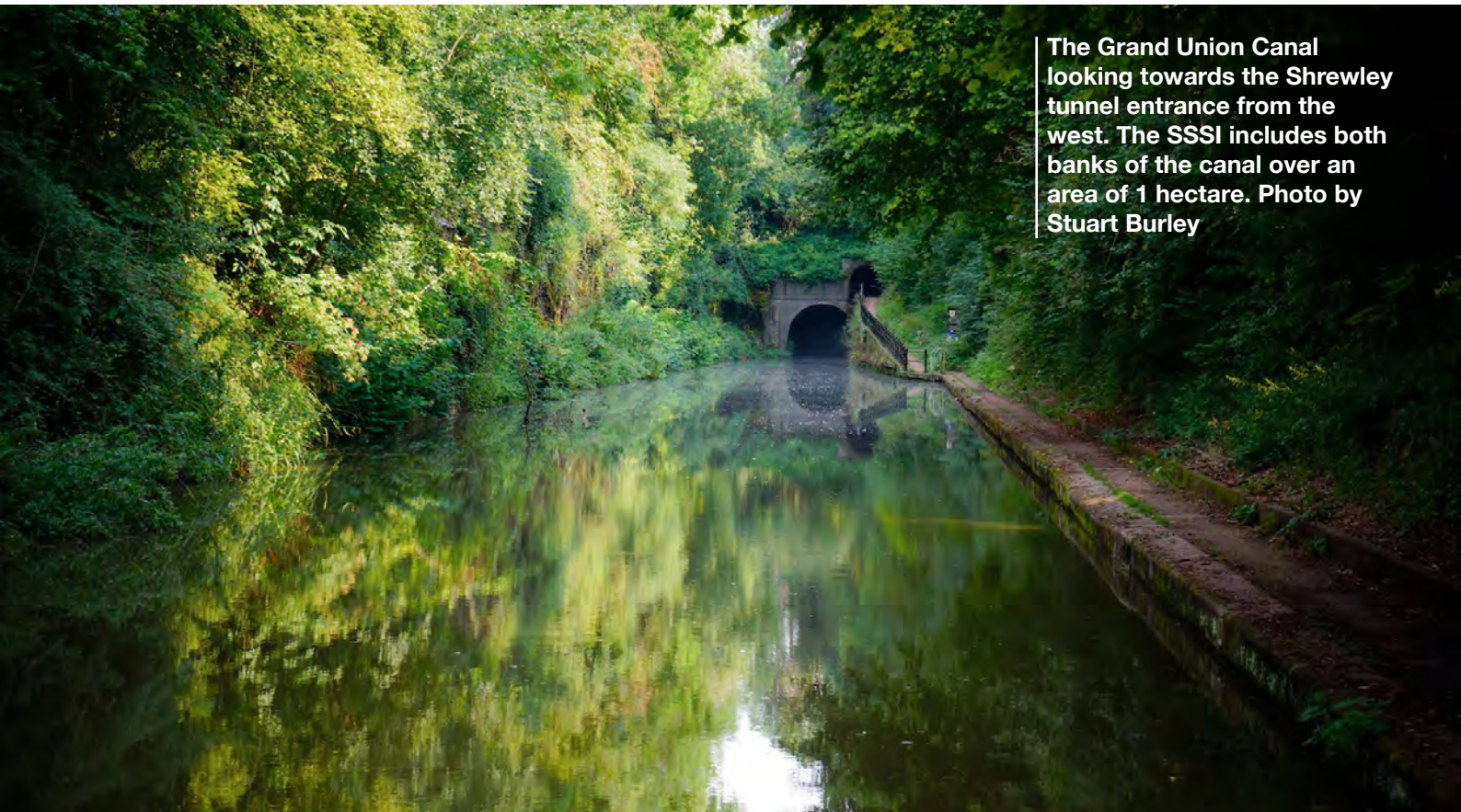
***Right*: A visitor information panel about the Norwich Crag, provided by GeoSuffolk at Westleton Common Pit, October 2021**

Geoconservation partnerships enable restoration of Arden Sandstone outcrops in the English Midlands

Stuart Burley, Warwickshire Geological Conservation Group & Basin Dynamics Research Group, Keele University and **Jon Radley**, Warwickshire Museum

Warwickshire may not be renowned for its bare mountains and expansive rock exposures, but the county is host to more than 100 Local Geological Sites and a significant number of geological SSSIs. The Warwickshire Geological Conservation Group (WGCG) (https://www.wgcg.co.uk) works closely with local councils, land owners, Natural England and other interested parties, including water and wildlife organisations, and the county museum service, to maintain and document these sites and provide publically available information about them. The WGCG is also very much involved in public education, promoting its geodiversity and geological sites through events, activities and social media.

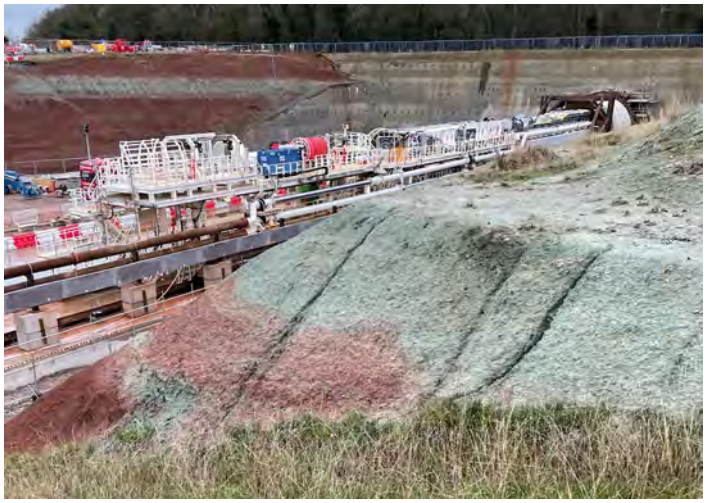
Many readers through their experience will understand that geoconservation is a slow and time-consuming process. One project which has made progress through COVID lockdowns is the WGCG's work on conservation of the Arden Sandstone localities in the county through many Zoom collaboration meetings and, more recently, actual clearance work. The Arden Sandstone is of Carnian age and divides the continental Late Triassic Mercia Mudstone Group into a lower sequence of dominantly red desert mudstones and an upper unit of rather very similar red mudstones. The Arden Sandstone takes its name from the Forest of Arden in Warwickshire and the type locality for the formation is the cutting on the Grand Union Canal immediately west of the Shrewley tunnel [Grid Reference SP 21413 67317]. It is a beautiful setting on the canal but is somewhat in an overgrown



The Grand Union Canal looking towards the Shrewley tunnel entrance from the west. The SSSI includes both banks of the canal over an area of 1 hectare. Photo by Stuart Burley

The Warwickshire County Highways traffic control system in action on Blackford Hill on the A4189 near Henley-in-Arden. The cars parked on the right, behind the cones, belong to the WGCG workforce clearing the Arden Sandstone exposure. Photo by Max Down, WGCG

A freshly cleared outcrop of the Arden Sandstone at Rowington, north bank of the Grand Union canal, revealing channelised sandstones previously unrecognised. Photo by Stuart Burley

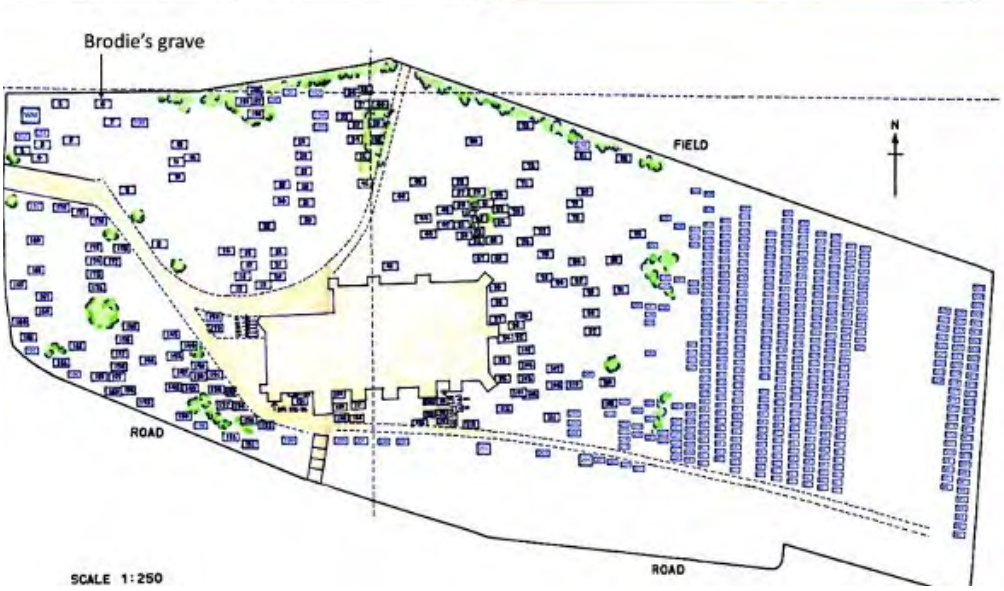


New exposure of the Arden Sandstone sandwiched between red coloured Mercia Mudstone Group mudstones at the north portal of HS2's Long Itchington Wood Tunnel. Dorothy, one of HS2's tunnel boring machines, is visible in the background. Photo by Stuart Burley

condition. It is thus very timely and appropriate that WGCG worked through lockdown with the Canal and River Trust and Natural England to arrange for work to be done later this year to clear a section of the SSSI and re-expose the type section of the Arden Sandstone.

In addition to the Shrewley Canal Cutting SSSI on the Grand Union Canal, the Arden Sandstone has been rediscovered in a roadside cutting in Henley-in-Arden. This was cleared by WGCG late last year with practical assistance from Warwickshire County Council Highways which provided a traffic light system to manage traffic flow. Another section on the Grand Union Canal at Rowington, one of our Local Geological Sites, was recently cleared with help of the Canal and River Trust. WGCG has made presentations to local parish councils to gain support and help from the local communities as these sites are also of interest to ecologists and bird watchers. A new exposure was revealed by the construction of High Speed Two (HS2) near Long Itchington, which together with access to shallow boreholes drilled by Balfour Beaty Vinci on behalf of HS2 in the area, has proved evidence of a north-eastern extension of the Arden Sandstone, east of the Warwickshire coalfield.

The Shrewley (Grand Union) Canal Cutting SSSI is not only the national type locality for the Arden Sandstone, but it has taken on new geological significance nationally and internationally. It is now recognised as the level in the Triassic which records an important inflection point in reptile evolution, and potentially the evolution of other fossil groups. This change was instigated by a sudden increase in rain and fluvial deposition during the latest Triassic deserts. The same event has been recorded from many places around the world. The Reverend Peter Brodie, palaeontologist and a former honorary curator of the County Museum, discovered fossil fish and reptile remains from the Shrewley Grand Union Canal cutting in the 1850s at the stratigraphic horizon in which the evolutionary changes began. This type locality has not been fully documented let alone described. Preserving the



Top left: The Rev. Peter Brodie, MA, FGS, 1815–1897 (from Woodward, H.B. 1897. Eminent living geologists—the Rev P.B. Brodie. Geol. Mag.). Top right: St Laurence church, Rowington, picture taken from where Brodie is buried. The church is a fine example of early 12th Century architecture and is constructed mostly of Arden Sandstone. The first written record of the church is contained in a deed of 1157 whilst the nave north wall is Norman; in the 1280s a new west wall was constructed and the building widened southwards. The red sandstone on the top course of the chancel stonework came from Kenilworth Priory. Brodie is buried at the front of the church. Bottom left: St Laurence graveyard map (from http://rowingtonrecords.com). The resting place of Brodie appropriately stands on the crest of the Arden Sandstone outcrop, on the boundary with his vicarage. Bottom right: The gravestone of Brodie, now partially obscured by the laurel hedge. Photos by Stuart Burley

Shrewley Grand Union Canal section and recording new temporary sections such as the HS2 cutting is thus important for further research, teaching and nature recovery activities, as well as bringing the Shrewley Canal Cutting SSSI locality to wider public awareness.

The Arden Sandstone in these outcrops is up to 7 m in thickness. It is typically fine grained, cross-bedded and contains a fauna which includes clam shrimps, crustaceans and bivalves, in addition to the fish and reptile remains recorded by Brodie. The base of the sequence begins with thinly bedded, rippled, highly dolomitic siltstone and very fine-grained sandstones interbedded with green mudstones full of worm and crustacean burrows. Reptile tracks have also been discovered. This is overlain by 2-3 m of fine- to medium-grained sandstone which is prized for its building stone qualities. Many of the churches in the Forest of Arden (Lapworth, Rowington, Wootton Wawen, and others)

The current condition of the Arden Sandstone Formation exposed on the south face of the Grand Union Canal cutting. This is the upper part of the sandstone, which is sought after as a building stone. Note the top of the thinly bedded sandstones in the bottom part of the cliff section.

and old stately homes (such as Baddesley Clinton) are built of Arden Sandstone. There is a pressing need for replacement building stone material in several of these buildings and one benefit of the WGCG conservation work may be identification of potential new quarry sites nearby.

The exact provenance of the fossils collected by Brodie is not known, but detailed description of the Shrewley and other related exposures will help better define which part of the Arden Sandstone the specimens most probably came from. This in turn will help reconstruct the environment of deposition of the Arden Sandstone and further our understanding of late Triassic palaeogeography and evolution.

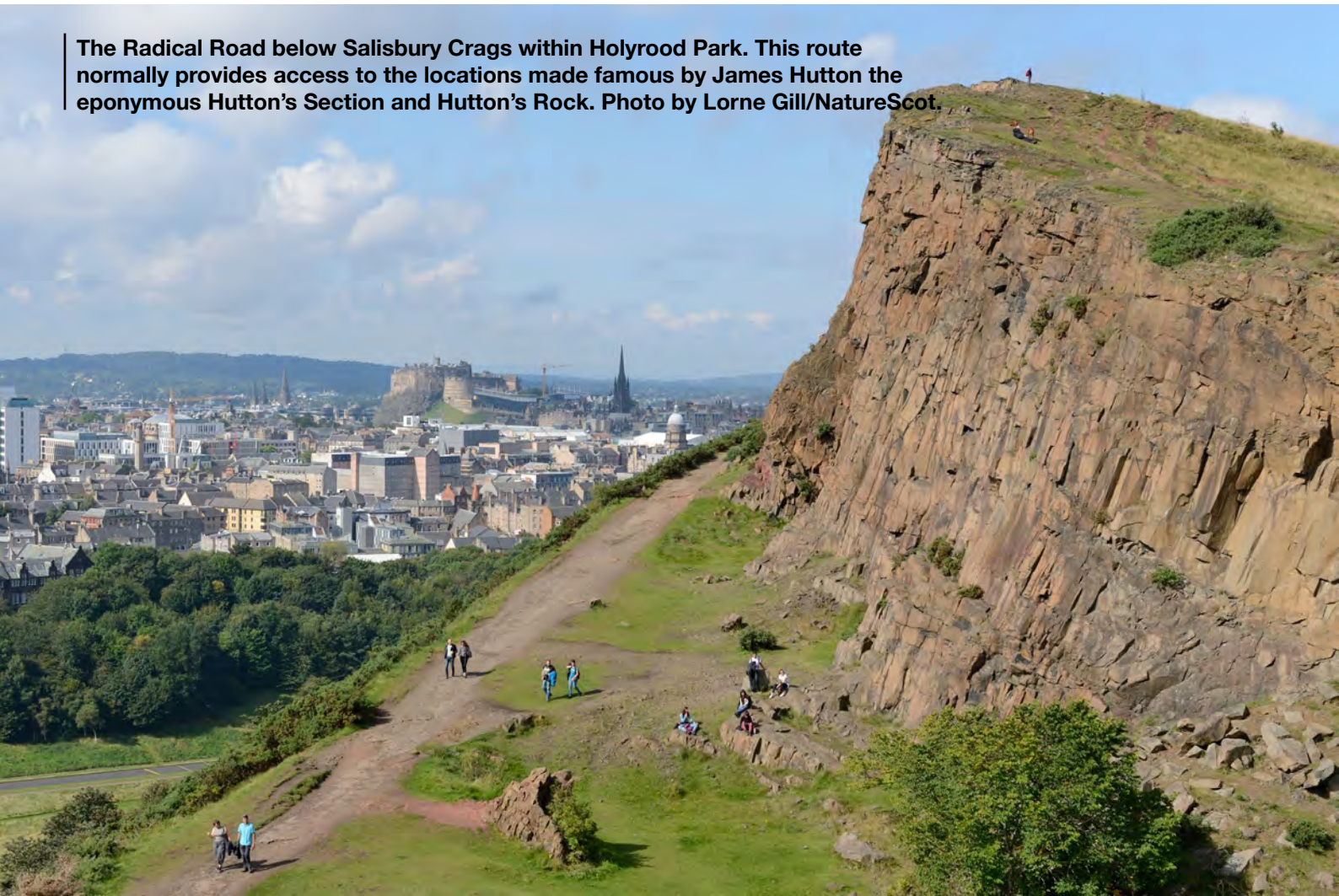
The conservation work plan for the type section at Shrewley is to clear a short length of the north and south bank to reveal as much of the vertical rock succession as is possible and is safe. There are clearly some safety aspects to be addressed as the section faces are steep and directly adjacent to the canal. WGCG intend to supplement the conserved site with an information panel that will present information on the story of the canal cutting as well as aspects of the important geological features of the Arden Sandstone. Early engagement and partnerships with local communities, land owners and other interested parties have enabled WGCG to make great progress in these important geoconservation activities despite COVID restrictions. Natural England, Warwickshire County Council, the Canal and River Trust, the Warwickshire Museum, HS2 Ltd and Balfour Beaty Vinci have all kindly helped facilitate the volunteer work of the WGCG.

A Virtual Journey Through Time: Making the famous Salisbury Crags localities of James Hutton, Digitally Accessible

Dr Ewan Hyslop, **Dr Lyn Wilson** and **Barry McPherson**, Historic Environment Scotland

Within Holyrood Park, nestled in the heart of Edinburgh, globally significant geological features can be found. Hundreds of millions of years ago, eruptions of Arthur's Seat Volcano gave rise to the bedrock that underlies the unique landscape that exists today. Salisbury Crags form part of this landscape and the famous localities of James Hutton can be found here.

Historic Environment Scotland (HES) is the lead public body set up to investigate, care for and promote Scotland's historic environment and is responsible for management of Holyrood Park. HES's duties include caring for the park's natural and cultural assets and park accessibility. The Radical Road is a historically important route situated directly below the cliff faces of Salisbury Crags and is the main access point for the internationally important locality of 'Hutton's Section'. However, providing safe access to the 'Radical Road' has not been possible since a rockfall event in 2018. Until we can safely allow visitors to return to 'Hutton's Section' we hope that the creation of virtual access will provide an interesting and informative route for learning and engagement for this important geosite.



The Radical Road below Salisbury Crags within Holyrood Park. This route normally provides access to the locations made famous by James Hutton the eponymous Hutton's Section and Hutton's Rock. Photo by Lorne Gill/NatureScot.

A portrait, by the caricaturist John Kay, of Dr James Hutton at a cliff of rock that is drawn to appear as though Hutton is actually communicating with rock 'faces'. © The Trustees of the British Museum. NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0).

Geological significance of 'Hutton's Section' and 'Hutton's Rock'

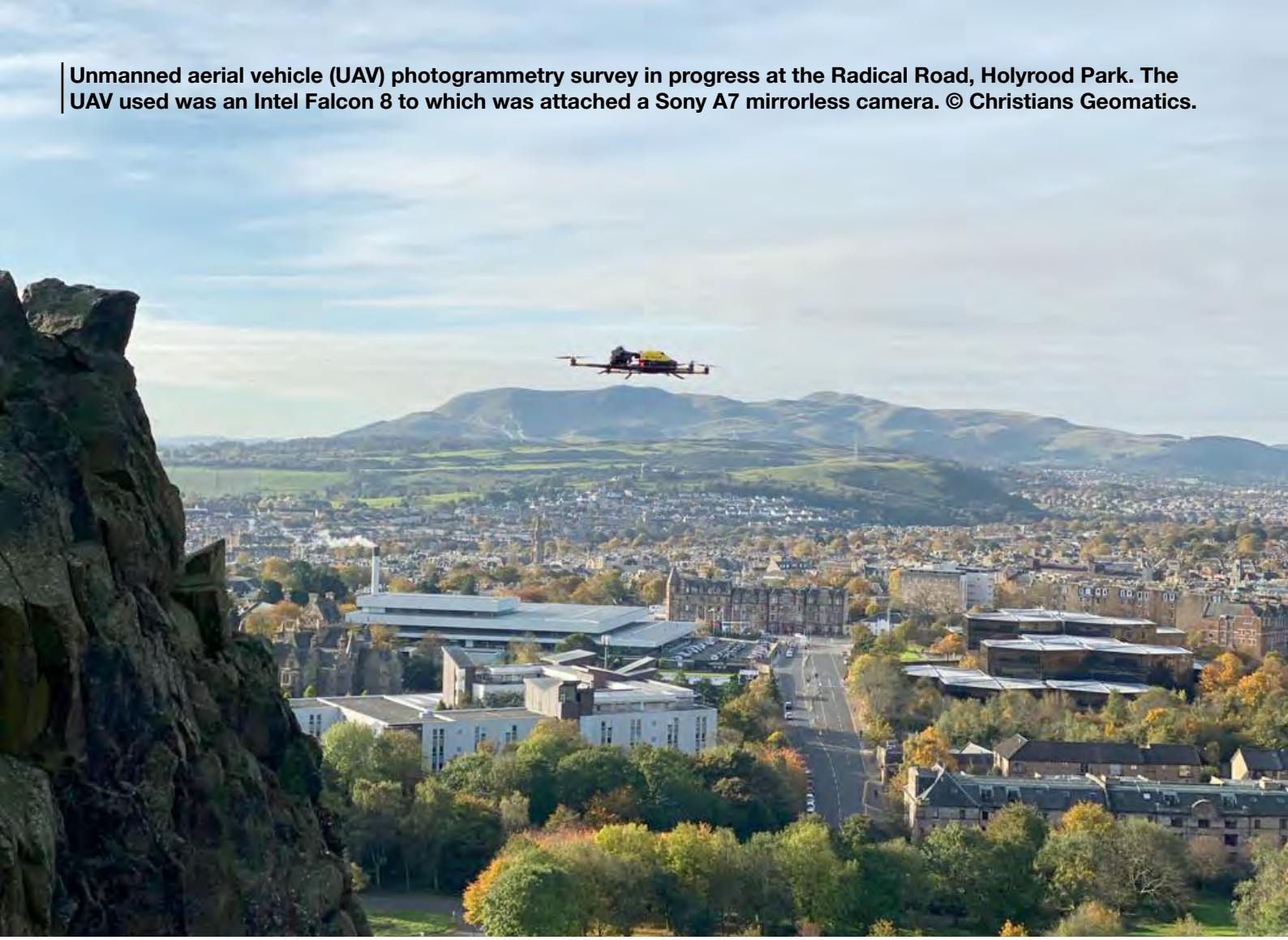
James Hutton (1726–1797) is known as the 'father of modern geology.' He lived during the Scottish Enlightenment, a period marked by significant advances in knowledge and understanding. Hutton's studies and discoveries made a great contribution to our understanding of Earth processes, most notably around the concept of 'deep time' and the idea that the Earth is very old and continually changing.

At the south end of Salisbury Crags, Hutton discovered geological features which evidenced his theories. By examining igneous and sedimentary rocks in this locality, Hutton understood that they had been formed at different times and by different processes. One exposure in particular, now known as 'Hutton's Section', shows an intrusion of magma between and across older layers of sedimentary rock, with the magma cooling to form igneous dolerite. This finding supported his theory that igneous rocks are formed via crystallisation of molten magma. The nearby 'Hutton's Rock' is a single outcrop containing a hematite vein in an otherwise disused quarry. It is believed that Hutton asked for this geological feature to be left intact and it is therefore possibly one of the earliest examples of geological conservation in Scotland.

Reasons for closures and action being taken

The Park's famous and historic Radical Road, which leads to Hutton's Section, is currently closed to the public due to the risk of falling rock adjacent to the path above Salisbury Crags. Given the nature of the site, some rock failure will always occur over time. This is a natural process, however, it has been exacerbated by factors such as climate change which accelerates the rate of deterioration. The ongoing management of the rock face in the park is complex and Historic Environment Scotland (HES) conducts regular descaling work as part of its approach, along with other forms of physical intervention. Whilst this work is ongoing, HES has looked at various ways to provide further insight into this area of the park including via a current digital scanning project and has released detailed 3D models of this area which are now available online.

HES has also commissioned further specialist input and is currently reviewing this, as well as embarking on discussions with other, relevant regulatory bodies to consider the best ways to help mitigate rockfall risk going forward. As HES has a statutory obligation to manage this risk across Holyrood Park, this has meant restricting access in certain areas for now, including the Radical Road which remains closed with an additional barrier system in place to ensure no general public access to an area of significant risk of rockfall within the park.



Unmanned aerial vehicle (UAV) photogrammetry survey in progress at the Radical Road, Holyrood Park. The UAV used was an Intel Falcon 8 to which was attached a Sony A7 mirrorless camera. © Christians Geomatics.

While access to the Hutton Section and Hutton's Rock remain temporarily affected by this wider closure, to provide managed access for specific groups, plans are in place to start risk-assessed, park-ranger-led educational visits to the site for students and educational groups with relevant personal protective equipment (PPE), over the next few months.

Creating digital documentation and virtual access

HES is committed to using cutting-edge digital technologies including laser scanning and photogrammetry to accurately capture and record all the properties in its care in 3D, a process known as *digital documentation*. This process is an ongoing and constantly evolving endeavour, but always providing high resolution and spatially accurate information in the form of a *point cloud* (a group of discrete 3D data points with x,y,z coordinates and colour imagery). We use this approach to record everything from buildings and archaeological sites to landscapes. The 3D data created is used for a range of applications from conservation and monitoring to interpretation and virtual access.

In 2019, we undertook a programme of digital documentation at Salisbury Crags and the Radical Road in particular. We commissioned a very high-resolution unmanned aerial vehicle (UAV) photogrammetry survey to create an accurate baseline of surface condition at that time. The survey was undertaken following advice from NatureScot and at a time when no nesting birds were present, with the UAV operator and spotter located a safe distance from the Radical Road. Over the course of several days, this survey produced approximately 14,000 overlapping photographs which were combined into one 3D model, accurate to 5mm. The file size for the final data set is 150GB.

We use a freely accessible online platform called *Sketchfab* to share our 3D models virtually. We take the point clouds produced and post-process to optimise them for sharing in this way. Once on Sketchfab, virtual visitors can explore the 3D environments on a range of digital devices such as laptop, tablets or phones, or in VR for an immersive experience. For Hutton's Section, our Sketchfab model allows visitors to pan, zoom and rotate the model, and it contains a number of annotated key points of interest to provide further information. Whilst we understand this is not the same as visiting the site in person, we hope it will provide an interesting and informative route for learning and engagement for this important geological feature until we can safely allow visitors to return.

Explore Hutton Section's and Hutton's Rock on Sketchfab in the links below:

- Hutton's Section: https://sketchfab.com/3d-models/huttonarea02-4978e5069fac4a16893ffb27833fda59
- Hutton's Rock: https://sketchfab.com/3d-models/rr-huttonarea01-08afeff0a15343cbb850f62e9530d1c7

Snapshot from the online Sketchfab 3D model of Hutton's Section, Holyrood Park. Many thousands of overlapping photographs were combined to form the 3D images of both this locality and Hutton's Rock. © Historic Environment Scotland.

Further Information

Historic Environment Scotland's *Rae Project*: https://www.engineshed.scot/about-us/teams/digital-documentation-and-digital-innovation/the-rae-project/

Historic Environment Scotland's *Applied Digital Documentation in the Historic Environment – Best Practice Guide*: https://www.engineshed.scot/publications/publication/?publicationId=9b35b799-4221-46fa-80d6-a8a8009d802d

Obituary - Professor Chris King

Peter Kennett, a teaching colleague of Chris King

Sadly, Chris King died after a relatively short illness in February 2022, aged 72. His loss will be felt very widely across the geoscience community, both at home and abroad, thanks to the many initiatives which he had developed during his 19 years as a teacher of Geology and other sciences at Altrincham Grammar School for Boys and as Lecturer, later Professor, of Earth Science Education at Keele University, from 1996 until his retirement in 2015.

Chris's first employment was for 5 years as a diamond prospector with De Beers in Southern Africa and Australia, but he found his true calling as a teacher, following a PGCE at Keele. Chris became an active member of the Earth Science Teachers' Association, and soon became known for his innovative ideas, so many of which involved teaching aspects of Geology in a fun way, which his students obviously enjoyed. This characteristic stayed with him for the rest of his career and it did not matter whether his audience consisted of school students, teachers or captains of industry—Chris's engaging personality meant that people willingly took part and went away feeling that they had really learnt something valuable.

Many of Chris's ideas were developed against the odds, sometimes even opposition from entrenched positions by other subjects. In 1999 he secured funding from the then UK Offshore Operators' Association (UKOOA) to set up the Earth Science Education Unit to train and employ, on an *ad hoc* basis, around 50 facilitators across Great Britain, resulting in an estimated 37,000 teachers attending one or more workshops during its 16 years of operation.

Chris also encouraged Elizabeth Devon and Peter Kennett to join him in forming a website, www.earthlearningidea.com (ELI) to provide an Earth Science teaching activity every fortnight, free of

Earthlearningidea - http://www.earthlearningidea.com/

Take it or leave it? – the geoconservation debate

When is collecting wrong, and when is it right? – try to decide for yourself

10 Can only be collected under licence. Take a photo instead

9 ↕

8 Should never ever be collected by school students. Take a photo

Should you take geological specimens away from the site where they are found? This is a difficult question and it depends on where you are and who you are.

Lots of geologists became interested in geology when they began collecting minerals, rocks and fossils when they were children. So it is a good idea to build up your own collection – but only if this doesn't damage rock exposures and the environment and if it is legal for you to do so. But, if a specimen is on the beach and about to be washed away by the sea and broken up, or if you find it in

Try 'thinking like a geoconservationist' by cutting out the cards on the third page, discussing them with your group, and putting them in the best place on the scale cut from the side of this page.

A plant fossil in a quarry – 'take it or leave it?'

Photo: Peter Kennett

charge. This continues, and now has world-wide reach, with translations of many activities into 11 other languages. Although not primarily a conservation body, ELI does what it can to promote good practice, including one activity, “Take it or leave it…” part of which is shown on the previous page.

Chris was hugely active in supporting and leading initiatives across the world, e.g. the formation of the International Geoscience Education Organisation (IGEO) in 1997. More recently he was involved in the setting up and ongoing appointment of Field Officers, with a world-wide reach through the auspices of the European Geosciences Union and of the IGEO.

Chris has received many honours during the course of his career, notably Honorary Life Membership of ESTA in 1994; the Geological Society’s Distinguished Service Award in 2003; and its RH Worth Prize in 2011, as well as the Geologists’ Association’s Halstead Medal in 2012. In 2018 the International Association for Promoting Geoethics (IAPG) honoured Chris with its Geoethics Medal.

Among the very many articles and books which Chris wrote, his most recent venture surely deserves to be his most lasting legacy. The IGEO has devised an international Geoscience syllabus which it believes every 16 year old should experience, and Chris set about writing a major online textbook to accompany it (Chris wrote an article about the new book a few weeks before he died, published in this issue, p 11). Chris’s typical clarity of wording and inspirational choice of examples make this an essential resource for every school student and of course it is completely free. The latest version is Exploring Geoscience across the Globe – England I International Geoscience Education Organisation (igeoscied.org). If readers with any connection to education could promote this wonderful free resource it would help to perpetuate Chris’s legacy of encouraging many more to understand and care for our amazing planet.

***Right*: Chris King at the start of the Earth Science Education Unit in 1999**

***Below*: Chris King demonstrating sedimentation in front of a series of beds on Barry Island**

Both photos by Peter Kennett

Earth Heritage in print

Earth Heritage is produced twice-yearly by the Geologists' Association, Natural England, Natural Resources Wales, NatureScot and the Quaternary Research Association.

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Ice Age ponds are typically found in areas of hummocky moraine, without source or outflow. They are important not only for the wildlife that they now contain, but also for the sediments, including peat, stored within them. These sediments can be up to 8 m deep and have a pollen record dating back over 10,000 years.

***Conserving Herefordshire's Ice Age Ponds* is a partnership project funded by a grant from the National Lottery Heritage Fund. The project, outlined on p.41) has raised awareness of the geological story behind the formation of the ponds and the ecological value they have within the landscape today. Photo by Will Watson**

Geologists' Association 1858

QRA Quaternary Research Association

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